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[HIT 400 (Capstone Design Project) Compendium of Abstracts]

The document captures the abstracts of HIT 400 Projects done by students in the School of Industrial Sciences & Technology and School of Engineering & Technology for the academic year 2017-2018

School of Engineering & Technology

DEPARTMENT OF CHEMICAL AND PROCESS SYSTEMS ENGINEERING

THE DESIGN OF A PLANT TO PRODUCE 5 TONNES / DAY OF PAPER FROM CORN HUSKS AND STALKS

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Paper is one of the products that we cannot go a day without due to its vast purposes which include printing, tissues, newspapers, packaging, writing among others. In line with this, there is an increasing demand for paper leading to rapid environmental destruction. Within this environmental situation, there is therefore a need for alternative pulp and paper means other than wood. This project focuses on utilising corn husks and stalks which are a waste product of agriculture to be incorporated in the production of paper. Experimental work including assessment of fibre morphology was carried out to depict optimum process conditions of producing competitive paper and to assess the physical qualities of the produced paper such as basis weight, thickness, burst index, tensile index and folding endurance through laboratory experiment, testing, and results. The experimental work was also used to form the basis for designing the process, equipment and a prototype. From the experiments it was observed that corn husks and stalks contain around 10, 12% moisture content and dried paper contains 8% moisture content. Also different appearances in the paper texture was achieved by bleaching and adding additives like kaolin. Scanning electron microscope showed corn stalks and husks contain an average fibre length of 1.72mm. Equipment design was done on 2 major equipment; the condebelt drier and a pulper. Hazard and

operability study and process control was also done on these pieces of equipment trying to monitor deviations that may arise in the plant. A detailed financial analysis was carried out to investigate the potential and viability of the project using profitability estimators and the project was found to be economically viable since it gives a Return on Investment of 49% and a Pay Back period of 2 years after requiring a capital investment of US$ 665 754.00.The selling price was estimated to be $0.69 per kg giving an annual net profit of $ 328 109.90. It can be concluded that it was feasible to design an economically viable 5TPD paper plant from corn husks and stalks.

Keywords: Pulp, Husks, stalks, fibre, morphology

DESIGN OF A PLANT FOR THE PRODUCTION OF 56TPM COPPER CATHODES USING SCRAP COPPER (A CASE STUDY FOR CAFCA)

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Copper is a very good conductor of electricity and is used for electrical wiring and cables. Economic hardships coupled with the RBZ's failure to provide foreign currency forced CAFCA, a cable manufacturing company to resort to harvesting scrap copper. The scrap copper contains impurities and this is detrimental since even small amounts of impurities can reduce copper's conductivity noticeably. The metal must be 99.99% pure to be used for cable and wiring, thus the scrap copper is electro-refined so that it can be used. This project focuses on the production of 56TPM copper cathodes from scrap copper From the analysis carried out it can be concluded that it is possible to design a plant. Electro-refining process parameters and copper sulphate production were assessed on the effect of process efficiency. Iron removal by chemical precipitation was also studied and from the results obtained in the experiment the pH which is optimum to use for iron removal without compromising or removing a lot of copper is 4.8-5. At this pH the iron removal efficiency is 85.7%-86%. The mass of sludge that was filtered off was 0.6553g per 100ml of solution neutralized and volume of NaOH used to reach this pH is 40ml. These values were used to come up with a detailed process and equipment design which led to the design of an electro refining cell circuit and a copper sulphate reactor. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 3.7years and return on investment of 26.5%. The electro refining process is an energy intensive process thus for scrap copper recovery to be profitable the difference between copper sales price and scrap copper purchase price must exceed treatment charges. The researcher recommends that more active role on copper scrap generation research is needed from scrap traders/recyclers/dismantlers. There is need for economic variables and public end use data to improve scrap analysis and forecasts.

Keywords: electro refining, copper sulphate, iron removal, scrap copper

DESIGN OF A HYBRID PLANT THAT PROCESSES 1 000 TPD GOLD ORE USING IMPROVED COPPER-CATALYSED THIOSULPHATE LEACHING OF A REFRACTORY GOLD ORE WITH SODIUM HUMIC ACID AS AN ADDITIVE (CASE STUDY: JENA GOLD MINE PRIVATE LIMITED)

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Jena gold mine Private Limited is one of the top gold producers in Zimbabwe wholly owned by Zimbabwe Mining Development Cooperation (ZMDC). The prevailing poor gold recoveries at company and also alarming environmental effects of sodium cyanide initiated the design of hybrid plant to process 1 000 TPD of gold ore using improved copper-catalysed thiosulphate leaching in the presence of sodium humic acid to alleviate gold passivation by sulphides as well as reducing high thiosulphate. Experimental work was done to compare the recoveries of gold between cyanide and thiosulphate. Thiosulphate leaching had higher recovery of 95.3% compared to conventional cyanide of 80% and also the residence time reduced from 24 hours when using cyanide down to 8 hours with thiosulpahte leaching. A 115m^3 capacity leach tank reactor with diameter of 3.14m and a height of 4.71m to leach gold with 8 hours retention time was successfully designed and a pressure leaf filter was also designed. A HAZOP analysis was done on the leach tank reactor, ball mill, cyclone crushers and the thickener to identify any potential deviations that may lead to hazards and their migratory measurements were formulated. Site selection was done and the EIA was done for the project. An in depth economic analysis was also performed to access the economic viability of the project. A capital investment of $12 222880 is needed to initiate the process which corresponds to a payback period of 3.3years. The annual net profit after tax is $ 3684 9634and breakeven point of units was calculated and found to be 487.5 units (kg) and net present value of $15 819. It is concluded that it is technically and economically feasible to design thiosulphate leaching plant using copper sulphate as the catalyst and sodium humic acid as an additive to alleviate gold passivation which contributes to high reagent consumptions.

Keywords: *Sodium thiosulphate, sodium humic acid, sodium cyanide, copper sulphate, leach tank reactor, gold*

DESIGN OF A 350TONNE/YEAR PLANT FOR THE SYNTHESIS OF BIODEGRADABLE PLASTIC FROM SUGARCANE BAGASSE

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The usage of plastics in electronic industry, packaging industry and disposable products and the production of plastic waste have increased significantly, making the environment worse for living.

This project aims at the synthesis of biodegradable plastic from sugarcane which have approximately the same mechanical properties as those of petroleum-based plastics. The bagasse was pre-treated to remove moisture and later hydrolysed with 0.2 M dilute sulphuric acid in order to break the chains down to liberate sugars before fermentation with yeast. 14% sugar content was obtained on completion of hydrolysis compared to the 19.2 % theoretical value. A yield of 72.9% of sugar was obtained. Fermentation was completed after five days and 1.5g of sugar remained unconverted to ethanol. The produced ethanol solution was distilled and from the distillation bath,8.4 ml of ethanol was obtained at 78°C from 100ml filtrate and a theoretical yield of ethanol produced was 61.3 %. Dehydration of ethanol over a heated catalyst was done to produce ethylene gas. Several experiments were carried out to determine the amount of ethylene obtained per kg of ethanol and the highest conversion of ethylene was obtained at 400°C with a yield of 79.4% using 0.1g of catalyst. The obtained results were used to design an optimum process including a detailed design on the batch fermenter and fluidized bed reactor. The mechanical properties of the plastic were examined and were found to have similar properties with those of petroleum-based plastic although with a very short half-life compared to the petroleum-based plastic. “

“**Keywords:** *Biodegradable, bio plastic, tensile strength, magnesium stearate, Plasticizer*

DESIGN OF A PLANT THAT PRODUCES 10TPD OF KRAFT PAPER FROM TOBACCO STALKS

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Currently, there is no kraft paper producing plant in Zimbabwe. This causes high costs in the importation of the paper by the local paper manufacturing companies. On the other hand, a huge tonnage of tobacco stalks is produced annually and are currently considered agricultural waste as they have no commercial value. This project intends to utilise and design a plant that produces 10TPD of kraft paper from tobacco stalks. If commercialised this process would reduce foreign currency usage on importing kraft paper. The use of tobacco stalks as suggested in this paper constitutes value addition and beneficiation. A comparative study was made to appreciate the work done by other researchers. The experiments carried out included characterising tobacco stalks, moisture content determination, Cobb test, and tensile strength of kraft paper produced. From the experiments it was observed that composition of the tobacco stalks contained 6.45% of moisture, 50.8% of alpha cellulose and the acid insoluble lignin of 19 % and tensile strength of 51.3Nm/g. A detailed design was done for the two major pieces of equipment; the digester and cylindrical dryer. Hazard and operability study was also carried in trying to monitor deviations that may rise in the plant. From economic evaluation done a total capital cost of $424 782.93 is required for this project. At a selling price of $182 per tonne and an annual net profit of $126 355.64 being generated after taxes. The project has a breakeven of 508. 15 units that translates to $ 92 483.58, a return on investment of 29.75% and a payback period of 3.36 years which are acceptable financial indicators. It can be concluded that it is possible to design an economically viable 10 TPD kraft paper plant.

Keywords: *Tobacco stalks, Kraft paper, cylindrical dyer. pulp digester, cobb test.*

PRODUCTION OF 1 TONNE PER DAY OF ZINC OXIDE NANOPARTICLES FROM ZINC ACETATE DIHYDRATE

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The disposal of poorly treated and untreated sewage into surface water sources such as rivers and dams surrounding urban areas is common in many developing countries, including Zimbabwe. Bacteria from sewage leads to high levels of pollution which cause waterborne diseases. Zinc oxide nanoparticles exhibit antimicrobial properties. These properties can be incorporated in the coating and paints so as to reduce the growth of bacteria. Incorporating nanoparticles in coatings and paints also improve performance, like durability, self-cleaning, scratch resistance, indoor air quality, UV protection and anti-fouling properties. This project focuses on the design of a plant that produces one tonne per day of zinc oxide nanoparticles. Experiments were done to find if it feasible to produce zinc oxide nanoparticles using the sol gel method of synthesis. Characterization of zinc oxide nanoparticles was carried out using UV vis. The results of these experiments were used in mass balance to determine the amount of raw materials needed and hence the sizing and designing of equipment. A detailed design was done for the two major equipment which are batch reactor and rotary dryer. Hazard operability and environmental impacts and its mitigation have been analysed in trying to monitor deviations that may rise in the process. Economic analysis reviewed that capital investment of $1 839 620.19 is required for the plant set up with a payback period of 3.28 years and a break-even point of $566 609.40. From the process and equipment design it can be concluded that it is possible to produce 1 tonne per day of zinc oxide nanoparticles.

Keywords: antimicrobial, zinc oxide nanoparticles, sol gel approach

DESIGN OF A PLANT THAT PRODUCES 2500 LITRES /DAY OF BIOETHANOL FROM SEWAGE SLUDGE

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This capstone design project focuses mainly on sewage sludge management by looking at suitable methods of recovering and reuse of valuable products such as energy. Production of bioethanol using sewage sludge has been chosen considering current rising energy demand as the government has put up a target to substitute 10% of its liquid fuel and also as a diversified alternative of bioethanol raw material. The ethanol use could benefit the country make massive savings from increased blending. The main organic components of sewage sludge are 40-60% proteins, 25-50% carbohydrates and fats and oils 10%. Using sewage sludge containing more than 20% cellulose it was found that cellulosic solids having a purity of more than 70% can be recovered using the autoclave method. Further analysis of cellulose, lignin and hemicellulose which can be characterized using the NDF, ADF and ADL to note the respective percentage of each in the residual sample recovered. Fermentation was carried out using baker's yeast Saccharomyces Cerevisea at a temperature of 30^0C and pH of 5.5 for about 48 hours with glucose dosage of 125g/L and yeast dosage of 5.01g/L and gave the maximum bioethanol yield of 10.8%. Production of bioethanol from sewage sludge is feasible from the economic point of view in since the rate of return on investment was and a payback period of 4.6 years and rate of return on investments of 21.6% as well as internal rate of return of 14%.

KEYWORDS: *autoclave method, bioethanol, cellulose, fermentation, sewage sludge.*

DESIGN OF A 10 MGW COMBINED HEAT AND POWER GENERATION PLANT THROUGH CO-DIGESTION OF ORGANIC FRACTION OF MUNICIPAL SOLID WASTE, CATTLE DUNG AND SPENT GRAIN.

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Zimbabwe has an energy deficit of around 450 MGW and currently producing around 1200 MGW which are produced from ZPC`s 5 Power Stations. Of the 5 Power Stations 4 of them are thermal power stations which use coal to generate electricity. This has a huge impact to the environment since coal combustion releases greenhouse gases like carbon dioxide that has a threat to the environment. The energy deficit has resulted in ZETDC importing electricity from other countries like South Africa and Mozambique, which has resulted in the country losing above $10 million in energy imports in an already foreign currency strained economy. Economic hardship in the country has led to overpopulation of major cities. This is due to rural to urban migration of people is search of a way of leaving. This has generated a lot of waste around 1 649 558 tons/annum that the city councils are failing to manage beyond their capacity. The problem of waste management and energy demand in the country can be linked by waste separation and recovery of the biodegradable fraction of the waste that accounts for 32 % of the total waste produced. A biogas to electricity plant is designed to handle 283 500 tonnes of the organic fraction of municipal solid waste, 9000 tons/annum of spent grain from local breweries, 3990 tons/annum of manure from local cattle breeders. The amount of methane at 97 % purity produced per annum with this waste during a co-digestion process is 20 504 516 m^3 which produces 9.429 Kwhel (9.249 MGW) of electricity in a gas engine generator Combined Heat and Power Unit. 10 221.5 kWhth of heat energy is also produced and around 8 % is converted into electricity using the Kalina cycle waste heat recovery unit to produce another 654 Kwhel (0.654 MGW). The total electricity generated by the process is 10 084 Kwhel (10.084 MGW). The biogas to electricity plant has an initial total capital investment of $ 25 942 659, a payback period of 7 years and a return on investment of 14 %. The Net Present Value after a period of $ 10 years was found to be $ 5 641 126.

Key words: *biodegradable, biogas, Co-digestion, greenhouse, energy*

DEISGN OF A PLANT TO PRODUCE 3 TONNES PER DAY OF A KERATIN BASED BIOFERTILIZER

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The growth of the Zimbabwean agricultural sector has put a great pressure on the local fertilizer producers. Environmental management Act (EMA) has also noted the increase in keratin waste biomass as a major environmental menace. The major drive for this project was to tackle problems within the agricultural sector, economic sector and the environmental sector by providing a possible biofertilizer from a keratin substrate which is cost effective, eco-friendly and efficient. Keratin is a durable, fibrous protein which is mainly present in higher vertebrates (mammals, birds and reptiles) and human's epithelial cells. Experimental work carried out showed that it is feasible to convert a keratin mesh of hooves and horns into amino acids and nitrates when they are fermented in the presence of crude chicken excrete. The bioconversion process took place under anaerobic conditions, at a pH of 9.5 and temperature of 55°C. The nutrient value of the fertilizer was tested in the laboratory and found to contain 10% Nitrogen,2% Potassium and 0.5% Phosphorus. The HAZOP study on the designed equipment was done to ensure equipment operability and safety. The EIA was carried out for the mitigation of identified negative project impacts. Economic analysis was done in order to validate the project. The project requires a total capital investment about $591 349.7. The projected sales volume was considered viable with a breakeven of 581 000 units, 6.2 years' payback period and ROI of 16%.

KEYWORDS*: Keratin; Biofertilizer; Bioconversion*

DESIGN OF A PLANT THAT PRODUCES 10TPD OF WATER PURIFICATION GRADE GRANULAR ACTIVATED CARBON USING SORGHUM BREWERY SPENT GRAINS FOR DELTA BEVERAGES BREWERY WASTE WATER TREATMENT PLANT

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Proper disposal of brewery spent grains upon completion of the brewing process has traditionally caused some challenges for most breweries across the world hence the need to explore alternative uses of the waste brewery spent grains. The aim of the project was to design of a plant that produces 10TPD of granular activated carbon from sorghum brewery spent grains as the major source of carbon, instead of coal. The experiments undertaken to assess the feasibility included bulk density for physical properties tests, iodine number and methylene blue number for adsorption properties test and moisture, ash and pH for chemical properties test. Experimental results showed that ash content increased linearly with increase in temperature whilst (%) activated carbon yield decreased with increase in residence time and temperature. Iodine number increased with increase in concentration of chemical activating agent. Activated carbon made from brewery spent grains has lower bulk density than that made from coal. A pellet mill and a rotary drum furnace were designed, together with their respective process control and HAZOP analyses and EIA assessments. Bulawayo, Harare and Kwekwe were considered for site analysis but since raw material supply is from all breweries dotted around the country, Kwekwe seemed more suitable due to its central location and closeness to the major Harare Bulawayo highway. An economic analysis of the project showed a net profit of $2 243 381.22; a payback period of 3.94years and a return on investment of 25%.

Keywords: *Spent grains, granular activated carbon, iodine number, methylene blue number*

DESIGN OF A PLANT THAT PRODUCES 1500T/YR OF FURFURAL USING CORN COB LIGNOCELLULOSE

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Furfural is an organic chemical that is gaining attention again because it is a bio-based feedstock for the production of plastics, paints, fertilisers and pesticides. The present work reports the production of furfural from corn cob lignocellulose in a glass lined reactor. This is achieved by a process in which the lignocellulose is first hydrolysed to xylose sugars and subsequent dehydration of xylose to yield furfural. Effect of temperature, catalyst concentration and residence time were investigated. The application of dilute hydrochloric acid as the catalyst at low temperatures enabled a higher production of furfural of about 90% of the theoretical value with minimal losses due to steam purging. Butyl chloride was also used as a solvent for its extraction and selectivity of furfural from the furfural- water mixture. Mass and energy balances were carried out which also enabled the design of a distillation column and a reactor. A hazard and operability study was carried out on the designed equipment to enable the safe operation of the plant. The maximum yield of furfural was achieved at 4% acid concentration and 120^0C within 2hours. The economic analysis carried out produced a payback period of 2.5years, return on investment of 39.35% and a break-even point of 93 units (tons). The project is therefore technically and economically feasible.

Keywords: *Furfural, corn cobs, lignocellulose, hydrolysis and solvent extraction*

DESIGN OF 6700L PER DAY BIO-ETHANOL PLANT FROM BANANA WASTE USING THE SIMULTANEOUS SACCHARIFICATION AND FERMENTATION PROCESS

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Fabrication of fuel ethanol from biomass present an interesting alternative to traditional fossil fuel that is used as sole fuel in cars with dedicated engines or also in fuel blends. The project identified ways of making use of waste biomass to important fuels. Bioethanol can be used as a fuel, either pure or blended with gasoline (gasohol). The present policy states that Jatropha *carcass* and sugarcane will be the feedstock's promoted to process biodiesel and ethanol, respectively. The purpose of this project was to come up with an alternative process for the production of bioethanol from banana waste using fermentation and distillation. From the analysis carried out it can be concluded that it is possible to design of a 6700L per day SSF ethanol processing plant. A pH of 3.9 (optimum) was found .$K_2CO_3$is produced as a by-product and used in many sectors.100g of cellulose produces 52.2g in theory; however 36.6g was produced by SSF. The high concentrated acid was responsible for low yields of glucose at 67.59% due to hindrance and hence 20.8ml of ethanol compared with theoretical yield of 34.1ml was produced. Experimental result show that the yield of peel and pulp mixture is relatively low than the pulp yield and higher than the peel yield. Aspects of temperature, flow control and HAZOP analysis of the distillation column and shell and tube heat exchanger were also covered. Site selection was done and put in the midlands region with easy availability of raw materials. Economic analysis of the project gave a payback period of 2.3yrs, return of investment of 43%. The total capital investment was calculated to be $2.2million.Complementary extraction technique of ethanol such as enzymatic extraction have to be done in order to investigate the variation that could be arise on the quality and quantity of the ethanol yield as a result of using different extraction methods.

Key words: *saccharification, blended, enzymatic, bioethanol, fermentation*

DESIGN OF A PLANT PROCESSING 10 TONNES PER DAY OF GOLD CALCINE DUMPS USING ULTRAFINE GRINDING AND THIOSULPHATE LEACHING (CASE STUDY KWEKWE ROASTING PLANT)

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An experimental approach was taken in the design of a process for the leaching of gold from calcine dumps using ultrafine grinding and thiosulphate leaching which can be used as an alternative for the cyanidation process. Experimental work was undertaken to determine the moisture content, recovery and enrichment ratio of calcine dumps. Maximum recovery was found to be 75%. The vertical leaching vessel and ion exchange vessel were designed to help achieve the desired gold concentrate. The thiosulphate leaching process gave the company a net present worth of US$1.6 million with a payback of 6years from an invested capital of $1.2 million and a breakeven at 460 units (ounces). It is further recommended that optimization approaches be in-cooperated in further study and a prototype be developed.

Key words: *leaching, ultrafine grinding, thiosulphate, ion exchange*

DESIGN OF A 25000LITRES PER DAY HYBRID CPTL PLANT THAT PRODUCE DIESEL FROM COPROCESSING COAL WITH MUNICIPAL SOLID PLASTIC WASTE.

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The coal and plastics to liquid hybrid plant (CPTL) relates to a hybrid plant design that produces diesel, petrol, naphtha and light petroleum gas(LPG) by co-processing coal with municipal solid plastics waste (MSPW) using waste oil as a liquefaction solvent and red mud from aluminium processing as a catalyst. This project seeks to obtain environmental sustainability by maximum utilisation of waste to be recycled, reused or processed with zero health and environmental hazards. Using municipal solid plastic waste in the process enabled large scale production which reduced hydrogen production costs. Hybridising coal with waste plastics made a brilliant solution for an affordable, fuel from locally available raw materials thus securing energy supply, promoting economic sustainability (ZIMASSET) and protected the climatic changes associated with transportation sector. Experimental work provided significant results which suggested that mild temperatures and lower bubble formation rate increases the formation of oil yield and decreases the yield of gas. All experimental runs were conducted at 350-375^{o} C and a gas hourly speed velocity of 0.70-1.70m^{3} / hr yielding oils of 89-92%wt oil and carbon laydown decreasing from 12.5-11.4%, which is shown to be favouring the formation of middle distillates. The project requires a total capital investment of USD$2 800 000.00 with total manufacturing cost of product at USD$0.85 / litres and a factory selling price of US$ 1.10/litre. The projected sales are considered viable with a 2 years' payback period, breakeven point of 1 year and a return on investment of 47,9%.

KEYWORDS: *Co processing, diesel, liquefaction, red mud, plastics.*

DESIGN A PLANT THAT MANUFACTURES 140 TONNES PER DAY OF NANO REFRACTORY CEMENT

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Zimbabwe was once, after Russia, the world's largest producer of corundum. Over 160 000 tons was mined in the Mazowe district, which was by far the most productive deposit and still contains substantial reserves of boulder corundum which causes environmental problems. Much of this can be used to produce a useful product at it contains high amounts of Aluminium oxide. However, by paying attention to the Zimbabwe Agenda of Sustainable and Socio-Economic Transformation (Zim-ASSET) blueprint under the value addition and beneficiation cluster, this report focuses on production of a durable, reliable and affordable refractory cement which was found to have various applications in Cement, Chrome, Iron and Steel and Foundries industries. A highly resistant temperature nano refractory cement was synthesized by mixing the cement with water. It was dried at 105 degrees for 24hours.The castable was then treated from room temperature to 1700 degrees. The castable obtained withstand high temperatures and has a compressive strength of 84.37Mpa, water absorption of 3.2% and apparent porosity of 9.1%. The project requires a total capital investment of about $ 646,049 and has a return on investment of 50 % with a payback period of 2 years.

KEY WORDS: *Corundum, Compressive strength, Refractory Nano-castable*

DESIGN OF A PROCESS THAT MANUFACTURES 6000L / DAY OF ALKYD RESIN FROM ALGAE OIL

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The term Algae refers to a group of microorganisms which are aquatic and usually green in colour although other species may resemble a different appearance. The term Resin refers to a wide variety of solid or highly viscous substances of plant or synthetic origin that can typically be converted into polymers. The term "industrial resins" generally refers to any synthetic polymer resin made for commercial use. They are often mixtures of organic compounds and principally terpenes. Natural resins are those that are produced by woody plants which produce resin in response to damage. There are several types of resins including unsaturated polyester resins, Emulsion polymers, Amino resins, Polyurethane resins, Polyamide-epichlorohydrin resins, Formaldehyde resins and Alkyd resins. This project work focuses on Alkyd resins which are a kind of polyester synthetic resin produced through the poly condensation reaction of polyhydric dibasic acids, alcohols and modified with oil or fatty acids. Algae produces a lot of lipids up to 60% of their total weight. Studies were carried out as shown in the literature review so as to gather information concerning the production of oil from algae and about the vast potential use for this oil including the production of biodiesel. Experiments were carried out to determine the cultivability of algae, methods of algae harvesting and the extraction of the oil itself. The solvent extraction method was used and upon extraction was then characterized and then its properties weighed for use in the alkyd resin synthesis process. The experimental results were recorded and they showed that the best method for separating algae from water is to first sieve the algae and water mixture and then dry the remaining algae paste to obtain dry algae. The amount of algae in a algae and water mixture was found to be 15.2% of the total mass and after drying 21.5% of dry algae was obtained from the wet algae paste. A total of 42.7ml of oil were obtained from 93g of dry algae. This meant the amount of oil in the algae is 45% of the total mass. This meant that the relative oil composition of algae is higher than other oil sources like corn, peanuts etc. the emulsion test was done to confirm the presence of fats in the presumed oil and it yielded positive results characterized by a milk emulsion. Material balances were carried out based on the experimental results and these were then used in the equipment design. The block flow diagram and process flow diagram were also set up. The equipment designed for this particular project included an Alkyd resin synthesis batch reactor and an Algae photo-bioreactor. All the dimensions and specifications of the two reactors were specified and tabulated with the latter, algae photo-bioreactor

being made on prototype scale. The control of the reactors was also done to control variables like temperature, pressure and flow rate. The necessary instruments for the control process were also determined. The HAZOP analysis was carried out to ensure safety during the operation of the plant with safety measures and procedures also put up. The site location analysis together with the Environmental Impact assessment were also done to determine the effects of the project to the environment. The chosen site was Mt Hampden due to its more favourable factors upon comparison with other locations such as Ruwa and Darwendale. The economic analysis was carried out to ensure the economic feasibility of the plant. The conclusion was then determined and it was deducted that the project was feasible since the economics of the project were deemed achievable and the payback period which was found to be 3 years was also accepted. Recommendations were also suggested to improve certain areas relating to the project work.

Key words: *Algae, Alkyd, Photo bioreactor, Soxhlet extraction*

DESIGN OF A 4000 TONNES PER DAY GOLD LEACHING PLANT TO REDUCE THE AMOUNT OF CYANIDE USED FOR A GOLD LEACHING PROCESS

(A CASE STUDY FOR FREDA REBECCA GOLD MINE – BINDURA, ZIMBABWE)

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The Freda Rebecca Mine gold processing plant was using an expensive gold leaching process. The company's leaching process uses vast amounts of cyanide which is very expensive, hence the project focuses on the design of a 4000 tonnes per day gold processing plant to lower down cyanide consumption. Bottle roll leach experiments were done to determine the minimum permissible cyanide concentration for the gold leaching process. The CIP feed grind tests that were done indicated that the sample had 83% passing 75µm screen which surpasses the standard 80% passing 75µm screen. The bottle roll leach tests that were done with oxygen addition showed that 300ppm cyanide concentration was ideal since it gave high recovery (90.4%) and lowest residual gold (0.24 g/t). A comprehensive process and design of equipment of the and the adsorber for the oxygen Pressure Swing Adsorption (PSA) was carried out. To assess the on the economic feasibility of the research project, the author did an economic analysis. The design of a 4000 tpd plant has proven to be viable economically. The research piece has shown a payback period of 3.4 years and an ROI (return on investment) of 29.4% which proved the project's economic viability. Freda Rebecca Gold Mine should consider having a full automation of the process to increase cycle time for production. The plant should be continuously improved for maximum operations.

Key words: *adsorber, cyanidation, cyanide, concentration, gold, leaching, residual.*

THE DESIGN OF A CRYSTALLIZATION PROCESS THAT PRODUCES 1TPD CRUDE NICKEL SULPHATE CRYSTALS FROM NICKEL ANOLYTE SOLUTION (CASE STUDY FOR EMPRESS NICKEL REFINERY)

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Empress Nickel Refinery, is a base metal refiner producing high quality nickel and copper metal. All spent solutions (nickel anolyte solution) from leaching operations in the processing plant are disposed in the 10 000m³ pond onsite that stores the solutions until they can be recycled as a leachate. Presently the ponds' carrying capacity is full, presenting storage challenges for future projects. Suggestions have been to crystallize the solute metal compounds from solution and free the pond of all its contents. This study was conducted to design a process and equipment for the crystallization of crude nickel sulphate crystals from the nickel anolyte solution. Evaluation of the most suitable crystallization method comprised laboratory experiments of batch heating and cooling of the nickel anolyte solution. Evaporation was carried out at a boiling temperature of 98°C and cooling at ambient conditions. The product crystals formed showed different characteristics for different residence times of heating and/or cooling. At high evaporation rates meaning high heating residence time and less cooling time the nickel hexahydrate crystal is formed, whereas at low evaporation rates and high cooling residence time, a nickel hepta-hydrate crystal is formed. The results obtained proved that the evaporative-crystallization method was best, as solutions sampled from the pond with 42.4g/l Ni concentration could be crystallized up to 16% Ni concentration. Determination of saturation temperature for the crystals revealed that the hexahydrate crystallizes from solution at temperatures between 30.7°C and 53.8°C. Data for the nickel hexahydrate crystal were used to come up with the design for an evaporative-crystallization process and equipment, mainly a Forced Circulation (FC) crystallizer and a shell and tube heat exchanger to recover the valuable minerals. An economic analysis was also done to test the viability of the project and a pre-tax profit margin of $1.32/kg crystals from a selling price of $3.20/kg and $1.88/kg production cost was made. The project proves to be viable at the capacity of 1TPD stretching up to 9 years of project life and a return on investment (ROI) of 13.3%. The internal rate of return (IRR) was also calculated at 23.35%.

Keywords: *Evaporative-crystallization, nickel anolyte, nickel hexahydrate, FC crystallizer*

DESIGN OF A PLANT THAT PRODUCES BIO-BASED POLYETHYLENE TEREPHTHALATE (PET) FOR BEVERAGE BOTTLING.

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Increasing relevance of competitive, sustainable, and biodegradable alternatives to petroleum-based plastics has encouraged the development of bio-based plastics. Need for plastics has increased with increase in population and demand yet petrochemicals are non-renewable and slowly running out. The aim of this project is to design a plant that feasibly produces 100% bio-based polyethylene terephthalate (PET) for beverage bottling using ethanol and iso butanol from sugarcane fermentation as an alternative to traditional plastic manufacturing process. The project focuses on production of bio-based polyethylene terephthalate. Experiments were done to produce the PET. Experimental results showed that it is possible to produce bio-based polyethylene terephthalate from products of fermentation of sugarcane. The results obtained led to the design of an esterification batch reactor and counter current rotary dryer. Process instrumentation diagram (PID) and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. The report also covers work done by other researchers in the field, and this is covered in the literature review chapter. A detailed economic analysis was done to assess the economic feasibility of the project. The project has a payback period of 5years and a return on investment of 19.8% which are acceptable financial indicators. It was concluded that it is possible to design an economically viable and environmentally friendly bio-based polyethylene terephthalate producing plant.

Keywords: *Bio-based Polyethylene terephthalate, ethanol, fermentation, iso butanol, plastics*.

PRODUCTION OF A 1.5TONNES PER DAY THIOGLYCOLIC ACID PLANT FROM ETHANOL AND CAUSTIC SODA

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The production of thioglycolic acid or its salts provides valuable products which are widely used in the chemical industries as froth collectors, depilatories and cosmetics. This project seeks to reduce the high importation bill by locally producing thioglycolic acid from abundant ethanol, monochloroacetic acid and caustic soda. It cascades to job availability, secures foreign currency, chemical supply, promotes economic sustainability and protects the climatic changes associated with exploiting metal sulphides as raw materials. This project focuses on the design of a 1.5TPD thioglycolic acid production plant. Experimental work conducted included synthesis, characterisation, and optimum process conditions giving out a conversion of 60.4% and a reaction rate of 4.236×10^{-3} M $s^{-1.}$ The optimum operating temperature was 110^{o}C and a pressure of 1 atm for the xanthation, etherification and thiohydrolysis process. The results from the experiments were used in the mass and energy balances hence translated into the process and equipment design. Process instrumentation and control diagrams (PID) and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. A detailed economic analysis was done to assess the economic feasibility of the project. The financial analysis proved favourable and positive as evidenced by calculations yielding a return on investment (ROI) of 33.4% and a payback period of 2.88 years.

Keywords: *depilatory, collectors, thioglycolic acid, xanthation, etherification, thiohydrolysis*,

THE DESIGN OF A NICKEL RECOVERY PROCESS FROM FURNACE SLAG USING THIOBACILLUS FERROXIDANS

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Until recent decades, smelting of ores had been the technology of choice for the production of Nickel, Cobalt and Copper in the world. Trojan mine with a generation of 80 000tons/ year of furnace slag over the years the waste from the furnace has accumulated to 3million tonnes. The recovery of base metals from slags (intermediate products and wastes of smelting) poses a problem that has not been resolved satisfactorily. A number of technical and environmental considerations discussed in further detail emphasize the importance of finding a technology capable of processing slags in an environmentally friendly and economical way, thus the need to come up with this project that incorporates bioleaching as a way to recover the metals.

This project is the design of a recovery plant that produces 1.3 tonnes per day of Nickel cathodes from bacterial leaching. A bacteria *Thiobacillus Ferroxidans* is used for the process of leaching to free Nickel ions from smelter slag. Experiments were carried out and detailed mass and energy balances that aided the design of the process of producing the nickel and the major equipment (Leaching vessel and Ball mill). Under the experimental conditions considered, the set of conditions that produce the optimum nickel recovery (79.8%) were found to be a pH of 2.0, 75µm particle size, and 2.6% pulp density. The economics of the project show that the return on investment is 21%, with a payback period of 4.9years.

Keywords: *bioleaching, dissolution, base metals*

DESIGN OF A FERMENTER AND DISTILLATION COLUMN FOR THE PRODUCTION OF 10 000 LITRES PER DAY, BIOETHANOL FROM JATROPHA SEED CAKE FOR BLENDING WITH GASOLINE

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The ethanol production process is cost-intensive, with two-thirds of the costs allocated to the raw materials. Therefore, new raw materials like biomass are now being employed to reduce the production costs. In this work, Jatropha seed cake is used as the biomass and is processed by Simultaneous Saccharification and Fermentation (SSF) to produce bio-ethanol. Approximately 14% of bio-ethanol was produced after physical and chemical treatment of Jatropha seed cake, fermentation and distillation. Residual fatty-acids were accounted for and removed by solvent extraction using petroleum ether.

Three different distillation columns were used namely the stripping, rectifying and anhydrous column to achieve absolute bio-ethanol (100% pure). The flash point, Phosphorus content, Sulphur content, density and ignition temperature of bio-ethanol were measured to characterize the product. A detailed process design was carried out followed by material and energy balances. Equipment design was carried out for the rectifying column (19 plates; diameter 0.854m; height 8.6m) and bio-reactor (diameter 3.6m and height 1.2m).

Process control and HAZOP analysis was carried out controlling temperature, pressure and pH on bio-reactor and pressure, top product composition and flow for the distillation column. Environmental Impact Assessment and Site selection was carried out. Murewa was found to be the best site for commissioning a bio-ethanol plant. Lastly the economics of the project were carried out and the following was obtained, the payback period was 2.4 years, the Return on investment was 40.9%, the breakeven was 1 477 907 litres and $1 418 791 and the selling price was pegged at $0.96 per litre. The net present value after five years was found to be $1 314 539.

Keywords: *Jatropha seed cake; Bio-ethanol; Bio-ethanol Plant; Simultaneous Saccharification and Fermentation; Physical Pretreatment; Chemical Pretreatment; Residual fatty acids*

SYNTHESIS OF 1TON PER DAY ALUMINA / ZINC OXIDE NANOCOMPOSITE

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Hydrometallurgy technique can be used to extract important or the most valued metals from various resources or ores. In this project, alumina was extracted from coal fly ash a waste material generated as a result of combustion of coal in fertilizer industries, power plants and other industries that burn coal. Alkaline leaching was a method that was employed Alumina nanoparticles were synthesized by using the alkali lime sintering process and zinc oxide nanoparticles were synthesized by using the sol gel method. To obtain alumina zinc oxide Nano composite both nanoparticles were heat in a furnace for 3 hours at 1000^0C. The material was allowed to cool and samples were taken for analysis. Using and XRF the results showed that little zinc oxide was present this was due to the ratios that were used for the formation of the nanocomposite and alumina was shown to have been present in large amounts however other oxides such as silica and iron oxide were also detected. The presence of other oxides was due to the fact that they dissolve in alkali so that was a drawback of the method that was used to synthesize alumina. UV- vis showed the absorbance of alumina and zinc oxide nanoparticles. This showed that alumina nanoparticles can be obtained by alkali lime sintering process and alumina zinc oxide nanocomposite was synthesized.

Keywords: *sol-gel method, extraction, coal fly ash, alkaline lime sintering process, alumina zinc oxide Nano composite*

DESIGN OF A PLANT THAT UTILIZES EXTRACTED ANIMAL FAT FROM TANNERY FLESHING WASTES TO PRODUCE 1 TPD OF FATLIQUOR FOR USE IN LEATHER PROCESSING

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Tannery could have easily passed as an environmentally friendly industry, due to its processing of hides, a waste product from the meat industry into leather, a product of value. On the contrary the industry is regarded as a major polluting industry due to gaseous, solid, and liquid waste it produces. Of the solid waste, fleshings makes up 50 to 60% by weight and currently these fleshings are haphazardly disposed of, causing environmental pollution. The purpose of this design and innovation capstone project is to develop a process that utilizes the waste fleshings as a raw material to produce one tonne of fat-liquor, oil in water emulsion that is used in the later stages of the same tannery process. Animal fats were extracted from the fleshings using hexane solvent, giving a 34.75% weight yield of fats to the weight of waste fleshings. The animal fats had an Iodine value of 60.96g Iodine per 100g fats and a saponification value of 192.8mgKOH which are within the standard range. Mass and energy balances were done and they formed the basis of the design of an Evaporator and a Batch reactor. Hazard and Operability analysis for the designed equipment together with process control was carried out to ensure safe operation of the process. An economic analysis was also carried out, proving the project is feasible with a payback period of 3.15 years, a Return on Investment of 31.8% and Breakeven Point of 70 488.72 units (kilograms) of fat liquor.

Key words: *Tannery waste fleshings, Fat-liquor, Emulsification, Sulfation*

DESIGN OF A PLANT TO RECOVER GOLD FROM IRON DUKE TAILINGS WITH A THROUGHPUT OF 400 TPD USING PIONERA L-800 BIOPOLYMER IN CYANIDATION PROCESS (CASE STUDY CASMYN TURK MINE)

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The depletion of high gold grade reserves is a continuous worldwide concern which is of increasing prominence due to the extinction of high gold grade reserves. This research seeks to investigate the use of new technologies for retreating the tailings dump to recover gold. It has become a major concern for most gold processing plants to focus attention on the recovery of gold from the tailings dump in the most economical method, in these technologies there is also the issue of reducing sodium cyanide use. The project focuses on processing tailings utilizing L-800 Biopolymer as the additive in the Cyanidation process of a gold ore that mostly comprises of hematite. Experimental results carried out showed that it is possible to leach Iron duke ore (hematite ore) in the presence of L-800 Biopolymer and reduce sodium cyanide consumption. Experiments were done to determine the pulp density, grind, residence time in the presence and absence of L-800 Biopolymer, dosage of L-800 Biopolymer, dosages of sodium cyanide, caustic soda and hydrogen peroxide were carried out which led to the design of a continuous stirred leach tank and a regenerative kiln for the reactivation of activated carbon. A detailed process and equipment design of the continuous stirred leach tank and regenerative kiln was carried out. It was concluded that it is possible to design an economically viable and environmentally friendly 400 tonnes per day gold from Iron Duke tailings using a L-800 Biopolymer as an additive in the cyanidation process. The project has a payback period of 4.96 years and a return on investment of 20.2% which are acceptable financial indicators.

Keywords: *Gold, Head grade, L-800 Biopolymer, Sodium Cyanide, Leaching, Regenerative kiln, Activated Carbon, Carbon in Leach Circuit, Elution Circuit*

THE DESIGN OF 700KG / DAY PLANT TO MANUFACTURE ZEOLITES FROM WASTE GLASS

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With its unique structure, Zeolite X has tremendous properties for micro filtering in air and water. The aim and objective of this study is to design a plant that produces Zeolite X from waste glass bottles (WGB). It also caters in the mitigation of waste of WGB. Zeolite X naturally occurs and also is synthesized from coal fly ash. The composition of aluminium and silica is a result of the synthesis of Zeolite under specific conditions. In this study several experiments were conducted that includes particle size distribution of the WGB, ratio of KOH to Silica used for alkali fusion, concentration of $Al(OH)_3$ to attain a great yield of Zeolite X and the characterization of Zeolite X. The experiment on the determination of the ratio of KOH to silica was obtained to be 1:2 respectively with a high percentage in extraction. On evaluation of material balances, alkali fusion in the rotary kiln required 903kg per day of the WGB and KOH extracting 708.3 K_2SIO_3, hydro thermalized in $Al(OH)_3$ to produce aqueous Zeolite X, then dried in a spray dryer producing 700kg of Zeolite X. A rotary kiln of 50m^2 capacity and spray dryer of 5.378m^2 where designed in detail. Economically the project is viable with a payback period of 5.7 years and a return on investment of 17.43%. Break even occurs when $768 567.10 worth of Zeolite X sold.

Keywords: *Zeolite X, WGB, aluminium, silica, hydrothermal*

DESIGN OF A PLANT FOR PRODUCTION OF 1165.45 KG / HOUR OF ALKYD RESIN DERIVED FROM AN OIL BLEND SOYABEANS AND TOMATO SEEDS

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Alkyd resin is a valuable raw material in the production of paint most paint companies in Zimbabwe are importing alkyd resins. Alkyd resins are produces from dibasic acids, polyols and vegetable oils. Average oil content in soya bean seeds is 22.1%. Tomato seeds have an oil content of 21.8%. Soya bean seeds obtained 19.5% extractable oil, specific gravity of 0.90kg/L and viscosity of 60.7cp. Tomato seeds obtained 18.8% extractable oil, specific gravity of 0.87kg/L and viscosity of 59.3cp.The reaction temperature is 240^{o}C and one batch takes about 4hours to be fully completed. An economic analysis done showed a payback period of 4.2years and return on investment of 24.5%, Internal Rate of Return(IRR) of 15% and Net Present Value (NPV) of $21 555.64 .

Key words: *Tomato seed oil, Soya bean seed oil, Alkyd resin*

THE DESIGN OF A 3 TON / HR ORGANOSOLV LIGNOCELLULOSIC PROCESSING PLANT

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It is important to note that Organosolv is being employed in countries like Netherlands, USA, Germany and China. This project was done to determine the technical and economic feasibility of valorising lignocellulose biomass. Experiments were carried to determine the composition of lignocellulosic material as well as the temperature required to successfully decompose lignocellulose. The research has shown that lignocellulose biomass can be fractionated at 160 degrees Celsius effectively giving a fraction of 55.4% Lignin. 30.3% Cellulose and 14.3% hemicellulose. 966.5kg/hr of Lignin can be recovered from the designed process. The study was entered of determining the optimum conditions that will results in the fractionation of the three constituencies, of great importance was the ability of the product to be used in downstream processes without inherent restrictions in further valorising them. The design of the process was carried out using the experimental data and a continuous stirred tank reactor was designed as major equipment. The performance index has shown that the rate of return is 48.6% with a payback period of 3.5 years.

Key Words: *Lignocellulose, biomass, valorising, lignin*

DESIGN OF A PLANT THAT PRODUCES 1000L / DAY OF NAPHTHA FROM WASTE PLASTICS

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Production of naphtha through the use of waste plastics has proven to have potential of providing solutions to petrochemical industry thereby reducing the amount of pollution caused by these waste products. The purpose of this project was to come up with an alternative process for the production of naphtha as a feedstock in the petrochemical production and also in gasoline blending. All the experiments were carried out at atmospheric pressure, at high temperatures of 400^{o}C. The polyethene plastic waste was heated in a pyrolysis reactor and a conversion of 86% of the plastic waste to plastic oil was obtained. The plastic oil obtained was further refined by fractional distillation to produce naphtha, kerosene, diesel and solid residues. The obtained results were used to design an optimum process including a detailed design of the pyrolysis reactor and distillation column. Process control and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. The economic analysis carried out showed that the project is a viable project with a total capital investment of $1 220 229.54, a payback period of 4.2 years and a net present value of $83 561.93 at a rate of return of 24%. On completion of the project it was proved that it is technically and economically feasible to design a process that produces naphtha.

Key words: *plastic waste, pyrolysis oil, naphtha, fractional distillation, thermal treatment, petrochemical feedstock*

PRODUCTION OF 148 KG / DAY OF TANTALITE CONCENTRATE FROM TANTALITE TAILINGS BY USE OF FLOTATION PROCESS.

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Bikita Minerals Pvt. Ltd Company is the major producer and supplier of tantalite and other related products in Zimbabwe. The company is recovering tantalite from lepidolite ore by use of gravity separation process recovering 65% of tantalite from its ore, from the recovery results we can see that 31% of tantalite is going to the tailings; this has led to the implementation of froth flotation process to increase the tantalite recovery and grade of tantalite tailings. The specific objective was to establish the optimum mesh of grind, best pH conditions, best type of the collector and frother. Experimental work was done to compare the impact of a collector (olive oil, soya beans and groundnut oil) on tantalite flotation. Experiments were done to determine tantalite tailings grind size, pulp optimum pH and collector dosage for highest tantalite recovery. Tantalite recovery of 75% was obtained from the ground size of 75µm and collector dosage of 50kg. The optimum mesh grind was 80% passing 75µm. X-ray Fluorescence (XRF) gun type was used for chemical analysis of the ore for minerals present expressed in part per million (ppm). These results lead to the design of a froth flotation tank and a ball mill. Aspects, of level control, flow control was also done and HAZOP analysis was done on the flotation tank and also on a ball mill. Site selection was done and the EIA was done for the project. A detailed economic analysis was also done to access the economic feasibility of the project. The project has a payback period of 2.5 years and a return on investment of 40% which are acceptable financial indicators. It is conducted that it is feasible to design an economically viable and environmentally friendly process for tantalite froth flotation.

Key words: *tantalite tailings, froth flotation tank, collectors, frothers, tantalite*.

THE PRODUCTION OF 3000 KG / DAY OXALIC ACID PELLETS FROM BANANAS BY THE NITRIC ACID OXIDATION PROCESS

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This project focuses on the design of a 3000 kg/day oxalic acid plant from waste bananas as raw materials. The starch and cellulosic material in bananas will be hydrolysed to glucose which in turn will be oxidised to form oxalic acid. An experimental method was engaged in the design of a process for the oxidative production of oxalic acid from bananas which can be used as an import replacement. Several experiments were carried out to determine the effects of mixing time, reactant concentration, mixing speed and temperature on the rate of oxalic acid production. Maximum overall extraction was found to be 68%. From the experiments carried out the maximum overall extraction was obtained by adding a large molar excess of the nitric acid in oxidation. A continuous stirred tank reactor and a crystalliser were designed to aid the achievement of the desired product quality i.e. 98% pure oxalic acid crystals. The site selection and plant layout were focused on the actual physical location of the oxalic acid synthesis plant taking into consideration various factors which help determine the most suitable location for the plant . After comparing the grand totals Mutare area was found to be the most suitable. The proposed process gave the company a payback period of 5 years and 2 months. The break-even in units was 876 701 units and the Return On Investment (ROI) was 19.3 which are acceptable financial indicators that show that the project is profitable. It was concluded that it is possible to produce oxalic acid from bananas and various improvements can be made on the process to improve the yield of the oxalic acid pellets.

Key words: *oxalic acid, hydrolysis, oxidation, conversion, crystals, glucose*

DESIGN OF A 1.6 TPD POTASSIUM DICHROMATE MANUFACTURING PROCESS BY ELECTROCHEMICAL OXIDATIVE DECOMPOSITION OF CHROMITE SLAG AND LOW-GRADE CHROMITE IN A CONCENTRATED ALKALINE SYSTEM.

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Chromite processing is an important metallurgical industry in Zimbabwe, done primarily by ZIMASCO, where the chromite ore is processed to get Ferro-chrome. It is however a major source of pollution, with large amounts of chromite ore processing residue (COPR), chromite dust, slag and waste gases disposed of after during roasting and refining. The industry is characterised by large amounts of waste, in the form of slag that not only pollute the environment but also are a health hazard. The manufacture of potassium dichromate by electrochemical oxidative decomposition of chromite slag and low-grade chromite in a concentrated alkaline solution is the proposed process.

In today's society environmental issues are ever more important, however this does not hamper the fact that industrial production must go on. The agenda is trying to ensure that future generations have access to the same environmental benefits as us. In this regard, this document proposes a novel method to produce potassium dichromate, using a much more efficient and environmentally friendly route whilst adding value to the ferrochrome slag. With Zimbabwe producing over 50 000 tonnes of slag annually and a dump of over 2 million tonnes (*Mineral commodity summary 2006).* From the results obtained from laboratory experiments, the best optimum operating conditions for the electrochemical oxidation of low grade chromite ore and slag is at 60 wt. % alkali, current density of 750 A/m^2, ore to slag ratio of 3:1, airflow of 1L/min, stirring speed of 700rpm, a particle size distribution of less than 75µm, reaction temperature of 160^{O}C and a residence time of 4 hrs. At these conditions the expected recovery is 89.67%. This process proves to be an efficient way of using EAF slag.

An economic analysis carried on the economic feasibility of the project showed that with an initial capital investment of $1 259 823.85, a payback period of 3.02 years and a rate of return of 33% is realised.

Key words: *electrochemical oxidation, EAF slag,*

THE PRODUCTION OF 500MT / MONTH ELECTRODE PASTE MANUFACTURING PLANT USING BIO COAL, ANTHRACITE, AND PITCH AS THE BINDER

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The high electrode paste landed cost of **US$950/MT** has led to an in house design of a **500MT/month** Electrode Paste Manufacturing Plant. Other notable ferrochrome producers like Xstrata have integrated paste manufacturing into their processes thereby reducing operating costs as well as exercising better control over electrode performance. ZIMASCO consumes a total of **45OMT/month** of electrode paste with the option of selling the extra **50MT/month** of paste on the domestic market to local smelters i.e. Zimalloys, Zimplats, and Bindura Nickel Corporation. The extra 50MT also gives flexibility for continued self-sustenance in terms of paste requirements in the event of ZIMASCO expanding beyond the current 4 furnaces. The proposed plant is to be located inside ZISCO works adjacent to Zimchem Refiners and has a footprint of **5000m^2**. The supply and handling of soft pitch from Zimchem Refiners was a major factor in the selection of this site. The process raw materials are anthracite, coke and pitch with a raw-mix design of **37%** calcined anthracite, **38%** calcined coke and **25%** pitch. The soft pitch is to be procured and metered from Zimchem Refiners to the new paste plant at a cost of **76US$/MT.** The coke is to be acquired from the bio coal which is produced during the start of the process (bio coal made from biomass), the coke is within the required specifications for the raw electrode paste coke. Anthracite is to be sourced from South Africa at an estimated landed cost of **223US$/MT**. Detailed costing (95% accuracy) has indicated that a total capital investment of **US$8 688 646.108** is required to set up a **500MT/month** Electrode Paste Manufacturing Plant. The project is expected to have a payback period of **5.7 years.**

KEY WORDS: *Anthracite, Bio coal Pitch, Rotary calciner, Pyrolysis batch reactor*

DESIGN OF A PLANT THAT SYNTHESIZES 500KG/DAY OF NANO ZERO VALENT IRON FOR WASTEWATER TREATMENT

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Pollution of surface and groundwater by nitrate is a crucial factor as far as the environment and health are concerned. To remove these nitrates, chemical reduction through the use of metallic iron can be employed. The efficiency of metallic iron to reduce nitrates is more pronounced at the nanoscale. This project focused on the synthesis of nano zero valent iron (NZVI)and its use in reducing nitrates in wastewater.

NZVI was synthesized by reducing the ferric ions with sodium borohydride. The resulting slurry of iron nanoparticles was thoroughly filtered under vacuum and washed with deionized water three times and lastly with 5%ethanol solution to prevent oxidation. The reduction of nitrates was studied under various ranges of pH and NZVI dosage. The reduction reaction favoured a low initial pH (3.5) of and a high iron dosage (2.5g/L), were the nitrate reduction efficiency reached 86%.

A batch reactor with a volume of 7,6m^3 for the synthesis of NZVI and a rotary drum filter with a surface area of 13,9m^2 were designed. The reactor designed was jacketed to facilitate cooling. Temperature and level were controlled via a feedback control mechanism. In the same manner pressure and level were also controlled on the rotary drum vacuum filter.

Since the project focuses on nitrate reduction, the plant had to be located near a nitrate rich wastewater source and this site was found to be just opposite Sable Chemicals, an ammonium nitrate fertilizer producing company, in Kwekwe. An environmental impact assessment was carried out and NZVI proved to be environmentally safe. Through this study, control measures were put in place to minimize and mitigate (were possible) the negative impacts of this project to the environment from site preparation during construction to the operational stages of the plant.

Apart from the project being technically feasible, its economic feasibility was analyzed and the payback period was found to be 8 years with a return on investment of 12.6%. This led to the conclusion that the project was technically feasible with a very low return on investment and a long payback period.

Key words: *nitrate, nanoparticles, denitrification, reduction, NZVI, wastewater*

PRODUCTION OF 15 TPD CEMENT FROM WATER TREATMENT SLUDGE AND LIMESTONE FOR CONSTRUCTION OF ROADS AND PAVEMENTS

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Pot holes have plagued the roads in our country and this is due to the lack of maintenance of the roads as it is costly to do so. This has prompted the researcher to investigate alternatives to the convectional asphalt currently being used to surface roads and cement roads have been found to be cheaper. This study focuses on solving two major issues which are management of municipal water treatment sludge which is being currently dumped at treatment plants and secondly the formation of potholes that have become the characteristic feature of Zimbabwean roads due to excessive traffic. The experimental work carried out proved it was possible to make road construction cement from sludge and using an Induced Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) to analyze the clinker produced, the best ratio was 10% sludge. The optimum temperature that produced the best clinker was 1500^0C with the decomposition of $CaCO_3$ to 71% CaO in the clinker at a rate of 8.8×10^{-5} mol $dm^{-1}s^{-1}$. Mass balances were carried out, and the final product was 15 tonnes of cement from 20.33 tonnes of quarry and the wet sludge and the information was used to size a rotary kiln and drier. Hazop analysis and process control were performed on the rotary kiln and drier for safety in the plant. For the implementation of the project an investment of 3.4 million is needed with a payback period of 4.66 years and rate of return of 21.5% and the information was obtained from a detailed economic analysis.

Key words: *sludge, clinker, potholes, quarry, rotary kiln*

PRODUCTION OF 6 TPD OF GELATIN-STARCH BLEND BIOPLASTIC BY UTILISATION OF GELATIN FROM WASTE CHROME TANNED LEATHER SHAVINGS.

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The use of petroleum based plastics has tremendously increased over the past years due to their wide range of applications. However, despite the numerous applications these plastics can be used for, their nature of being non-biodegradable is a major concern. As a result of their non-biodegradability, the petroleum based plastics tend to exist on land or in landfills for up to about 500 years. This causes a number of negative impacts such as build-up of waste in landfills, blockage of sewer systems and discharge of heavy metal and other hazardous chemicals from the plastic into soil. The existence of biodegradable plastic may serve as a promising solution to this problem. The sole purpose of this design and innovation capstone project was to develop a process to produce a gelatin-starch blend bioplastic that will act as a competitive substitute in other applications where petroleum based plastics are used. Gelatin for the blend was extracted from CTLW by the process of hydrolysis with MgO and water at 70℃. The hydrolysis process was carried at different residence times of 3 hours, 4 hours and 5 hours and the maximum yield of gelatin solution was obtained on the 5 hour hydrolysis. The gelatin solutions were analysed to determine actual gelatin concentration in the solutions using a UV-VIS Spectrophotometer and the solution obtained from 5 hour hydrolysis provided the highest concentration of 172.75 mg/ml. Characterisation of the gelatin solution for MgO content was carried out by titration of the solution by EDTA and a MgO concentration of 1620ppm was obtained. The gelatin solution was mixed with 4g of starch and 1.6g of glycerol at 85℃ into a paste. The paste produced was dried at 40℃ for three different residence times of 4 hours, 5 hours and 6 hours. The best gelatin-starch blend bio-plastic film was produced after drying for 6 hours. The lower melting point of the plastic was found to be 85℃ and the upper melting point was 105℃. Mass and energy balances were done and these formed the basis of design of a hydrolysis reactor and a short tube evaporator. HAZOP and process control was done for both of the designed equipment to ensure safe operation and product quality. Gweru was the suitable site selected for location of the plant. An economic analysis of the plant was carried out and it showcased the feasibility of producing a starch blend bioplastic with a payback period of 3.68 years and a return on investment of 27.21 % with a break-even of 580 598 units. It is then concluded that it is feasible to produce a gelatin-starch based plastic of low cost by utilising waste from tannery industry as gelatin source.

Keywords: *non-biodegradability, hydrolysis, gelatin solution, gelatin-starch blend, bio-plastic*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 4.6 TPD FUEL BRIQUETTES FROM COAL ASH AND SAWDUST

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The project designed a process that produces coal ash-sawdust briquettes in a sustainable way. The main objectives were to carry out a technical and economic feasibility of setting up the processing plant, to determine the conversion of coal ash and sawdust to solid fuel (briquettes). The briquetting process conditions and behaviour were examined experimentally for each process step. Experimental work carried out showed that it is possible to produce briquettes from coal ash and sawdust. From the experiments, the following results were obtained: calorific value of sawdust was 8557.087kJ/kg, coal ash was 9700kJ/kg, and briquette with a ratio of sawdust to coal ash of 60:40 was 18 751.48kJ/kg, briquette with a ratio of sawdust to coal ash of 70:30 was 14 082.16 kJ/kg, carbon content was 41.67%, volatile matter was 71%, moisture content was 5.86% and the ash content was 2.5%. Mass balance results were used to draw up material usage ratios in equipment sizing. Detailed process and equipment design of the major equipment were done. The HAZOP study on the designed equipment was done to ensure equipment operability and safety. The EIA was carried out for the mitigation of identified negative project impacts. Economic analysis was done in order to validate the project. The project required a total capital investment of about $1 512724.037. The projected sales volume was considered viable with a breakeven point of $857524.328, 4.3 years' payback period and ROI of 23.3%.

KEYWORDS: *Briquettes; coal ash; sawdust; coal; energy*

DEPARTMENT OF ELECTRONICS ENGINEERING

ENERGY CONSUMPTION MONITORING AND USAGE MANAGEMENT SYSTEM

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Electrical energy efficiency has become an important matter for sustainability, development and cost at both commercial and domestic levels. Energy wastages have become prominent in modern environments due to lack of awareness among energy consumers as a result of incomprehensive data display and rigidness of present energy meters. This, as a consequence stressing the power system. The main focus was the design of a Bluetooth based remote energy consumption data collection, graphical display, monitoring and management system through control of a number of loads. A Personal Computer via a C# based windows application was used as the control panel, display unit and data logger which communicates over a Bluetooth network with a microcontroller based sub-metering unit. The measured data was displayed in both raw and graphical format for the user to view the consumption trend more comprehensively. The system allowed the user to remotely monitor energy consumption peaks and potential wastages hence choose which loads he or she wishes to turn on or off. Ultimately effecting on the energy usage efficiency and cost minimization.

Key Words: *Bluetooth, energy, consumption, power, microcontroller monitoring, management*

SPEAKER IDENTIFICATION SYSTEM

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In this project a speaker identification system was designed and implemented using the Matlab application. The system aimed at identifying an individual by using their voice. This system was targeted to be used at an educational facility with the aim of replacing the use of a card for user authentication. The system offers more user convenience and flexibility than the use of other biometric solutions. A total of 8 different speakers were used to create the dataset, train and test the system The Mel Frequency Cepstral Coefficients (MFCCs) were used for feature extraction and the K

nearest Neighbors classification technique was used for the classification. The system identified speakers in real time with an accuracy of 73 % and an average confidence level of 55% which was due to session variability effects.

Key Words: *Authentication, biometric, classification, MFCCs, speaker, user, voice*

A HYDROPONICS SYSTEM WITH A MONITORING UNIT

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Food security has become an issue in most countries. The main cause of which is mostly due to lack of productivity in the agriculture sector. All this is as a result of poor farming methods, lack of nutrient rich soils and also inability of humans to closely monitor and control their farms or gardens in order to achieve maximum yield. Therefore, there was need to come up with a farming method which is more efficient so as to help reduce the issue of lack of food. The aim of this project was to design, develop and construct a hydroponics system with a monitoring unit, which basically monitors the status of the nutrient solution. It monitored the pH, the temperature and the electrical conductivity of the hydroponics solution. The GSM technology was used for alerting the user of any changes of the monitored parameters from the predefined ranges. The pH, the temperature and the electrical conductivity sensors were immersed in the nutrient solution and the microcontroller polled the data from the sensors. When the measured parameters got out of range, a message was sent to the user via GSM, to notify them of the changes. The message came with what to do to rectify the change.

Key Words: *Hydroponics, farming, monitoring, GSM, parameters, microcontroller, sensors*

A HOME BASED TELEMONITORING SYSTEM FOR PATIENTS WITH CHRONIC ILLNESS

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The aim of this project was to design and implement a home based tele monitoring system for patients with chronic illness. This was achieved by interfacing a temperature sensor, ECG sensor, pulse sensor and Wi-Fi module with PIC microcontroller. The vital signs of a patient were acquired from a his/her body using sensors mentioned above, processed in the microcontroller and send wirelessly to a health care setting local server. On the local server the received data was stored in MySQL database and dynamic graphs of the data were plotted. For the medical personnel to view this data a user interface was created which requires a username and a password to login into the system. The advantage of this type of monitoring is continuous monitoring of the patient at maximum comfort and independence inside their homes. Other benefits are replacement of the need to frequently visiting the doctor for check-ups and early detection of anomalies like worsening of a chronic condition. The results obtained in this project came out as expected.

Key Words: *chronic, GSM, sensor, server, tele monitoring, user interface, wireless*

AN IOT BASED TRAFFIC MANAGEMENT SYSTEM

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An IOT based traffic management system was designed in this project. It utilizes the finite state machine (FSM) controller to allow and implement adaptive traffic signal timing, the system incorporates fault detection and logging such that a fault at the field devices will be quickly registered. A finite state machine was developed in Simulink using MATLAB software which models the behavior of the traffic controller under varying traffic volume conditions. The microcontroller provides the switching mechanism for the traffic signals and is supplied with the signal from the fault detection circuit to continuously monitor the status of the field devices. The microcontroller would give an indication if any of the traffic lights were malfunctioning. A microcontroller program was developed in C language and loaded into the microcontroller, allowing it to implement traffic signal switching and status reporting for field devices. This project was designed to model a two-phase traffic intersection.

Key Words: *devices, detection, fault, FSM, IOT, microcontroller, signal, traffic*

IOT BASED CARBON MONOXIDE AND METHANE MONITORING SYSTEM

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The project concentrated on the Design and implement an IoT based air pollution (carbon monoxide and methane concentration levels) monitoring system. The system ensures continuous monitoring of air pollutants for the purpose of ensuring sustainable management of natural resources, protection of the environment and prevention of pollution and environmental degradation. The system comprised of a MQ4 methane sensor, MQ7b carbon monoxide sensor, ESP8266 a single-chip device which enables the system to connect to Wi-Fi, a microcontroller and a LCD. The sensors are responsible for detecting and capturing the values of respective gases. The microcontroller is responsible for receiving via analogue to digital channels and running all the conversion algorithms of the values obtained from the sensors, as well as establishing a serial communication with the ESP8266 Wi-Fi module to send data to the web server and lastly to send data to the LCD for display, all those components make up the wireless sensor node. The system was designed in such a way that the wireless sensor nodes are portable and can be moved from one place to another easily, the user places the wireless sensor nodes at strategic positions and switch on the nodes from a power button, after switching on the gas readings can be visualized on the LCD and simultaneous data displayed on the web platform.

Key Words: *Internet of Things, Sensor node, MQ series gas sensors, Methane, Carbon Monoxide, Wi-Fi, Microcontroller, Wireless*

GSM BASED CAR SECURITY SYSTEM

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The revolution of Mobile and Technology has made 'GSM based car security system'. The car security system is prominent worldwide. But it is not so secure. Every car owner wants maximum protection of his car; otherwise a thief can easily steal the car or what is inside the car. So, by coming up with the idea of mobile and car security system, GSM based car security system. Aim of the project is to try the save the car. The name project itself suggests that it is based on GSM. So this GSM based car security system works when someone tries to steal the car, immediately an SMS will be

sent on the mobile of the car owner via the GSM modem and the buzzer will also make an alert sound. The system senses door openings, boot openings, bonnet openings and vibration detection. .This system sends a text message through GSM modem and generate sound at every sensing point. A buzzer has been incorporated in this project, which sounds when any parameter is sensed. With all these above mentioned features, this GSM based car security system is more advantageous as compared to the simple car security system.

Key Words: *Alert, car, security, mobile, GSM, text message*

A MICROCONTROLLER BASED SUBSTATION MONITORING SYSTEM

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The main aim of this project was to design a microcontroller based substation monitoring system to deal with the problem of transformer losses and burning due to lack of monitoring systems and effective quick control. Voltage transformers, current sensors, GSM modules, LCD, SD card where the main components used to achieve the functionality of the project. In the substation monitoring system project the transformer was particularly monitored as it is major component in a power substation. Three step down 230-12VAC transformers were connected to model a three phase transformer in order to monitor parameters of a distribution transformer. Monitoring was done at the LV (Low Voltage) side so that the low voltage transformers could be used to measure the parameters. The parameters monitored were temperature, voltage and current. Ambient air temperature was monitored not to exceed 50 degrees Celsius which is the maximum operating environment for most distribution transformers. To monitor the current, the output of the transformers was connected to a load which was 100-watt hair dryer. Voltage varies with current so as current increased voltage decreased and vice versa. For monitoring a microcontroller PIC18F452 was used. The values measured by the sensors were fed into the ADC of the microcontroller and displayed on an LCD for monitoring at the substation. The microcontroller was programmed in such way that when threshold operating values were exceeded a trip signal was sent to the relays which de-energized the contactors to isolate the transformer for protection. A message was sent to the number of the person in charge for control and the same message was also sent to the GSM at the monitoring station for recording purposes. To read the SMSes at the monitoring station a C# application was created and the GSM was connected using a USB to TTL cable. At the end monitoring and control of the substation transformer was achieved.

Key Words: *current, control, microcontroller, monitoring, sensors, temperature, transformer, voltage*

A MICROCONTROLLER BASED FUEL TANK SECURITY SYSTEM

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Fuel is one of the most important and vital sources of energy throughout the world. However, some countries have fuel sources while other countries like Zimbabwe have to import. During the transit of fuel to those countries that import, fuel has been subjected to diversion, smuggling, theft and even dilution. This results in huge amounts of money being lost by companies. A microcontroller-based fuel tank security system was developed in this project in order to address this issue. It utilizes the RFID technology to provide an electronic means of sealing a fuel tank. The integrity of the seal is the continuously monitored and should the seal be compromised; the system will alert the relevant authorities of the location where this incident has occurred. A GPS/GSM module was interfaced with a PIC18F45K22 as was the RFID module. The two modules communicate serially with the microcontroller through its two UART ports. This GPS module obtains coordinates of the incident location. They are sent (using GSM) as a text message containing a hyperlink which will, when clicked open, direct the user to a google maps page that will display the incident location on a map. That same data will be sent to a web server via GPRS and stored in a database. The program responsible for coordinating and controlling all these activities was developed in mikroC and was loaded into the microcontroller. The database was a MySQL database. A desktop application which was developed using C# will fetch these coordinates upon request and also display them on a google map. One drawback that this system has experienced is that the coordinates are not sent to the web and displayed on the application in real time. This was as a result of effects such as ionospheric signal refraction which can only be countered by using certain signal frequencies when transmitting. The project can be improved by adding google earth and street view to the application so that the fuel truck itself can be viewed and not just its location.

Key Words: *database, fuel, GSM, GPRS, security, communicate, microcontroller, monitoring,*

AQUAPONICS MONITORING SYSTEM USING IoT

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Aquaponics is the cultivation of fish and plants together in a constructed, recirculating ecosystem utilizing natural bacterial cycles to convert fish waste to plant nutrients. As a closed loop system, it consists of hydroponics and aquaculture elements. Aquaponic systems offer a solution to environmentally conscious, fiscally responsible individuals who wish to produce food products without the use of pesticides, genetic modification, or non-renewable resources. The aim of this project was to design a monitoring system using Internet of Things (IoT) for aquaponics which is an eco-friendly system for ornamental fish and hydroponic plants. The parameters monitored were water temperature, water level in the aquarium and water flow rate. The system developed utilized a WSN (wireless sensor network) to obtain the monitored parameters. The system displayed the status of each parameter monitored in graphical format on an IoT platform, ThingSpeak.com. The graphs were updated once every minute and allowed remote monitoring by aqua culturists from an internet enabled device such as a laptop, a cell phone or a tablet. Analysis of the graphs provided insight into predicting the health of the aquaponics system.

Key Words: *Aquaponics, Aquaculture, Hydroponics, IoT, parameters, WSN*

A MICROCONTROLLER BASED AUTOMATIC POWER FACTOR CORRECTION SYSTEM

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In Zimbabwe, industrialization is the growing and due to growth of industrialization there is primarily increasing of the inductive loading hence result in most loads in modern electrical distribution systems to be inductive. Almost every large, medium and small industries uses inductive loads for their processes. Inductive loads introduces inefficiencies into the electricity supply network by drawing additional currents, called inductive reactive currents and increase the load on the supplier's switchgear & distribution network and on the consumer's switchgear & cabling and hence they caused a very low power factor. The utility charges for low power factor which is the *KVA billing* because industrial companies draws additional currents which they do not use and due to the billing structure of utility company of a *100% KVA + 100% KW Billing Structure,* this causes very high energy bills in industrial companies. This project is for the design and implementation of a microcontroller based automatic power factor correction system to increase the power factor near to unit and hence reduces high energy bills to normal. The system monitors power factor, ac current, reactive power, apparent power and true power, line voltage continuously and correct the power factor by the using of high voltage (450VAC-1000VAC) capacitor banks which provides a negative reactance to the system. The pic18f4550 microcontroller monitors and control the switching of the capacitor bank, also monitor and measures all the required energy parameters. The high voltage capacitor banks (450VAC-100VAC) are switched through

a high voltage circuit driver which consist of a number of high voltage and current contactors and the high voltage circuit driver is controlled by a low voltage relay driver which is switched by pic18f4550 microcontroller.

Key Words: *Current, circuit, energy, inductive, loads, power, power factor, microcontroller, voltage, reactance*

AN FPGA DC MOTOR SPEED CONTROLLER BASED ON A TILT SENSOR - FOR ELECTRICAL POWERED WHEELCHAIRS

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A tilt sensing DC motor speed controller for electrical powered wheelchairs was developed in this project. Electrically powered wheelchairs make use of DC motors to produce torque and movement, tight speed controlling mechanisms need to be employed, with a simple and yet effective control mechanism for the user. This system utilizes accelerometer, FPGA as well as Bluetooth technologies to tightly control the speed and direction of a robotic vehicle with the use of a mobile phone. An android Bluetooth based application was configured so to allow the user to send direction commands to a Bluetooth transceiver on the system. The Bluetooth transceiver is interfaced with a Cyclone IV E FPGA and it communicates serially with the FPGA using a UART interface. An accelerometer onboard the DE0 Nano FPGA card communicates with the FPGA using an SPI interface and controls the PWM signal that control the DC motor speed. Only the x-axis of the digital 3 axis accelerometer is used to measure the tilt and control the speed autonomously. A structural program was developed and loaded using VHDL programing language into the Altera Cyclone IV E FPGA to interpret the incoming data from the Bluetooth module and accelerometer data and control the speed and direction of the motors. Effects due to gravitational force on the DC motors' speed in cases of ascending and descending a hill or an uneven planes are minimal and hardly noticeable.

Key Words: *Accelerometer, Bluetooth, communicate, DC motor, interface, FPGA, program.*

AUTOMATED BOTTLE FILLING MACHINE

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The main purpose of this project was for the construction of a liquid filling system which is to be used in emerging (small to medium) indigenous liquid filling factories. This liquid filling machine is a combination of the electronic components and mechanical design. The control circuit controls the pump, conveyor and sensors. IR sensor is used to know the position of the cup in this system. The touch screen acts as the user interface as well as the input control system for the machine. An android application would also couple this action by remote control via Bluetooth. The machine uses a programmed microcontroller the PIC 18F4520 which functions as the brain of the system. It has a predefined program and instructions that are responsible for the liquid dispensing processes and conveyer belt movement that the machine performed as directed by the user. When a bottle or container was picked up by the infra-red sensor at the filling position the conveyer motor automatically stopped and filling system started. After the filling process, the motor would automatically operate enabling the conveyor to start moving.

Key Words: *Android application, Bluetooth, Conveyor, liquid, filling, microcontroller, sensor*

FACE RECOGNITION ACCESS CONTROL SYSTEM

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Face recognition access control system is a system that is based on providing security to information. Face recognition is a biometric personal identification which is based on the human physical characteristics that is a human face. It is secure because very face is unique, and it cannot be duplicated or stolen. The system starts off with enrolment; the user's details are recorded and stored in a C# logbook. MySQL database is used to store these details. The input image frames are analysed using the Viola Jones algorithm for face detection. The detected faces can then be used to create a training set and these training set images are stored in a windows folder. The detected face is then recognised using the Principal component analysis algorithm. Using serial communication, a command is sent to a PIC16F877A microcontroller to turn the appropriate LED to indicate the status of the system. If the greed LED is on and the relay is on there has been a successful recognition. Red led represents no face recognised and yellow led represents the standby mode.

Key Words: *Algorithm, biometric, communication, face recognition, database, detected, microcontroller, training.*

DESIGN AND IMPLEMENTATION OF AN ANDROID MOBILE BASED SECURITY LOCK

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The purpose of this project was to design and develop a system capable of controlling security lock through android application. The user would enter a password commands through his/her Android Based mobile phone application and the information would be sent over established Bluetooth piconet connection to a microcontroller system which then serviced the requests. This project report provides the steps undertaken in developing an application which can be installed and run on android phones as well as controlling the home appliances remotely via Bluetooth connection.

Key Words: *Android application, appliances, Bluetooth, microcontroller, system, security, remote.*

WEB OF THINGS BASED NETWORK INFRASTRUCTURE MONITORING SYSTEM

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Network Infrastructure buildings contain fundamental routers, switches, servers and gateways enabling internet and data connectivity of companies' subscribers. Unplanned network downtimes as a result of servers, routers and switches failing in the server rooms result in huge losses to telecommunications companies. These network downtimes can be as a result of the internal Network Infrastructure housing environmental conditions being unfavorable to the operation of the equipment. This project focuses on an WOT (Web of things) based power factor and physical environmental conditions monitoring of temperature and humidity in server rooms in order to prevent network downtimes. In addition, the system is also able to calculate fuel level by use of generator uptime periods and provides a grounded Faraday's cage effect for Electromagnetic Radiation shielding. Faraday's cage compatibility test is based on principles of electromagnetic induction theory. The system developed utilizes Ethernet (IEEE 802.3) Communication Protocol to obtain the physical environmental conditions from local and remote locations in order to get a complete view of the environmental status of distributed systems' Network Infrastructure. The system displays the status of

each parameter at each location in graphical format on a web platform, locally hosted. The graphs are updated once every five seconds and allow remote monitoring by system administrators from any VLAN connected device such as laptops, desktops, mobile phones or tablets. Analysis of the graphs can provide insight into predicting the health of network nodes and prevent future network downtimes. In the event of fuel level being too low, system administrators are alerted via the same web platform.

Key Words: *Communication, Infrastructure, Network, Physical Environmental Monitoring, Ethernet (IEEE 802.3) WOT, VLAN, Faraday Cage, parameter*.

A HYBRID WIND AND SOLAR POWER GENERATOR SYSTEM

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The purpose of this project is to design a hybrid system that can harvest and harness the energy from both wind and solar thereby acquiring more power for consumption. This is to mitigate the energy deficit created by fossil fuel energy productions in the country, local power utilities are producing little energy due to regular breakdowns since they have outlived their lifespan and are in need of repairs and perennial droughts caused from climatic changes causing less power generation at hydro stations. Power is imported from neighboring countries to meet the increased energy demand at a high cost and yet still demand is outstripping supply. The use of a hybrid system which is a renewable energy source does not emit carbon dioxide which is a major culprit in causing global warming and is produced from coal power stations. Peak operating times for wind and solar occur at different instances, with solar dominating in throughput during the day and wind at night hence the hybrid system provides steady energy throughout the day. A hybrid system offers several advantages over either single wind or solar system.

Key Words: *energy, hybrid, solar, wind, power, consumption, production*.

GSM-GPS BASED ELECTRONIC SEALING AND TRACKING SYSTEM

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Examination in broad perspective is an instrument for testing, assessing, evaluation and accreditation. It is also used for the purpose of selection, placement, certification and promotion. Examination bodies have in the past lost hundreds of thousands of dollars to examination re-sits due to examinations malpractices. The integrity of ZIMSEC can only be maintained when there is maximum security of the examinations and when the examinations are run professionally without leakages. Many factors contribute to this menace of examination malpractice with research findings revealing that among those factors is leakages during transportation of examination papers from ZIMSEC headquarters to provincial offices where they are kept at the provincial managers' guard and from there to district offices then to their respective schools. The current transit system at the organization involves the use of conventional locks and restricted access to school heads, which are easily prone to tampering which can go unnoticed. This project focuses on GSM and GPS technology for tracking purposes, Atmel controller and anti-tamper switch for tamper proof sealing. The electronic sealing and tracking system not only enables ZIMSEC to ensure that examination papers have not opened before their official dates during transit and the time they are kept at provincial and district offices as well as the schools, prior to examination writing but also track the location of the boxes after dispatch from examination body center through the use of an application that uses Google maps to estimate the approximate location of the examination boxes. In the event of tampering, system administrators are alerted via SMS (short message service).

Key Words: *Examination, Electronic Sealing, GSM, GPS, SMS, ZIMSEC, Tracking*.

A MICROCONTROLLER BASED SUB-METERING UNIT

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The main aim of this project was to design and develop a microcontroller based sub metering unit. The system is meant to be used in multi-family homes, conjoined houses or rental flats where there are many separate families living under one roof. As is the case with many such places which are master metered (single meter), payment of utility bills electricity included is always an issue as conflicts always arise over how much money or percentage of the total bill each person or family should contribute. This project serves to address this issue using a technique called sub-metering whereby each tenant is given their own sub-meter to measure their own consumption and

disconnected from the mains supply after they have used up all their units. They will be connected back after recharging their meter. A current sensor and voltage transformer were used to measure current and voltage respectively. On recharging the tenants have to first recharge the electricity token in the ZETDC master as usual and go on to enter the number of units in the sub meter. The development of the sub-metering unit was a success as the system is accurately measuring the energy consumed by each tenant and disconnecting them when all units are used up.

Key Words: *Sensor, Sub-metering, microcontroller, monitoring, voltage transformer, units, utility.*

GPS-GSM BASED ANTI-DRUNK DRIVING SYSTEM

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The unavailability of adequate technologies to constantly monitor our roads and vehicles has led to many road traffic violations going unpunished taking for example driving under the influence. An anti-drunk driving node is a GPS (Global Positioning System) and GSM (Global System for Mobile communication) based system with Google map linked monitoring and engine control. It is a flexible and universal product that can be mounted to any vehicle (both those with electronic fuel injection and carburetors) that operates on carbon fuels or electricity. It is a solution to the problem of driving under the influence of alcohol which has a tactful combination of different fields such as communication technologies, software development and hardware integration. The focus of a GPS and GSM based anti-drunk driving system is to make use of the knowledge of the driver's blood alcohol concentration measured by the system in order to control and locate a vehicle. The GPS module obtains coordinates of the incident location and the microcontroller in turn prompts the GSM to send the coordinates in the form of a hyperlink. When clicked, the hyperlink will, directly open a google maps page that will display the incident location on a map. On the map the user is provided with services like getting directions, approximated time required to reach the place and also various routes depending with the mode of transport. The program responsible for coordinating and controlling all these activities was developed in mikroC and was loaded into the microcontroller. The embedded system encompassing the GPS receiver, processing unit and GSM module sends the position information using SMS which can be accessed from anywhere to ascertain the whereabouts of the vehicle to be tracked. Now, that GPS based solutions are available and affordable, its benefits are no longer limited to long-haul trucking companies but also to a host of other services. This system is used for vehicle fleet management.

Key Words: *Communication, GSM, GPS, SMS, vehicle, driving system, monitoring, microcontroller, tracking*.

AN AIRCRAFT DISTRESS AND TRACK SYSTEM

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Black box recorders are the common tools used for search and reporting of distressed aircrafts. However, it has been unable to provide real time distress report and tracking facility. The project aims to report a distress and track the aircraft when a distress signal is triggered by means of sending text messages from the aircraft in distress to the remote control center were emergency and rescue team can be notified so that they can react quickly to try and save life and property were possible within Zimbabwe's sphere of influence. In the design a gadget was made using appropriate technologies for the wireless transmission of data to a remote control center in real time so that the responsible authorities will be alerted to take action within the shortest possible time and thus save human lives. The design used the PIC 16F877A as the transmitting and receiving controller respectively due to storage memory requirements. The controllers have cheap price and they have eight Analogue to Digital Converter channels since the controller will handle analogue data. Various sensor technologies are available for wireless communication but RF modules have been employed. A prototype was designed to showcase the functionality of the system in the actual implementation.

Key Words: *Aircraft, communication, distress, sensor, tracking, wireless transmission.*

A MICROCONTROLLER BASED TRANSFORMER PROTECTION SYSTEM

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The Power sector is experiencing huge financial and commercial losses when replacing burn out transformers because of transformer oil theft. The aim of this project is to design a microcontroller based system that can be used in transformer protection and isolate the transformer from the distribution line to ensure that the transformer is safe from burning out. This gives a solution to the need to reduce cost of replacing the transformers and ensure that supply of electricity to consumers is not interrupted for long periods taken while repairing or replacing destroyed transformers. The proposed system integrates the GSM technology and a combination of ultrasonic sensor and the DS18B20 probe to detect oil level and windings temperature rise. Whenever microcontroller receives an error signal from the sensors, it is programmed such that it isolate the transformer using a relay, store the incident using real time clock module and sends a message text to the control office.

Key Words: *GSM, microcontroller, sensor, transformer, ultrasonic.*

POINT OF SALE SYSTEM

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The aim of this project was to design and develop a Fingerprint based Point of Sale Terminal. The customer first had to register his banking details at the bank. The registration process included enrolling a fingerprint using a fingerprint module the enter PIN, name, initial deposited amount and the type of account. These details were then stored in a secure bank database. Upon payment of any goods or service at a merchant, the customer was to swipe his fingerprint. The template was sent via GPRS to the bank database where it was compared to those in the database. If a match was found the systems would retain the other information with it to the POS Terminal. Then the customer was prompted to enter his PIN and if it was correct, the purchases amount was entered. If the bank balance was greater than the purchases amount the transaction was approved. The system increased the securing of financial transactions as only the account holder get access to the account.

Key Words: *Finger print, GPRS, point of sale, PIN, security.*

A SMART POULTRY RUN MICRO-CLIMATIC CONDITIONS SYSTEM

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The project entitled "Design and Implementation of a Smart Poultry Run Micro-Climatic Conditions Monitoring and Control System" was designed and implemented to profer a solution to adverse micro-climatic environmental conditions prevailing in most poultry houses. These adverse conditions cause harmful digestive, respiratory and behavioural changes in the chickens resulting in high mortality rate and the apparent shortage of chickens and eggs. In Zimbabwe, the government has even resorted to importing fertilized eggs in order to restock the poultry. The motivation behind this project was to come up with a system that harness the functional ability of Internet of Things by assigning IP addresses to the system clients and hardware server in order to measure temperature, humidity and ammonia inside a poultry run using wireless sensor clients. The main components of the system are the hardware server and the wireless sensor clients. The server collects data from the sensor clients and stores the data in the MYSQL database for graphical display of the measured parameters on a Web-Portal as well as display values on the LCDs. The server and clients use PIC18F46K22 microcontrollers and ESP8266 WIFI modules. DHT11 sensor is used to measure the temperature and relative humidity, whilst the air quality with particular focus on ammonia is measured by the MQ135 gas sensor. The code executed by the microcontroller was developed using MicroC Pro for PIC. Selection of the appropriate week on the chicken growth stage was done from a password proctected controls page on the Web-Portal. In cases where the measured parameters deviated from the set points, the appropriate actuators were triggered either ON/OFF in order to maintain the temperature or humidity within the set range. Whenever the ammonia level exceeded 25ppm, a buzzer sounded on the hardware and clients in order to alert the user to attend to the state of the air quality in the poultry run. The objectives were attained. However, a limitation faced was failure to use the actual physical environment of a poultry run with live poulty due to cost constraints. In future, there is need to develop a Mobile Application that would act as back up to user connectivity as well as increase the range of remote system access.

Key Words: *climate, password, sensor clients, sensor, database, microcontroller, remote access.*

DEPARTMENT OF INDUSTRIAL & MANUFACTURING ENGINEERING

DESIGN OF A MAIZE DEHUSKER SHELLER MACHINE

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The purpose of this project was to design a machine capable of processing un-de-husked maize cobs to extract the maize seeds. Large scale farmers use combine harvesters whilst small scale farmers use manual de-husking and shelling methods on harvesting. These manual methods are tiresome and time consuming to the middle scale farmers hence there is need to increase productivity to attain competitive returns for them. The researcher used the pahl and beitz methodology, the main tool used was Autodesk inventor for design modelling, static load analysis and vibration analysis techniques. The machine developed was able to de-husk and shell the maize cobs to extract quality seeds. The machine was also able to clean the maize from chuff by means of a blowing mechanism. The machine was also driven driven by means of a PTO drive mechanism and has wheels which makes it convenient to use anywhere in the field. This machine operates best if used on dry cobs. It is mostly recommended for medium scale farmers who may not afford to hire combine harvesters and have large yields which makes uneconomic to use manual de-husking and shelling methods.

Key words: *De-husking, medium scale farmers, productivity, shelling, PTO drive.*

DEVELOPMENT OF A HARD FLOOR CLEANING ROBOT

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The purpose of this research was to develop a semi-autonomous robot with the ability to clean hard floors. The current cleaning methods like manual sweeping and mopping require an individual to be always available for the cleaning process and at times can be labor intensive. In addition, the cleaning robots which are currently been developed are ineffective especially when cleaning up corners and

very expensive making it unaffordable for most Zimbabwean people. The research made use of 3D modelling conceptual design, circuit modelling and dynamic simulations in developing the design. A robot was developed with the capability of being omnidirectional and which has a rectangular dual cleaning partition floor cleaning mechanism. The robot has the ability to perform three cleaning operations i.e. brushing, dry mopping and vacuuming at the same time whilst reaching and cleaning corners of a room easily. The design is recommended for use in hard floor cleaning and can also be used by disabled people in Zimbabwe who seek some autonomy in their lives when it comes to room cleaning.

Key words: *Semi-autonomous, Cleaning robot, Omnidirectional, Disabilities*

OPTIMIZATION OF A SOYA MEAL EXTRUDER

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The purpose of this research was to develop an optimized soya meal extruder die. Dies used in extrusion cooking on the current machines have a lower product quality consistency and lower production rates thus there is a gap to improve the extruder machines performance in this agricultural value addition industry. The Oshuga model was the guide map in the research project whereby an initial baseline model of a die was designed and iteratively checked to fit the objective of maximizing volume flow rate. The ANSYS DOE (Design of Experiments) was applied to determine the relationships between extruder die parameters (die profile) and production rate. The DOE was used to generate models with design points of a die whereby each input parameter had its respective output parameter calculated. Response Surface tooling was then applied to find the design point on which the design of the die is centred on (Response point). An optimized die profile which maximized production rate (volume flowrate) was developed which improved the production rate of the initial design. The optimized die and the technique used in the optimization can be used to improve value addition in any extrusion cooking process utilized in the food processing industry. Recommended application of the design is in production of corn snacks, ready to eat cereals and corn puffs by small to medium sized food industries in Sub-Saharan Africa.

Key words: *DOE (Design of Experiments), small to medium food enterprises, Value addition, Food processing, Response Surface, Optimization, ANSYS.*

DEVELOPMENT OF A COMBINED REACTOR AND PAVER FOR POLYMER MODIFIED BITUMEN ROAD CONSTRUCTION

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Polymer modified bitumen is the latest development in road construction. This bituminous mix incorporates the known ingredients with addition of shredded waste plastic in polyethylene (PE) polypropylene (PP), polystyrene (PS). The addition of the polymeric waste has been classified as to increase road surfaces Marshall Stability value from 10-15 KN to up to 18-20 KN indicating better road surface test values which are superior to those of unmodified bitumens. With the continuous increase in road traffic coupled with an insufficient degree of maintenance due to shortage of funds causing an accelerated and continuous deterioration of the road network in Zimbabwe, polymer modified bitumen is the answer. Through providing an avenue for waste plastic recycling through more stable, durable and water impervious road, polymer modified bitumen simultaneously injects longevity in road lifespan whilst also addressing the pothole problem. This project brings a mechanized system by which polymer modified bitumen can be produced and laid as road in Zimbabwe. The reactor and paver design, augmented by robust simulation modelling techniques, provides the necessary wet process polymer modified bitumen formulation requirements of 180ºC temperature, mixing parameters for complete material coalition, paving requirements on ground distribution and pre-compaction as well as laying height adjustments.

Key words: *Polymer modified bitumen, bitumen, mechanized, wet process*

DEVELOPMENT OF AN AUTOMATED COAL MINE METHANE EXTRACTION SYSTEM

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The purpose of this project was to develop an automated coal mine methane control system for methane gas extraction from active and abandoned coal mines roof as it is the lightest gas in coal mines. Zimbabwe has the richest deposits of methane gas in coal beds in Southern Africa, which

accumulates into the underground coal mines during mining operations and abandoned underground coal mines. Almost 50% of the energy expanded in coal mines goes to the ventilation system so as to ventilate the accumulated explosive gas which is also a source of clean energy. Due to lack of cost effective technology to capture and fully harness this coal mine methane gas, its accumulations are resulting in 10+% downtime which is a huge loss to coal mining companies such as Hwange Colliery. Analysis of methane gas behaviour in terms of emission and accumulation was done, circuit designing, conceptual modelling, simulations and 3D modelling. A system was developed which could capture methane gas through a suction process. A model of the system was developed and tested which could detect, monitor and extract coal mine methane gas. This project is recommended for methane gas extraction in active underground coal mines and abandoned underground coal mines in Zimbabwe and Sub-Saharan Africa.

Key words: *Coal mine methane, methane extraction, energy, automated control, ventilation*

DESIGN OF AUTOMATIC PAINT WEIGHING AND COLOUR RECOGNITION MACHINE

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This research project concentrates on design of paint weighing controller machine which uses gravitational filing method, in order to solve the problem faced by a paint manufacturing and packaging companies where there was an overfilling of paint and packaging of dirty paint. This research therefore was developed for paint packaging companies in order to maximize their profits and increase customer's satisfaction. From the literature reviewed the existing paint weighing machines consist of paint container conveying system and the dynamic weighing mechanism during filling, however the colour recognition technique and container size recognition system is not incorporated. Solidworks and arena software's was used for design and simulations. The system uses paint specific gravity values and for colour detection the red blue green colour sensors are used. The machine is incorporated with an automatic paint container type and size recognition mechanism. The machine is able to fill containers of different volumes without changing the command on the program. The machine has a maximum filling capacity of 156 litres per minute on wood paints and also a belt capacity 1 069 tonnes per hour with conveying speed of 0.5 m/s.

Key words: *weighing controller, gravitational, paint, colour, recognition*

DEVELOPMENT OF AN AUTOMATED WATER HYACINTH COMPOSTING MACHINE FOR ORGANIC FERTILIZER PRODUCTION

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The purpose of this research was to develop an automated composting machine to produce organic fertilizer from water hyacinth, which is a free-floating freshwater plant that has caused continuous eutrophication of water bodies in its extensive growth making it a vast source of organic biomass. Aerobic composting is used to convert biomass into organic fertilizer that is used as a supplement for plant growth to increase soil water holding capacity, ion-buffering capacity and improving soil fertility. Biological research has proven that the aquatic weed can be composted and used a bio-fertilizer in crop production. Methods used to develop the design include unstructured interviews, laboratory experiments, circuit modelling, and simulation. A system was developed that uses moisture, temperature and humidity sensors to detect and regulate inner conditions optimal for aerobic bio-digestion. The developed system is recommended for use to accelerate the composting process by 75% and tackle environmental concerns involved in aerobic decomposition such as unpleasant odours, greenhouse gas emission and leachates through bio-filtration. This project presents huge potential in controlling growth of water hyacinth in Zimbabwe's water bodies and beneficiation in production of organic fertilizer.

Key words: *Organic biomass, Water hyacinth, Aerobic composting, Bio-fertilizer*

IMPLEMENTATION OF AN ADVANCED SCADA SYSTEM ON THE DEVELOPMENT OF AN ACTIVE LEAKAGE CONTROL SYSTEM IN WATER DISTRIBUTION NETWORKS

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Water loss through active leakages has been a major problem around the globe since the introduction of water delivery systems. In order to mitigate this problem, various models have been developed that include pressure monitoring techniques, pressure regulation techniques and leak detection

techniques among others. Pressure monitoring and regulation models have by far been developed as they seem to be more realistic in terms of implementation and they have been coupled together in order to achieve best results in some cases. After all the development that has been done, a loophole exists on how to take action when a leak has been detected before the maintenance team arrives. With the implementation of a highly advanced SCADA system, a system capable of monitoring a Water Distribution Network (WDN) and terminate water supply to a small area that has a leak without affecting a large area coverage was developed. In this research project, the implementation of this concept is visualized and tested through software simulation in real time analysis. The system developed here is coupled with smart field devices that perform data collection and wireless signal transfer to a designated server. With the help of an algorithm, the data is analysed using the conditions governed by equations of fluid dynamics. The result is a quick response system that is capable of reducing leakage run time to a number specified by the water supply authorities. The steps followed in the development of the system allows room for application of the system in different fields that work with liquids or fluid delivery systems.

Key words: *Water Distribution Network (WDN), Non-Revenue Water (NRW), Active Leakage Control (ALC), District Metered Area (DMA)*

MICROCONTROLLER BASED AUTOMATION OF A MULTIPLE CYLINDER HEAD VALVE REMOVING MACHINE

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The manual valve removing methods that are currently being employed are time consuming. This project serves to design and develop a partially automated valve removing machine for the maintenance and repair of engine cylinder heads and valves for caterpillar big engine service garages. This project's aim is to improve productivity of the valve removal process and to reduce the cost of maintenance. A control system and algorithm to actuate the valve removing process were developed. Pneumatic power and electrical energy were employed to achieve the valve spring pressing for the valve removal task. Pneumatic solenoid valves, infrared sensors, electric motor, and a microcontroller were the instrumentation employed to execute the control algorithm. Autodesk Inventor software was used for the engineering drawing and finite element analysis to test the strength and behaviour of the materials in use under the operational loads. The machine managed to prove to be 400% more productive than a human worker.

Key words: *Cylinder head, Partially automated, Valve removal, Control algorithm*

ANALYSIS AND PREDICTION OF GEARBOX FAILURE BASED ON LUBRICANT PHYSICAL PROPERTIES FOR HIGH AVAILABILITY INDUSTRIAL MACHINES

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The need for machine failure prediction in predictive maintenance helps to make solid and informed decisions in maintenance planning and scheduling. In production processes where, high availability machines are used, effective routine maintenance scheduling is a challenge due to cost incurred in stopping machinery. The purpose of this project is to develop a gearbox predictive system based on gearbox lubricant physical properties such that inaccuracies due to delay in data acquisition and the sampling method used can be reduced. A real time data acquisition system using online sensors to detect changes in wear debris concentration and temperature of the lubricant were analyzed to predict gear box component failure in conjunction with the torque fluctuations in the process. System modelling and simulation was used to produce the dataset that was used to obtain the results. Through the application of machine learning; supervised learning algorithms such as linear regression using gradient descent as optimization algorithm; remaining useful life of a machine gearbox was modelled. The model developed was checked for accuracy using 3-fold cross validation method. Results obtained revealed that linear regression could predict gearbox failure with at least 70 % accuracy. The torque lost due to wear was used as a feature to improve the accuracy of the model.

Key words: *Gearbox, High availability machines, Loss torque, Linear regression, Gradient descent algorithm*

CONDITION MONITORING AND CONTROL SYSTEM FOR SILO STORED GRAIN

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The aim of the research was to come up with a real time condition monitoring and an effective aeration system. GMB (grain marketing board was reported in the 2011-2012 auditor general's report to have lost grain summing up to 61000 tonnes were lost to bin burn which is caused by unfavorable conditions like temperature and moisture. Bin circulation is a method currently being used to try and avoid this problem of bin burn by moving the grain from one silo to the other and in the process aerating the grain and applying fumigants to deal with insects and this process is being done after

every three months but reports of bin burn still surfacing. To achieve this goal the researcher implemented Pahl and Beitz design process as it gives from for feedback so that the researcher won't go astray. Data was gathered making use of both primary and secondary data. Concepts were developed that can help curb the present problem and one was adopted through concept scoring and design calculations embodied this chosen concept so as to come up with an effective duct network that delivers the cooling front across the diameter of the silo at different levels at one go. A monitoring and control system was developed that makes use of PT100 temperature sensor that goes down into the grain and DHT22 that will be located at the roof of the silo so that it records all humidity fluctuations. PLC microcontroller will process the data from the sensors and send out a signal to the aeration fan and the vent in real time in response to the status of the silo conditions (humidity and temperature).

Key words: *Aeration, Bin burn, Monitoring, Airflow rate, Real time*

DEVELOPMENT OF AN AUTOMATED AGRICULTURAL FARM MONITORING SYSTEM AND DISEASE DETECTION ROBOT FOR ZIMBABWEAN VIRGINIA TOBACCO FARMERS

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The purpose of this study is to develop an automated system for assisting flue-cured Virginia tobacco farmers. Tobacco is a cash crop of paramount importance to Zimbabwe's economy. New small-scale flue-cured Virginia tobacco farmers have experienced challenges in producing quality and elevated yields due to inadequate knowledge in farming methods and limitations in disease detection and control mechanisms. The use of manual labour in performing tobacco farming operations including spraying, disease detection and inspection has led to several problems such as green tobacco sickness in humans induced by radiation from tobacco plants, chemical exposure related sicknesses, high costs of labor, inefficiency of processes and theft of resources. The system developed was a smart automated tobacco farm monitoring system with an interactive online assistance platform which also performs tobacco leaf disease detection and selective chemical administration. The methods used for this study include unstructured interviews, experiments, electronic circuit modelling, programming and simulations. This system is very effective in offering assistance and service to customers both online and off the grid by making use of the internet and a network of inter-connected sensors which alert the farmers on extreme weather conditions, offers corrective action plans, procedural advice and decisions for tobacco farming as well as stores and processes data logged in

by farmers. This system is recommended for use in tobacco and other similar crop plantations as well as for new and old farmers who wish to perform automated farming and online consultations.

Key words: *Tobacco, Smart Farming, Disease Detection, Spraying, Consultation*

DEVELOPMENT OF AN INDUSTRY 4.0 BASED MACHINE MANAGEMENT PLATFORM FOR ZIMBABWEAN TOOL AND DIE SME INDUSTRY

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The purpose of this research was to develop a machine management platform for Zimbabwean Tool and Die SMEs industries. The lack of real time machine data and process performance data in most tool and die manufacturing industries results in reactive and unplanned maintenance, increased downtime, and plant unavailability. This has been a challenge in Zimbabwean Tool and Die SMEs industries; transformation into Industry 4.0 compliant factories with significant economic potential. Zimbabwean SMEs to upgrade and transform their businesses in the era of Industry 4.0 is a need. The researcher utilized Proteus for circuit design and circuit analysis, data analysis techniques, implementation of algorithms and computer coding development techniques. A system was developed with the capability of monitoring seven machine parameters to be able to predict machine status, these parameters obtained from the sensors are stored in a database where they are retrieved and made accessible on an online dashboard. The developed design is recommended for application in the Zimbabwean Tool and Die SMEs industries.

Key words: *Machine management, Industry 4.0, Real time data, Tool and Die SMEs*

OPTIMISATION OF A NON-DESTRUCTIVE QUALITY ASSURANCE SYSTEM FOR FRUIT USING SUPPORT VECTOR MACHINES

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The purpose of this research was to determine fruit quality at different maturity (ripe or rotten) stages. The current grading systems are time consuming, labour intensive, inconsistent and offer vague assessment by visual inspection are some of the factors influencing an ineffective quality control and assurance system for processers, consumers and producers. The research made use of Support Vector Machine (SVM) learning for training and testing in the development of an image classification system and also made use of laboratory experiments in determining spectral data at different maturity stages of a fruit. This research also utilized image processing algorithms and common sensing modes used to determine quality and safety evaluation of online fruit grading. The system developed retained a high classification accuracy during testing and evaluation of the image classifier for both maturity stages using MATLAB software. This research is recommended for extension into other areas within the food industry such as meat processing as a need to detect food borne diseases and hazardous foot prints. Due to the remote sensing capabilities this research can be of use by consumers as a mobile application on mobile phones by applying Convolutional Neural Networks CNN. Retail operators and farmers can adopt this system as a condition monitoring system for fruit inventory management.

Key words: *Machine learning, Support Vector Machine (SVM), image processing algorithm, food industry, food quality detection.*

DESIGN OF A PAINT BEAD MILL QUALITY CONTROL SYSTEM

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This research project is focused on the design of the bead mill automated quality control that monitor and regulate the quality of paint during its grinding operation. Paint manufacturing process is experiencing very high lead times as a result of the current methods being used in checking its quality. The time taken to collect the samples and then obtain the results from the laboratory increases the paint manufacturing lead time. In order to solve this problem an online system that measure and regulate the viscosity, particle size and density of the ground paint is developed and this resulted in improved customer satisfaction since the targets are now easily met thereby improving company profits. The system is able to measure the viscosity, density and particle size at any given time and display the results on the LCD. Once the viscosity and particle size the ground paint reaches 750 cP and 10 microns respectively, the agitation system of the bead mill is stopped since the paste produced will be ready for the next stage in the paint manufacturing process. The researcher

managed to review the literature from the information on the internet, text books and electronic journals. MATLAB and Arduino was used for design and simulation of results.

Key words: *Viscosity, Particle size, density*

ANALYSIS OF SELF-MANOEUVRING FIRE DETECTING AND FIGHTING ROBOT MOVEMENT

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The main purpose of the research was to develop a self-maneuvering fire detecting and fighting robot based on artificial intelligence. The robots that have been produced took longer to respond to an outbreak of fire, small range of operation, could avoid obstacles but it was not accurate. There are tools, which were used in the Oshuga model which were, the use of the 3D conceptual design modelling and other simulation on the material selection of the robot when the robot was exposed to certain environment and Proteus to verify the movement of the robot. There was also use of LabView software to gather data from the infra-red sensors and send information to the computer. The radio frequency through the UART protocol would send an impulse to the robot. The finite element analysis was used to identify which type of material was best suitable for the robot to operate in very high temperatures and under load. The prototype produced the following, it was able to stop after detecting the flame and it sent a signal to warn the people around about the fire outbreak using a cyrene. From the results that were obtained the project were a success such, it was able to avoid obstacles and warn people around.. There is also a recommendation in this project, which is focusing on the battery life of the robot.

Key words: *Autonomous robot, radio frequency (UART), self- maneuvering*.

OPTIMIZATION OF A BIO DIGESTER FOR RURAL HOMES

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The purpose of this research project was to develop an optimized biogas digester for rural households with the intention of supplementing for heating energy shortages thus reducing use of fossil fuels as they damage the ozone layer and deforestation causing soil erosion. Temperature and mixing effect experiments were done to assess the behavior of biogas producing organisms in different temperature and mixing conditions in order to determine the optimum digester conditions. Proteus was for circuit design, analysis and computer coding techniques to develop a control system and circuit to monitor and regulate the optimum conditions from the experiments. Ansys was used for analysis of different proposed digester material when exposed to the digestion conditions VisiMix for designing of an agitator and selection of proper speed. The researcher developed two prototype models of digesters in which one model was optimized and the other model was not optimized. Results from the prototypes presented a 60% optimization level from which the digestion period was not over meaning the percentage optimization level could have been higher if the digestion process was to be left until done.

Key words: *Bio-digester, anaerobic respiration, hydraulic retention time*

DEVELOPMENT OF MACADAMIA KERNEL SHELL GRADING AND SEPARATING MACHINE: CASE STUDY CLEARWATER ESTATE

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The purpose of this research is to develop a macadamia kernel shell grading and separating machine, a case study of Clearwater Estate. The poor recovery of the nuts is a result of uncracked or incompletely cracked nuts, and of kernels rejected in the bulk shells due to imperfect shells and kernel separation. There have been some research pertaining he cracking principles of macadamia nut and some of the machines are in commercial use, but the problem of separating shells and kernels remain unsolved. Low separation efficiency of the macadamia processing machine is approximately 50%, reduces overall productivity resulting in a labour intensive operation that causes fatigue and loss of concentrations to the operators. A three-stage separating and grading machine with a blower was

designed with cooperation with Clearwater Estate to separate the shells from kernels. The method is based on separating the shells and kernels according to size using vibrating sieves which is driven by a cam shaft. The vibration causes stratification, causing the geometrically smaller material to pass through the sieve. Quantitative and qualitative methods were used as tools to gather relevant information on how to come up with an effective grading and separating mechanism. The developed separating and grading machine is recommended for use at Clearwater and other macadamia farmers to increase sorting and grading time thereby increasing the productivity. The project was successful in removing shells from the cracked mixture which proved to be economically in implementing it and reducing the number of labour operators.

Key words: *Macadamia nut, Separation, Grading, vibration and screening*

LIQUID PETROLEUM GAS CO-GENERATING SYSTEM FOR PRODUCING HEAT AND ELECTRIC POWER FOR SELF SUFFICIENT HOUSEHOLDS

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The current power generating methods are not efficient and are not meeting the demand since the population has increased hence the need to develop self-sufficient homes which will be independent from the nation power grid for power. Using cogeneration (combined heating and power CHP) is more efficient and sustainable since it is the simultaneous conversion of one primary source of energy into useful heat and electric power. The primary source of energy will be Liquid Petroleum gas as it is available and is already being used for cooking and heating since the cost of using energy has increased. The system will use Stirling Engine as the prime mover, heating column and temperature buffer for the storage of useful heat. The useful heat will be used for heating water therefore removing the need to have a geyser. This also reduces the power loses due to transmission and distribution since it is done onsite. The system have was analyzed by energy 2D simulation technique which give a commendable justification and prototype produced electricity and hot water which will reduce the energy cost by $137.59 annually and the is no dependence on the nation power grid for power since the system produces 5kW and 3.1kW of useful which are able to power households. The system shows the potential of using Liquid petroleum gas in order to have secure of supply of electric power and useful for self-sufficient homes

Key words: *Cogeneration, Stirling Engine, Liquid Petroleum Gas, Useful heat, Electric power*

OPTIMIZATION OF TRIBO-ELECTROSTATIC SEPARATOR FOR MICRONIZED MIXTURES FROM E-WASTE.

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Electronic waste is increasing at a faster rate than the ability of local councils to recycle the waste. The available systems have recorded low efficiency in separating particles less than 1mm using tribo electrostatic which is the most cost effective method of separation in terms of energy and pollution. The aim of this study is to optimize tribo electrostatic for micronized waste. The researcher used computer based experiments with MODDE 12.01 to determine the impact of voltage applied, speed of electrodes, electrode configuration, feed rate and air flow rate to determine the optimal parameters using 50g of Copper and 50g of Acrylonitrile butadiene styrene (ABS). MODDE 12.01 was used to model the experimental data and find the optimal conditions to determine the design. Fitting the model data with partial least squares the following optimal conditions were established voltage applied = 25 KV, Feed rate= 6.5 kg/h, air flow rate= 11m^3/h and electrode speed = 30 rpm, at these conditions 66 % of Copper was recovered with purity above industry threshold, there was 12% increase in Copper output, 95% of ABS was recovered with purity less than 80% there was 10% increase in its purity. A second pass through the electric field would be necessary to obtain a better performance. A design was then made based on optimal conditions and analyzed using solid works.

Key words: *Electronic Waste, Tribo-electrostatic, Optimization*

IMPLEMENTATION OF CLEANER PRODUCTION AS A STRATEGY FOR DUST MANAGEMENT IN BAKERIES

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The purpose of this project was to implement cleaner production strategies for dust management in a local bakery. Advances in cleaner production and environmental management system (EMS) have completely transformed the manufacturing processes. Manufacturing companies are drifting from conventional operations which pose health issues to personnel and implement end of pipe technology

and cleaner production strategies. Zimbabwean bakeries are lacking closed loop systems that can analyze and control their environments automatically to effectively maintain a healthy environment; this has led to dust related diseases and eventually pneumoconiosis. The researcher undertook this research using a Paul and Beitz design and implementing a quantitative methodology and techniques to ensure efficient abatement of dust in a dry blend section of a bakery. An algorithm was developed to continuously monitor and control dust dispersion and a dilute and disperse system was implemented. A system that can induce fresh air and exhaust dust with the capability of controlling temperature, humidity and dust intensity was developed. This system is recommended for local bakeries with poor dust management.

Key words: *Cleaner production, Environmental Management System, Pneumoconiosis, Dust dispersion.*

EXPERIMENTAL STUDY AND ANALYSIS OF AN ALUMINIUM WIRE WOUND DISTRIBUTION TRANSFORMER.

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This project asses the failures in aluminium wire wound distribution transformers with the vision of improving the root cause of the failures, as in the recent years economic reasons have forced organizations to search for the new applications of aluminium alloys in electrical fields as an alternative material for the traditionally used copper which is depleting and becoming expensive. Due to the competition for markets in the global village Zimbabwe Electricity Supply Authority wants to join the world in offering affordable distribution transformers by the manufacturing of aluminium wound transformers. Therefore this research focused on the development of aluminium wire for winding distribution transformers with increased mechanical properties. This was achieved by experimenting the effects of increasing iron (Fe) and Silicon (Si) and Copper (Cu) in the new alloy. The base metal (1350 pure aluminium) was used as the basis of the experiments as it is the material being currently used for the winding of the distribution transformers. The alloy was casted following procedures of the manufacturing of aluminium alloys then tested for all mechanical properties (tensile strength, ductility, elongation %) keeping conductivity constant. Excel and Mat lab was used for analyzing the experimental data, Moode (Design of experiments software was for performing the iterations of varying the levels of iron (Fe) and copper (Cu) in order to come up come up with the optimum conditions for producing the alloy. A lot of literature was reviewed from previous work and a number of

considerations were done that led in to the experimental analysis of aluminum alloy in order to address the short falls of the current material.

Key words: *Transformer windings, Aluminium alloy, tensile strength, ductility and conductivity*.

DESIGN OPTIMIZATION OF AN AUTOMATED PAINTING MACHINE WITH MAXIMUM STABILITY FOR HIGH WALL APPLICATION

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The current construction industry is using manual method of painting high walls which is time consuming, risky and very costly. Analysis done after collecting data proved that 76% of the cost are actually setup costs coming from the use of scaffolding hence the need to automate high structure painting system. By introducing a high wall painting robot this industry can be able to shorten project time, drastically reduce labour costs and eliminate scaffolding hiring to further improve productivity. The robot climbed high walls using vacuum technology whereby suction cups were attached to prismatic joints and were provided with vacuum by a vacuum pump. The paint is carried on the robot and is balanced gravitationally by offsetting it 300mm below the center which lessens revolving motor torque. The robot is equipped rack and pinion drives to move the prismatic joints. The robot uses limit switches, ultrasonic sensors, low level as inputs to control motion direction and painting process. The robot is capable of painting 4 square meters per run per minute, which is three quarter of manual painting. Analysis was done using theoretical data from material density tables to ascertain the best lightest material to use for the robot framework of which the material was to also have the best strength to withstand 50N force including safety factor, which was found to be an aluminium alloy 6061. The material was further put to stress, strain and deflection test using solid works simulation (finite element analysis) and the analysis results proved that it was the best suitable material for the job. A code was developed and tested through simulation, the results were satisfactory.

Key words: *Painting robot, Vacuum technology, Prismatic joints*

DESIGN OF A MAGNETIC LEVITATION VERTICAL AXIS WIND TURBINE FOR AREAS WITH LOW WIND SPEED (ZIMBABWE CASE)

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The current electricity generation in Zimbabwe is at approximately 1 556MW against an estimated national demand of 2 200 MW which is as a percentage a power deficit of 29%. This research project aims at utilizing low speed wind power for energy production as a renewable method to help cover the deficit. A magnetic levitation vertical axis wind turbine was designed to operate with slow wind speeds and is able to produce an output voltage ranging from 220v to 240v alternating current. Turbine blade was designed considering the aerodynamics. The results obtained from simulation done using solid works show that the yield strength is bigger than the von Mises stress signifying that the design can withstand all the stresses which can act on it without breaking. The displacement of the turbine blades produced by simulation is very small which means that the blades will not change their length. The output voltage of the design is 8volts alternating current on average which can now be stepped up by a generator transformer to obtain the required voltage. The turbine must be secured tight with bolts for stability. Dust particles must be prevented from entering the generator.

Key words: *Magnetic levitation, vertical axis, wind turbine, renewable energy, electricity generation, low wind speeds.*

EXPERIMENTAL ANALYSIS OF THE APPROPRIATE METHOD FOR REPAIRING CRACKED VEHICLE CHASSIS .

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The present study was aimed at analysing and recommending the appropriate way of fixing major crack defects on heavy vehicle chassis. The chassis being the back bone of any vehicle, there is hardly any reported research on the repairing of major crack defects particularly on heavy vehicles. Various research methods have been used so as to come up with this project and the methods involves the use of electronic journals, heavy vehicle technology literature, informal interviews with truck operators to mention but a few. Taguchi's orthogonal arrays have been utilised so as to come up with the sequence of conducting the experiments. Welding of the samples was done with the help of a coded welder as stipulated in ISO 9606. The welded samples were grinded and polished. Microstructure of the welded sample has been examined with the use of a metallurgical microscope and the screen shots were taken and recorded. For further analysis, the Leab hardness test has been done on three zones of the test piece that is on the weld, heat affected zone and on the area away from the heat affected zone. From all the results obtained, it has been noted that high strength low alloy steel can be welded using a low hydrogen welding technique called tungsten inert gas welding. For further research, other researchers are encouraged to analyse the weld ability of chassis for light vehicles.

Key words: *Taguchi's orthogonal arrays, tungsten inert gas welding, Leab hardness test, micro structure.*

OPTIMIZATION OF A ROTATING SHELVING MACHINE: CASE STUDY

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This research project concentrated on optimization of the storage rotating shelving machine in order to solve the problem of inadequate and inefficient material storage methods practiced by Natprint company. Natprint company is currently experiencing problems of fully packed rooms and warehouses; congested aisles; blockages of fire exits and machines which is detrimental to production. The purpose of this research was therefore to increase storage density and storage accessibility by harnessing the vertical overhead space for storing materials through manufacturing higher vertical shelves and make sure that each shelf can be accessed the same way you can access any shelf. In order to achieve the purpose, relevant literature was presented to help build an efficient storage equipment. The researcher used interviews, observation, internet, analysis and prototyping. The results of this research was rotating shelves powered by a C++ and microcontroller for calling a particular shelf to a set ergonomic position for easy access of materials. The code was programmed in such a way that when we call a particular shelf, it would rotate to the set position using the shortest

possible route. Cycle time for each shelf is 25seconds that is the time it takes for each shelf to complete a revolution. The research went on further to include sensors imbedded within shelves for detection of loading and unloading of materials and send data to the computer of date and time of storage/retrieval operation so as to keep track with material stored. The rotating shelving system will help Natprint and other interested companies to become efficient in their storage/retrieval operations, keep track of material and also to reduce material pilferage.

Key words: *Storage density, Overhead space, Storage accessibility, Storage equipment, Shelves, Cycle time.*

UTILISATION OF FIBRE GLASS WASTE IN POLYMER CONCRETE

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In this study, the effect of incorporation of recycled fibre glass reinforced plastics (FGRP) waste materials, obtained by means of shredding process, on mechanical behaviour (compressive test, flexural test) of polymer concrete (paving tiles used on citric acid loading bay). For this purpose, different contents of FGRP recyclates, between 4% up to 12% in weight, were incorporated into mixture as sand aggregates and filler replacements. The effect of FGRP waste on conventional concrete and addition of a silane (Resin hardener) to resin binder was also evaluated. Applied waste material was proceeding from the shredding of the leftovers resultant from the trimming and assembly processes of fibre glass products. Currently, these leftovers as well as non-conform products and scrap resulting from manufacturing process are landfilled, with additional transport costs of producers. Hence, besides the evident of environmental benefits, a viable and feasible solution for these wastes would also conduct to significant economic advantages. Designs of experiments and data treatment were accomplish by use of Central Composite Orthogonal design composed of full factorial and star point. Experimental results were promising toward the recyclability of FGRP waste materials as partial replacement of aggregates and reinforcement for paving tile mixture, with significant improvements on mechanical properties with regards to currently used loading bay tiles.

Keywords: *Fibre glass reinforced plastics (FGRP), Wastes, Recycling, Concrete-polymer composite, mix design, mechanical properties*

OPTIMISATION OF A BOILER EMISSIONS MANAGEMENT SYSTEM USING REALTIME MONITORING

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The purpose of this research was to optimize the boiler emission management system at a local beverage company in Zimbabwe. Global warming has proved to be disastrous in both the climate and the health of ordinary people therefore it is of great concern that industry controls its pollution so as to minimize its raise. The local beverage organization was experiencing heavy penalties from local authorities due non-compliant boiler emission. Visual basic was used for creating the program and Proteus was used for coding the circuit system of the project. The system produces real time information in both graphical form, real numbers and alerts the responsible authorities with a message. The developed system is recommended for use at any organization that emits carbon gases through chimney.

Key words: *Real time, boiler emission, global warming, sensor technology*

DESIGN OF TRANSFORMER OIL THEFT DETECTION SYSTEM

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Theft of electric transformers' oil has resulted in business and individuals going for a long time without electricity. Electric transformer oil theft detection system can result in a local electricity supply authority saving millions of dollars due to real time warnings which will facilitate reaction of responsible authorities. The current security system of manning every place where there are transformers is not possible since there are more than thirty thousand transformers in a local city alone. The aim of this project is to design a system that will detect transformer oil theft before it happens. Microsoft Office Packages, C# and Simulation packages (Proteus and energy 2D) were used in the design of circuit and coding of the program. As a result, text messages were able to be sent when breach of the transformer happened, thereby alerting responsible authorities to react with urgency.

Key words: *Transformer oil, Theft, Real time, Electricity*.

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DEPARTMENT OF FOOD PROCESSING TECHNOLOGY

DESIGNING A MILK CAN COOLING SYSTEM

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The objective of this research was to design a milk can cooling system which can cool pasteurised milk from a temperature of 90^0C to 28^0C within a period of thirty minutes. At Women's University in Africa Farm, challenges are faced in trying to cool milk after pasteurisation due to lack of equipment. Aluminum cans containing 40 litres of hot milk are immersed in cold water at room temperature in an open trough. Long hours of cooling milk are experienced, thus the process is time consuming and there is contamination of milk as cooling is carried out in an open trough in which continuous stirring of canned the milk is done.

Each of the chosen designs was weighed using a decision matrix in order to come up with the best design concept. The factors which were considered are functionality of the design, design simplicity, energy consumption, ease of maintenance, cooling efficiency and the cost of assembly and materials. The design chosen by the researcher makes use of a water bath and water coolant which allows reduction of milk transporting, thus preventing milk contamination. Water is a low fouling liquid hence it can circulate in the piping for a long time before there is need to clean the pipes. The fan added to the plate and frame section of the design increases airflow and loses of heat via convection. The current process at the university has the milk canned from the heat treatment section hence this equipment did not require modification of the process line.

Experiments to evaluate functionality of the design were carried out. Determination of residence time of the water in the cooling tank was done. The cooling rate of the water was also calculated. It was found to be higher for the cooling system designed by the researcher than the cooling trough used at the farm. This was due to the continual cooling of the water in the cooling system. Finally, efficiency of the design was calculated and found to be 84%.

It was concluded that the cooling rate of pasteurised milk can be increased by continuously cooling the water. Also, there is still need to improve the cooling process and increase the rate of cooling by directly cooling the milk in the cooling system and increasing the size of the heat exchanger and pump. Some phase changing materials can be used to improve the cooling system. Cold water can also be sprayed on top of the milk cans if the milk is to be cooled in cans in order to quicken the cooling process.

OPTIMISATION OF A SOLAR DRYER WITH PHASE CHANGE MATERIAL FOR DRYING TEXTURED VEGETABLE PROTEIN

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The unit operation of drying is a crucial and critical process in the manufacture of textured vegetable protein. This is because the overall quality and shelf life of textured vegetable protein depends on the drying process. In Zimbabwe there are no locally and cheap solar dryers being produced to dry textured vegetable protein, so the design targets the SME's in the textured vegetable protein manufacturing industry. The aim of the project was to optimize a solar dryer by using paraffin wax as a phase change material and to develop a temperature and humidity control and monitoring system for drying textured vegetable protein. The objectives of the project were to dry textured vegetable protein to the required final moisture content of between 8-10 %, to improve the drying time of the solar dryer by extending its drying time by 3 hours from 8am to 5pm to 8am to 8pm and to control drying temperature to between 40-50°C. The design of the dryer followed Pahl and Beitz, (1996) design models. The design verification was done by carrying out comparative experiments on different methods used to dry textured vegetable protein. Samples of textured vegetable protein were dried using the designed solar dryer, oven dryer and air drying method. The solar dryer dried textured vegetable protein to the required final moisture content of 8-10% in about 5hours.The phase change material improved the thermal performance of the dryer and extended the drying time of the dryer by 3hours. In order to explain the drying behaviour of textured vegetable protein twelve different mathematical models were compared according to their adjusted coefficient of determination, sum of

squared error and root mean squared error. According to the results, the Gurlek*etal.*model could adequately describe the solar drying behaviour of textured vegetable protein in the new designed solar dryer.

COMPARATIVE ANALYSIS OF THE PHYSICOCHEMICAL AND FUNCTIONAL PROPERTIES OF *Colocasia Esculenta L.* (COCOYAM) STARCH AND CONVENTIONAL CORNSTARCH IN FOOD SYSTEMS.

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The aim of this study was to carry out a comparative analysis of the physicochemical and functional properties of cocoyam (*Colocasia esculenta*) starch and conventional corn starch (native) in food systems. Starch was first extracted from cocoyam powder using sodium metabisulphite while varying steeping times and the sodium metabisulphite concentrations. The physicochemical properties and functionality of the cocoyam starch were determined by considering the gelatinization, retrogradation, stabilizing and the thickening properties of the starch that is, the gelation capacity, temperature of gelatinization, water absorption capacity, solubility index, syneresis, freeze thaw stability, intrinsic viscosity and emulsifying capacity. The gelation capacity was characterised by determining the least gelation concentration (LGC) of the cocoyam starch. Water absorption capacity was determined as the percent water bound per gram of the cocoyam starch. Syneresis was determined by measuring water loss from 2% (w/w) starch gels with storage time. Freeze-thaw stability was measured as syneresis of cocoyam starch gel with increasing freeze-thaw cycles. The intrinsic viscosity, η_c was determined by considering the time taken by cocoyam suspension, Δt_s to flow through the pipette in relation to time taken by distilled water,Δt_w, at a particular viscosity of distilled water η_w. The emulsifying capacity samples was determined homogenizing the starch dispersions with refined sunflower oil. The emulsifying capacity of the starch was then expressed as the volume of the emulsion to the total volume of the sample. The study revealed that most of the functional and physicochemical properties of the starch obtained from cocoyam compare favourably to those of corn starch. The starch showed no significant differences in retrogradation, stabilizing and thickening properties from those of cornstarch as deduced from the characterisation of its solubility, syneresis, intrinsic viscosity, freeze-thaw stability and comparison to those of conventional cornstarch. Although the gelation and water absorption capacities of cocoyam starch obtained were slightly lower than those of cornstarch, they still compared favourably to those of the cornstarch. Cocoyam starch

showed better emulsifying properties than cornstarch suggesting its applicability as an emulsifier in solid particle based emulsions also referred to as Pickering emulsions. Compared to cornstarch, cocoyam starch had a higher temperature of gelatinization suggesting cocoyam starch will have more applicability as a thickening agent in products which undergo processing operations which employ higher temperatures as contrasted to cornstarch. However, the starch may also require some physical and chemical modifications so as to further improve its physicochemical and functional properties.

DESIGNING OF A MAIZE (ZEA MAYS) CLEANING AND GRADING MACHINE PRIOR TO STORAGE - CASE STUDY OF THE GRAIN MARKETING BOARD

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The objective of this research was to design a vibrating cleaning and grading machine for maize to remove foreign matter that is found in the maize after harvesting and threshing. Maize is contaminated by impurities such as, broken grains and foreign matter which can be of animal origin (insects, rodent excrete), vegetable origin (straw, weeds, seeds and chaff) and mineral origin (stones, mud, glass and metals).currently maize is being stored without being cleaned at the Grain Marketing Board. Cleaning is the phase of post-harvest system during which the impurities which are eliminated, all the materials other than grain are removed.to maintain high quality during storage maize should be protected from growth of microorganisms and insects. The estimates of the cost of grain loss due to insect and microorganism damage of grain stored in developing countries each year ranges from $500 million to $1 billion. The cleaning operation which may be accompanied by sorting of the grain according to quality is indispensable before storage, marketing and further processing of the maize grain. Cleaning aims at removing as much trash as possible from the threshed grain.

The design project aimed at developing a vibratory cleaning and grading mechanism of removing the impurities from the maize and grading the maize according to sizes. Maize samples from GMB Aspindale famers were used for experiments in the design. The design aimed at removing the foreign matter in maize in a possible short time without breaking the maize.

The design includes a sieve shaker which is driven by an electric motor to provide the vibration on the sieves during cleaning of the grain. The design also consists of a blower which blow away lighter impurities as the maize is fed into the sieve shaker. To ascertain efficiency of the design machine, pre

and post maize grade was determined and recorded. The foreign matter in the maize after cleaning was measured and calculations were done to show the efficiency of the design.

MORPHOLOGICAL AND BIOCHEMICAL CHARACTERISATION OF MICROORGANISMS RESPONSIBLE FOR FERMENTING TRADITIONAL ZIMBABWEAN *MAHEWU* AND STUDIES ON THE PHYSICO-CHEMICAL CHANGES THAT TAKE PLACE DURING PRODUCTION

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Mahewu is a non-alcoholic fermented cereal beverage prepared from either thin maize porridge or thick maize porridge which can used as a refreshing drink and as a weaning beverage for infants. The aim of the project was to study the morphological and biochemical characteristics of some of the microorganisms involved in the fermentation of *Mahewu* which was prepared traditionally as well as study the physical and chemical changes that took place during the *mahewu* production. The traditional preparation of *mahewu* was done using different methods carried out in three different provinces of Zimbabwe. The microbial analysis was carried out by isolating the microorganisms and purifying them. These were enumerated during the monitoring of the fermentation process. The purified colonies were analysed using light microscope for microscopic characteristics. The colonies were also analysed macroscopically for colony shapes and colour. The isolated microorganisms were subjected to biochemical tests which are also the confirmative tests. The physical and chemical changes which included changes in pH, alcohol content, moisture content, viscosity, and titratable acidity were also analysed. The results obtained showed that there was an increase in the microbial populations during the fermentation period in 72hours. Yeasts, mesophilic bacteria and lactic acid bacteria increased in their average populations to log 7.3 CFU, log 6.8 CFU and log 8.0 CFU respectively. The pH and the moisture content of prepared *Mahewu* decreased significantly to 3.21 and 76% significantly. There was an increase in alcohol content, viscosity, and titratable acidity in the *Mahewu*. From the results obtained from the biochemical tests and microscopic and macroscopic examinations, it was concluded that the predominant microorganisms throughout the fermentation process were yeasts and LAB bacteria. The characteristics deduced from the project led to the conclusion that the yeasts present were *Saccharomyces cerevisiae* and the LAB bacteria present was *Lactobacillus delbrueckii.* The statistical analysis carried out led to the conclusion that there was no

significant difference in the microflora responsible for fermenting mahewu in different provinces of Zimbabwe.

FABRICATION OF A BIOGAS FUELED INCUBATOR FOR CULTURED MILK FOR *MARIRANGWE* DAIRY FARM

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The *lactococcus lactis* species are a lactic Acid Fermenting type of Bacteria (LAB) which is generally regarded as safe (GRAS) and have been used in carrying out a number of fermentation processes to impart desirable quality attributes to a variety of foods and also to facilitate a preservative role. Amongst the types of food that can be fermented by the *L.lactis* species is milk which is fermented into different products that range from the cultured milk itself, youghurt and other products. The *lactococcus lactis* species can perform their fermentation role at mesophilic temperatures (25^{O}C -30^{O}C) hence most food processors have exploited this type of bacteria at room temperature conditions thereby saving costs associated with the facilitation of its optimum temperature range This is a common practice at a dairy processing farm Marirangwe Dairy located in Marondera. The most outstanding costs are associated with electricity costs incurred in running the facilities as well as costs of purchasing, installing and maintaining the facilities. The facilitation of room temperature incubation of milk cultured with lactococcus lactis bacteria can be a long process requiring a period far longer than the expected 12-24 hours where cooler atmospheric temperatures are experienced as typical of the Marondera area hence the incubation cycle time can be uneconomic and can result in inconsistency of the cultured milk produced. This project was therefore aimed at designing a biogas fueled incubator for cultured milk fermentation as a case study for Marirangwe Dairy so as to address the problem associated with the lengthy incubation cycle time of around 54 hours in average to attain milk maturation. This problem has been coupled with a number of problems such as production of inconsistent products in quality and failure to adequately supply the whole market. The project objectives were to design an incubator with a biogas fueled heating and cooling system, to reduce the winter milk incubation average cycle time for Marirangwe Dairy by atleast 67.3% and to compare the effectiveness of room temperature incubation and incubation using the biogas fueled incubator. The experimental work was aided by the use of simulation softwares to predict the expected prototype effectiveness evaluation values for the implemented parameters. The prototype average operating temperature is 27.5^{O}C and its range of operation is 25^{O}C-30^{O}C. The prototype was evaluated on its effects on the sensory attributes of the cultured milk with comparison to cultured milk fermented at room temperature and that fermented under conditions implemented at the farm. The analytical method of evaluation, implemented was the Quantitative Descriptive Analysis (QDA) method. Basing on the pH and Viscosity parameters, after an incubation period of 18 hours using the incubator

and the traditional system the milk incubated at 27.5^{O}C had an average pH around 4.84 whereas that incubated under room temperature conditions (22.5^{O}C) had a pH of 5.99. Although the pH values obtained were not within the standard final pH range of mature cultured milk of 4.6-4.2, the pH obtained for the incubator was closer to the upper limit of the range depicting its effectiveness over the room temperature incubation method. Basing on the expected viscosity of 37-47 cp for mature cultured milk, that incubated at 27.5 had a viscosity of 45.7cp which is within the required range whereas that incubated under room temperature conditions had a viscosity of 9.5 cp which is way below the expected viscosity for cultured milk hence the incubator proved to be more effective than the traditional system. QDA scores on flavour, sourness, aroma, colour and mouthfeel were analysed statistically using TWO-Way ANOVA for the 2 samples with an additional third sample from the Marirangwe Dairy, the mean panelist scores on the attributes proved the presence of significant effect of temperature on the quality of the cultured milk sensory attributes. The quality increased with increase in temperature with that incubated at 27.5 having higher scores than that incubated at 22.5 for the same period of time for all the attributes thereby depicting the effectiveness of the v

incubator over room temperature incubation. The Marirangwe based Galacto had the highest scores for other attributes except for the flavour attribute which is close to that of the incubator and the mouthfeel at which it is slightly less than that of the incubator thereby depicting the effectiveness of the incubator on attaining desirable ultimate cultured milk sensory attributes.

DESIGN AND FABRICATION OF PRE-STRAINING UNIT MACHINE FOR *LUNAR* CHICKENS.

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Aim of the project was to design and fabricate pre-straining unit machine that separates meat debris in brine drip loss produced by injecting machine. Literature provided a guide in design but more emphasis was on the objectives. The design was achieved in parts, which are namely concept design mechanical design and finally prototype design. The concept model involved outlining the objective and addressing the problem statement. The idea was to design machine that can separate meat debris in brine drip loss produced by the injection process. Three concepts were designed and concept 1 was chosen and developed in to final prototype called pre-straining unit machine. Brine pick up test and material balance were done. Table 4.1 shows the amount of brine gained without a strainer. The results mean show that 21% brine pickup for wings, 24.8% for drumsticks, 14.8 % for

breasts and mixed portions 29%. For the wings 30% brine pickup, 34.6 for drumsticks, 25.2% for the breasts and 38% for the mixed portions which were obtained after using pre-straining machine. The percentage increased by 10% gain was calculated using Anova and results are shown in table 4.2. An Anova single factor test of variance was conducted on obtained results to see if the strainer had effect on amount of brine regained in drip loss. The gathered qualitative and quantitate data proved effectiveness of the machine in the meat processing industry making it an asset for processing. The detailed working of the ANOVA one-way factor is attached in appendix I. Table 4.3-4.7 summaries the results. Since all the analysis results are above 95%, H1 hypothesis was rejected and Ho accepted. This shows statistically that the pre-straining unit machine has a significant effect on the amount of brine reclaimed from drip loss. Which means machine managed to separate meat debris in brine drip loss and produce a clear brine for recycle.

AN INVESTIGATION ON SHELF LIFE OF Textured Vegetable Proteins (TVPs): A CASE STUDY FOR *MONMOUTH PATH INVESTMENTS*

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Extrusion cooking is a continuous process by which many foods are produced on an industrial basis. Texturized proteins, a unique product made by extrusion, can he produced from a wide range of raw ingredient specifications, while controlling the functional properties such as density, rate and time of rehydration, shape, product appearance and mouthfeel. Additional benefits of extrusion cooking are denaturing of the proteins, deactivation of heat liable growth inhibitors, control of bitter flavors and the homogeneous bonding of ingredients that may include colors, chemicals and other additives which can have an effect on sensory quality, usually appearance or textural quality.

This research was a contribution on the increasing of shelf life of textured vegetable proteins at Monmouth Path Investments. The objectives of the research were to increase the shelf life from two to at least four months; to determine the optimum storage conditions of the TVPs; to investigate moisture barrier properties in textured vegetable proteins packaging by comparing High Density Polyethene (HDPE) and Biaxially Oriented Polypropene (BOPP) and to identify and determine the effects of process parameters in textured vegetable proteins production that can affect its shelf life. The research was company based and it followed the decrease in shelf life of TVPs produced at Monmouth Path Investment (Pvt) Ltd in Waterfall, Harare. This research was limited to properties such as fat content, moisture content, extrusion temperatures and packaging as the factors that cause

decrease in shelf life. The determination of moisture content was done by using a moisture analyzer, fat content was determined through the Soxhlet method. The results revealed that the shelf life was longer when the soy meals fat content was greater than 6.0%, with a moisture content less than 6.0%. The results also show that a longer shelf life was obtained for TVPs that were extruded at 160℃, oven dried and packaged in BOPP. The objective of determining the effects of feed properties on extrusion failures was achieved as well as that of implementing a solution. The objective of increasing Monmouth Path's TVPs shelf life from two months to at least four months was achieved. The determination of the optimum storage conditions was partially achieved since the implemented solution done to the TVPs is not yet measurable.

OCCURRENCE OF AFLATOXIN B1 IN DAIRY CATTLE FEED IN RELATION TO FARMER PRACTISES: A CASE OF *NHARIRA* DAIRY DEVELOPMENT PROGRAMME

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Aflatoxin B1 is a secondary metabolite produced by fungi of the Aspergillus species. Aflatoxin B1 is a listed group one (most toxic) human and animal carcinogen. Its occurrence in dairy feed is a global concern because it causes dairy cattle mycotoxicosis and is carried over into milk as aflatoxin M1 with almost similar carcinogenicity to AFB1 in humans. The objective of the study was therefore to determine the occurrence of AFB1 in dairy cattle feed from Nharira Dairy Development Programme in Chivhu, Zimbabwe in relation to their farming practises and suggest probable mitigation strategies. Information on demographics, farming and storage methods of both grain and silage was obtained using a questionnaire. The method used for AFB1 analysis was High Phase Liquid Chromatography, (HPLC) following the Association of Analytical Chemists (AOAC) standard procedures. A moisture analyser was used for determination of moisture in the feed samples. Farming, storage and handling practices are directly related to the AFB1 levels. Where grain from previous years was used in the silage the AFB1 levels were high. The AFB1 range in dairy cattle feed after analysis were as follows; maize silage 2.5699 - 5.855 ppb, maize and grass silage 11.132 – 13.289 ppb and maize and sorghum silage1.074 – 1.002 ppb. Moisture average was 64.431%, 74.776% and 63.296% for maize, maize and grass and maize and sorghum silage respectively. Aflatoxin B1 was found in all the dairy feeds, although below the maximum allowable 20ppb limit set by the World Health Organisation (WHO), aflatoxin B1 has a likelihood of being carried over into milk as aflatoxin M1especially for the maize and grass silage. Therefore it is imperative for the Nharira dairy development programme

farmers to practise good agricultural practises as those suggested by the researcher to prevent carryover of AFB1 to milk.

INVESTIGATION ON COLOUR DETERIORATION OF ORANGE COLOUR NON-CARBONATED READY TO DRINK JUICE: A CASE STUDY AT AD - LIFE BEVERAGES

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The objectives of this study were to investigate on to the causes of colour deterioration in orange colour non-carbonated RTD produced by Ad-life beverages. The contribution of some possible different factors which included temperature, light, type of packaging material, pH and ions in water on the stability of the orange colourant was studied. Consumers can tell the quality of a product simply by looking at the colour. Investigation on the possible causes of colour deterioration is essential for better formulations, better keeping qualities and better appearances to the consumers of the product. Simple random sampling was used for collection of noncarbonated orange colour RTD samples. Experimental studies were done to see the effect of storage temperature, type of packaging material, light exposure as well the effect of water as the main ingredient. Measuring orange colour absorbance at a wavelength of 600nm using UV Visible spectrophotometer. Colour intensities were measured as absorbance values. The initial colour absorbance before the experimental studies was 1.430 and with the increase in number of storage days it decreased. Light, temperature, PET had an effect on colour deterioration. It was concluded that the best storage condition is the combination of glass bottle, at refrigeration temperature, away from light exposure.

REGENERATION OF USED FRYING OILS USING ACTIVATED CARBON-(MGO NANOPARTICLES) ADSORPTION TECHNOLOGY.

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The aim of this project was to regenerate used frying oils using activated carbon-magnesium oxide nanoparticles adsorption technology. Changes that take place during deep fat frying deteriorates the oil, affect the quality of fried products and potential health hazards. So a combination of highly porous material with a metal oxide can increase active sites for adsorption process. A pilot laboratory test was carried out determine the effect of time and column height of the adsorption system which guided in design calculation. The mapping of the design used the Hertz model. Product analysis tests were carried out on the unused, used and regenerated frying oils. The composition analysis of the oils was determined which is the total polar compounds and a percentage reduction of 80.32% with standard deviation of 0.06, 0.32 and 0.17. The pH percentage increase of 15.55% and standard deviation of 0.03, 0.20 and 0.10 for unused, used and regenerated oil. Rancidity tests were determined, the percentage reduction of free fatty acids was 49.29% with standard deviation of 0.00, 0.00 and 0.00 for unused, used and regenerated oils. The peroxide value percentage reduction was 77.59% and the standard deviation was 0.23, 0.30 and 0.17 for unused, used and regenerated oils. The viscosity of the oils was also determined and the percentage reduction was 19.59% with standard deviation of 1.12, 1.29 and 2.01 for unused, used and regenerated oils. The stability test were carried out and the peroxide value was determined. The peroxide value percentage increase after every two weeks up to six weeks was determined. The peroxide value average percentage increase of unused oils was 19.94 and standard deviation of 0.59 and for regenerated oils the average percentage increase was 8.30 with and standard deviation of 1.11. Oxidation, hydrolysis and polymerization caused the undesirable quality attributes in regenerated oils. The percentage increase and reduction of the parameters was due to the effect of the adsorbent, pressure in the column and high contact time between the adsorbent and the oils. Sensory evaluation was carried, to determine the degree of difference of regenerated oil from the control and the level of liking using the 9 point hedonic tests. There was a significant difference in the quality parameters of the deep fat frying oils as determined using Anova ($p=0.05$). Deep fat frying had an effect on the quality of the frying oils as high levels of oxidative and polar compounds, high viscosity and dark colours was determined. The updraft adsorption column can result in the removal of these oxidized and polar compounds from the used frying oils. The high percentage reduction is as a result of maximum contact time between the adsorbent and the frying oils.

DESIGNING A TRIPE WASHER FOR THE COLD STORAGE COMPANY (CSC)

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Cold Storage Company (CSC) offal department is having hardships in washing the tripe because it needs a lot of water and agitation to clean between the flaps. Due to this CSC has experiences high water usages to wash the tripe, high labour costs, sewer blockages because of the coarse gastro-intestinal material, backlogs in delivering tripe to customers, energy costs in storing the tripes and customer complains on the poor cleaning of the tripe. This project sort to design, construct and evaluate a Tripe washing machine. The objectives were to design a tripe washing machine, to reduce the time, take to wash 1 tripe manually that is 195 seconds to 60 seconds and to compare the effectiveness of cleaning tripes manually and machine washed using plate count for microbial analysis. In the methodology, Cross 's design model was used to design the Tripe washer. It included the following procedures objectives, establishing functions, finding requirements, determining the characteristics, evaluating alternatives, evaluation of the design, finding improvements and opportunities in a never ending cycle. The design considerations were functionality, usability (user friendliness and user manuals), cost, ergonomics, safety, environment, durability, materials, time, aesthetics, failure and ethics. During operation the electric motor is switched on and the gear throttle is switched to connect the electric motor and rotating drum, the connection is made via the gear box. When the drum is rotating, high turbulence caused by the bidirectional circulation of the drum in the washing machine, this is due to the interchange between the kinetic and potential energy of water flowing in the rotating. Abrasion, cavitation and friction leads to the wear of the gastro-intestinal material on the tripe thereby cleaning it. After carrying trails, average time taken to wash the tripe was reduced from 195 seconds, in manual washing to 70 seconds using the tripe washing machine. The average log colony forming units (CFU) per cm^2 enumerated was reduced from 7.24 (in manual washing) to 2.13 by using the tripe washing machine. Using contour plot from response surface methods, the prediction is that the number of log CFU can be reduced by increasing time of washing to more than 85 seconds and increase speed from 100 rpm to 125.

OPTIMISATION OF LACTOSE FREE YOGHURT PRODUCTION: A CASE STUDY OF KEFALOS CHEESE, ZIMBABWE

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To produce lactose free yoghurt Kefalos uses the β-galactosidase enzyme Ha-lactase 5200 from Chr-Hansen. Lactose free yoghurt is supposed to have a value of 0.01g/100g of lactose residues. This is the lactose levels at which people with lactose intolerance will not show adverse reactions to lactose. This study was therefore focused on finding the optimum conditions for the lactose hydrolysis enzyme β-galactosidase and the starter culture *Lactobacillus bulgarius* and *Streptococcus thermophillus* so as to produce a stirred yoghurt that is lactose free and has a good viscosity. The enzyme is synthesised from *kluyveromyces lactis* and has been proven to have an optimum pH and temperature of 6.5 and 45℃ respectively. The aim of the study was to optimise the process of producing a lactose free yoghurt and the objectives were to determine current lactose residues in "lactose free" yoghurt after the enzyme has acted upon the lactose, to determine the optimum pH, temperature and time of the enzyme and to optimise the working conditions of the enzyme through use of the response surface methodology. Testing the factors one at a time the optimum pH was found to be 6.5 and the optimum temperature for hydrolysis was found to be 45℃. These values were used to come up with the high and low values for the optimisation experiment. The factors temperature (Factor A), pH (Factor B) and time (Factor C) were screened using full factorial method against the degree of hydrolysis as response A and consistometer reading response B. The factors A and B were found to be the most significant for %DH and time was the most significant for factor B. The optimisation experiment was carried out using only two factors A and B and the time was kept constant at 4.5hours. The optimum conditions for %DH were found to be 48.75 for factor A, temperature and 6.7 for factor B, pH. The optimum conditions for consistometer reading which shows the stirred yoghurt viscosity were for factor A 48.76 and for factor B 7.1. The optimum conditions showed a fairly high degree of hydrolysis of 99.9% with lactose resides of 0.13g/100g. However, this is still not a lactose free yoghurt. Further studies should be done on finding the mechanism of galactose and glucose as β-galactose inhibitors and other possible inhibitory ions that may be present in the milk, yoghurt additives and in the enzyme.

DESIGN OF A PORTABLE DEVICE FOR RAPID AND ONSITE DETERMINATION OF FREE FATTY ACIDS IN EDIBLE CRUDE OIL (THE ELTOMETER).

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The most and commonly used method for determination of free fatty acids (FFA) in edible oils, titration, is plagued by several problems. In the current study, a new method to determine FFA concentration in edible oils that allows for fast and onsite measurements has been developed based on electrical conductivity. The model was developed using multiple regression analysis (stepwise parametric analysis). This was done by collecting and preparing raw soybean oil samples from Monmouth Path Investments with varying FFA concentrations and measuring the variables of interest. These parameters included electrical conductivity and pH and they were measured at a constant temperature of 25±0.5°C. The best model was the relationship between %FFA and electrical conductivity and the equation for the model is y = 1.4882ln(x) + 4.2599 (where y is the electrical conductivity and x is the %FFA). The high R2 for the model, 0.9414, showed suitability of the model. When 13 samples of crude oil were tested by this method and results compared with results of titration it showed that the model can accurately determine %FFA at low concentration, less than 0.41%. The predicted %FFA showed no significant difference with the observed %FFA at 95% confidence interval and a high correlation of 97.94%. A residuals t-test was also carried out to determine the accuracy of the model. It was concluded from the residual test that the model is sufficiently accurate for the determination of FFA concentration in crude soybean oil since the mean of residuals was equal to zero. An analytical device called the Eltometer was therefore fabricated using the developed model. Because of its simpler and quicker analysis as well as no use of solvents and minimum labour, the Eltometer has proved to have an advantage over the other methods.

AN INVESTIGATION ON THE ROOT CAUSE OF SOURING AND OFF-FLAVOUR DEVELOPMENT OF SACHET PACKAGED ULTRA HIGH TEMPERATURE (UHT) TREATED MILK (CHIMOMBE): A CASE STUDY FOR DAIRIBORD ZIMBABWE PRIVATE LIMITED

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Prompted by high rates of customer complaints (souring, development of bitter taste and gassing resulting in blown unit and product returns of 250ml and 500ml UHT milk(chimombe), the researcher realised the need to identify the factors causing the spoilage of UHT milk (chimombe) at Dairibord Harare plant. The research focused on the verification on the microbiological quality of raw milk used for UHT processing. Factors considered on the post process contamination of the product were the packaging integrity of the package of UHT milk, effectiveness of the sterilisation of the packaging material and the effectiveness of the cleaning regime used for cleaning the UHT milk packaging machine. The researcher found out that the souring of the product was due to the poor seal integrity

of the product packaging and the growth of lactic acid bacteria in the product due to biofilms in the packaging machine. The bitter flavours were found to be due to the enzymes released due to elevated psychotrophic counts. Statistical analysis indicated that there was a significant difference (t-test, P< 0.05) between the SCC of raw milk compared to Dairibord Grade A raw milk SCC standard and there was also a significant difference (t-test, P<0.05) between the psychotroph count of raw milk comparing to Dairibord grade A raw milk psychotrophic count. To determine the effectiveness of the sterilisation process for the raw milk microbiological tests were carried out on the UHT milk units. Microbiological tests were carried out on swabs and rinse taken after the cleaning of the packaging machine using C.I. P to determine the effectiveness of the cleaning regime used to clean the packaging machine. Tests on packaging integrity were done on the product package, both for samples under shelf life analysis and units returned through customer complaints. The study concludes that the souring and off flavour development in the UHT milk is due to a combination of raw milk quality, packaging material properties and quality and packaging machine sealing conditions. The study recommends that there should be the revising of the hazard analysis for the UHT milk production and the close monitoring and control of the problem causing factors. There is need to also closely monitor and validate the cleaning regime of the packaging machine.

DEPARTMENT OF PHARMACEUTICAL TECHNOLOGY

IN VITRO EFFICACY EVALUATION OF THE THROMBOLYTIC ACTIVITY OF A TINCTURE INCOOPERATING *Allium sativum Bulb, Gingo biloba* Leaves And *Salix alba* LEAVES FOR POTENTIALLY TREATING VENOUS THROMBOEMBOLISM (VTE)

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Thrombosis is a fatal disease which is characterized by the formation of blood clots (thrombus) in the circulatory system as a result of a defective homeostatic system process. This is a critical event in the arterial diseases connected with acute coronary disorders that account for sudden morbidity and mortality. Thrombosis leads to vascular blockade and while recovering it causes fatal consequences, (Atherothrombotic diseases) such as cerebral or myocardial infarction and even death which are some one of the diseases of major concern here in Zimbabwe. The current treatments on the market have significant shortcomings i.e several side effects, inaffordablility and unavailability to the generality of the population in Zimbabwe, leaving most health institutions using only heparin as treatment drug.

The tests that were done in this project were phytochemical tests, and in-vitro thrombolytic efficacy investigation on healthy human blood samples. Phytochemical tests were done so as to find the presence of the secondary metabolites that would aid in the thrombolytic activity of *Allium sativum bulb, Gingko biloba* leaves and *Salix alba* leaves. The **phytochemical screening** of the plants revealed the presence of alkaloids, tannins, flavonoids, and coumarins in all three plant extracts. Saponins are not present in the *Gingko biloba* extract however present in the other two plant extracts

, Cardiac Glycosides are not present in the *Allium sativum bulb* extract however present in the other two plant extracts.

An ***in vitro*** thrombolytic model was used to check the clot lysis effect of the different plant extracts along with streptokinase as a positive control and water as a negative control. In the ***in vitro*** thrombolytic model, ethanol extracts showed 28.984, 29.206 and 25.226% clot lysis for *Allium sativum bulb, Gingko biloba* leaves and *Salix alba* leaves, respectively (Manicam, C.; Abdullah1, J.O. et al 2010). Among the extracts the combined ethanol extracts of the three plants showed significant percent of the clot lysis (46.934%) with reference to streptokinase (80.514%). From our study it was found that *Allium sativum bulb, Gingko biloba* leaves and *Salix alba* leaves possesses thrombolytic properties that could lyse blood clots **in vitro**; however, in vivo clot dissolving properties and active component (s) of the plants responsible for clot lysis are yet to be discovered. Positive results obtained prompted subsequent formulation of the plant extracts into a tincture containing 43 % pure vodka.Drug release studies of the tincture in an animal model are still yet to be done. Once discovered, 'Thrombobust Tincture' could be suggested as a thrombolytic agent in the treatment of patients suffering from atherothrombotic diseases.

Key words:*Deep Vein Thrombosis, Allium sativum bulb, Gingko biloba and salix alba , tincture , positive and negative control*

EVALUATION OF THE USE AND ACCURACY OF POINT OF CARE DEVICES IN MONITORING BLOOD GLUCOSE LEVEL IN DIABETIC PATIENTS

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Diabetes mellitus is one of the leading non-communicable disease affecting millions globally. The incidence of diabetes mellitus and the associated complications in Zimbabwe is rising significantly. There is need to regularly monitor the glycemic levels in diabetic patients to avoid complications due to uncontrolled diabetes. The use of point of care devices commonly known as glucometers is on the rise due to the need to carefully monitor the glycemic levels. Point of care (POC) devices and the Self-monitoring blood glucose (SMBG) technique were introduced to make routine blood glucose monitoring more timely and easier for diabetic patients. SMBG devices are used routinely in various settings as a replacement for conventional laboratory as method for checking glycemic control and as a diagnostic tool.

The investigation was carried out to determine the accuracy of blood glucose measurements with glucoplus and codefree meters compared to lab methods in patients requiring blood glucose value. Patient blood samples were tested in triplicate for glucose level using the Glucoplus^{R} and Codefree glucose testing devices and laboratory hexokinase technique. The values obtained were then compared to laboratory reference point

A p-value of 0.182 was obtained using One-way ANOVA to test for statistical significance. There was no statistically significant difference among the three mean values for laboratory, Glucoplus^{R} and Codefree devices blood glucose values

Key words: *glycemic, hexokinease, diabetes, glucoplus, codefree*

FORMULATION AND EVALUATION OF HERBAL CAPSULES CONTAINING *RICINUS COMMUNIS (MUPFUTA)* LEAF EXTRACTS FOR THE TREATMENT OF DIABETES.

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Background and Objectives: The management of the blood glucose level is a critical strategy in the control of diabetes complications. There are many and diverse therapeutic strategies in the management of Type II diabetes. The inhibition of carbohydrate hydrolyzing enzymes such as α-amylase can be an important strategy to lower postprandial blood glucose levels. *Ricinus communis* leaves are reported to contain multiple antidiabetic constituents and hence widely used for the treatment of diabetes mellitus. The present investigation was aimed to formulate capsules containing crude extract of the plant in order to obtain antidiabetic formulations with more effective oral hypoglycemic activity, less side effects, increased patient compliance thereby providing multifaceted benefits

Methods: Capsule formulations were prepared by encapsulation of fine powder prepared from the *Ricinus communis* leaf extract. Finished capsule formulations were evaluated for weight variation, disintegration time, drug (*Ricinus communis)* content and organoleptic properties.

Results: *Ricinus communis* capsules formulations pass the test for weight since the percentage deviation of individual weight of capsule from mean were found within ±7.5%. Drug (*Ricinus communis)* content of all the formulations were more than 85%. Disintegration time ranged from 7-15mins. Dissolution profile showed 77.06 - 90% drug release in phosphate buffer of pH 6.8 after 6 hours. Antidiabetic activity studies of capsules significantly ($p \leq 0.001$) reduced blood glucose level in diabetic rats after 15 days of treatment when compared to diabetic control group

Conclusion: From the results, we concluded that formulation of Ricinus communis leaf extracts into suitable and appropriate herbal dosage form may be more desirable, advantageous and therapeutically more beneficial.

Key words: *Diabetes Mellitus, Ricinus Communis, Capsule, Hypoglycemic.*

FORMULATION AND EVALUATION OF A POLY-HERBAL CREAM FOR MANAGEMENT OF OPEN WOUNDS INCORPORATING *STRYCHNOS SPINOSE* (MUTAMBA), *AZADIRACHTA INDICA* (NEEM) AND *CUCUMIS ANGURIA* (MUGAKA) EXTRACTS.

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The open wounds is a poorly managed, injurious condition imposing discomfort, pain to the patients Patients with the open wounds grapple with infections, which are not being fully eliminated due to the expensive costs of conventional medicines to the patient. The flora of plant life within Zimbabwe contains medicinal plants with strong antimicrobial, antifungal, analgesic, antioxidant, anti-inflammatory and wound healing effects and such plants include *Strychnos spinose, Azadirachta indica and Cucumis anguria*. This project analysed these plants to investigate their potential use on open wounds and to formulate a poly-herbal cream to help in the management of these open wounds. The plants above were collected, plant metabolites were extracted from them and phytochemical screening was done on the extracts by performing chemical tests. Antimicrobial activity of the plants was accessed by carrying out MIC tests on *Pseudomona auruginosa, E.coli, Candida albicans and Staphylococcus aureus* which are the most troublesome microbes on the open wounds. The poly-herbal cream was formulated using the organic and water phase approach and the extracts were incorporated into the formulation and was mixed thoroughly using the homogenizer. The poly-herbal cream was then applied to Sprague dawley rats to test for any skin sensitivity/irritation to the extracts in the cream and it was observed that the cream did not cause any irritation to the skin and no pruritus or redness was observed on the rats and the extracts were also evaluated on physicochemical properties. Machinery such as the rotary evaporator, autoclave and homogenizer were utilized in this project. The poly-herbal cream was used to carry out MIC test against the four microbes and it showed a good response compared with the two positive drugs available.

Key words: *Open wounds, antimicrobial, phytochemicals, poly-herbal cream, homogenizer*

A STUDY INTO THE COMPOSITION AND SKIN TOXICITY OF *TSUNAMI*

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Introduction: In the last couple of years, the Zimbabwean healthcare system has experienced a high influx of unregistered medicines and drug formulations. Many of these products have obscure ingredients lists, varied somewhat conflicting medicinal claims without any record of clinical trials or claim substantiation. Medications with unclear origin pathways may do more harm than good in patients who're more concerned about the price of the medication rather than its effectiveness and may result in conditions worsening, serious adverse reactions or even death. One such product is Tsunami, a green volatile solution, packed as a 3.5ml package that is allegedly able to treat more than fifteen minor ailments.

Aims and objectives: There was need to demystify the myth behind this mystery formulation. This became the core objective for this research, to investigate its active constituents. The other objectives for the research included analysis for its dermal and oral toxicity modelling its use by patients.

Materials and methods: Various samples of Tsunami were collected from different locations around Harare. Chemical composition analysis for the active volatile oils in the sample was done using gas chromatography, coupled to an FID detector. A total of 6 rabbits were subjected to the skin sensitivity tests as guided by OECD Guideline 427 and Draize Tests.

Principal Results and observations: The results from the GC-MS examination gave close peaks, of more than 80 constituent oils. These multiple peaks indicated that the sample was made from crude extracts. Of interest were the terpenes, cineoles, aldehydes, ketones, phenols and alcohols found in significant quantities. Literature has supported evidence of skin irritation linked to excess exposure to terpenes, cineoles, aldehydes and ketones. The skin toxicity tests showed evidence of ample inflammation and redness when applied a volume that is greater than 7ml over an area of 25cm2 in skin patch testing.

Conclusion: Tsunami can be concluded to consist of a very wide range of volatile essential and synthetic compounds, most of which are potential skin irritants. The intentional failure of the label to warn on notable allergens and potential irritants like cineoles and terpenes was noted. The tests done on the rabbits further proved that tsunami is a potential allergen that could cause skin irritancy.

Keywords: *tsunami, gas-chromatography, skin-toxicity, irritation, sub-standard medicines*

FORMULATION OF A NEUTRACEUTICAL POWDERED FORMULA FOR BURNS INCORPORATING *VIRGNA UNGUCULATA* SEEDS, *CUCUBITA PEPO* SEEDS AND *ADANSONIA DIGITATA* FRUIT PULP.

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Burns affect vulnerable groups of people mostly children under the age of 5 years and epileptics Burns are characterized by trauma, pain, severe discomfort, hypermetabolism and sepsis. Unchecked hypermetabolism result in decline of host immune system, impaired wound healing, organ dysfunction, muscle wasting and susceptibility to infection which will result in long hospital stay thus straining the budget of the health care. Nutritional support has become an essential element of burn care hence the idea of formulation of a neutraceutical powdered formula incorporating *virgna unguculata* seeds, *cucubita pepo* seeds and *adansonia digitata* fruit pulp. Neutraceutical and functional foods have received considerable interest because of their presumed safety and potential nutritional and therapeutic effects. The above plants were chosen because of their high content in proteins, vitamin C, carbohydrates and low fat content which are essential in burn wound healing. *Virgna unguculata* seeds and *cucubita pepo* seeds were collected from Seke boiled, dried and processed into a powder. *Adansonia digitata* fruit was collected from Mutoko. Qualitative tests were performed on the ingredients. A neutraceutical powdered formula was formulated incorporating *virgna unguculata* seeds, *cucubita pepo* seeds and *adansonia digitata* fruit pulp. Nutritional analysis and safety evaluation of the product was done at Standards Association Of Zimbabwe (SAZ.) Efficacy of the product was assessed using guinea pigs. Unguculata powdered formula was found to possess high carbohydrates, proteins, vitamin C, Iron and low fat. No heavy metal contamination was found. Stability tests were also performed on the product. High protein, high carbohydrate and low fat neutraceutical powdered formula was found to improve burn wound healing.

KEY WORDS : *Burn wound, Virgna unguculata, Adansonia digitata, Cucubita pepo, Guinea pig, Hypermetabolism, Neutraceutical***.**

FORMULATION OF A NEUTRACEUTICAL POWDERED FORMULA FOR BURNS INCORPORATING *VIRGNA UNGUCULATA* SEEDS, *CUCUBITA PEPO* SEEDS AND *ADANSONIA DIGITATA* FRUIT PULP.

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KEY WORDS : *Burn wound, Virgna unguculata, Adansonia digitata, Cucubita pepo, Guinea pig, Hypermetabolism, Neutraceutical.*

FORMULATION OF ANALGESIC AND ANTI - INFLAMMATORY CAPSULES USING *AZADIRACHTA INDICA* LEAF EXTRACTS AND *ZINGIBER OFFICINALE*

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An ethanol extract of the dried leaves of *azadirachta indica* and *zingiber officinale* was investigated for anti-inflammatory and analgesic activities. Administration of plant extracts of *azadirachta indica* and *zingiber officnale* to acetic acid-induced writhing in mice as compared to placebo treated mice, not only demonstrated a significant reduction in the number of acetic acid-induced writhing effects, but also exhibited an anti-inflammatory activity by inhibiting albumin denaturation by membrane stabilization. Additionally, anti-inflammatory function of plant extracts were compared with anti-inflammatory drug diclofenac sodium (10 mg/kg)]. Interestingly, results showed that plasma plant extracts were capable of reducing severity of inflammation comparable to diclofenac sodium. *Azadirachta indica* leaf aqueous extract (10mg/kg, 20mg/kg, 50mg/kg and 100mg/kg) produced dose-dependent and significant ($p < 0.05$-0.001) inhibition of fresh egg albumin-induced acute inflammation in rats. The plant extract also produced dose-dependent and significant ($p < 0.05$-0.001) analgesic effects against chemically induced nociceptive pain in mice. The analgesic activity of the samples were evaluated using acetic acid induced writhing method in mice following the method of Karami et al. In this method, acetic acid was administered intraperitoneally to the experimental animals to create pain sensation. The animals were divided into four groups with six mice in each group. Group I animals received distilled water, Group II received Diclofenac sodium at 10 mg/kg while animals of Group III and Group IV were treated with 10mg/kg,20mg/kg,50mg/kg and 100mg/kg of the ethanol extract of A. indica and Z.officinale after an overnight fast. Test samples and vehicle were administered orally 30 minutes prior to intraperitoneal administration of 0.7% v/v acetic acid solution. Inhibition of licking response in mice due to the administration of the test drugs during acetic acid-induced writhing test was recorded. The oral administration of both doses of A. indica and Z. officinale

rhizome extract significantly ($p < 0.001$) attenuated the acetic acid-induced abdominal writhes in mice in a dose dependent fashion. The percent inhibition of writhing response by the extract was 48.5 %(with 10mg/kg Z. officinale extract and 54% with 10 mg/kg dose of A. indica respectively while the standard Diclofenac sodium (10 mg/kg) showed 60% inhibition in comparison with the control. The capsules were formulated and tested for moisture resistance.

Key words: Azadirachta indica, zingiber officinale, ethanol, diclofenac, acetic acid

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FORMULATION OF A BODY BUILDING SUPPLEMENT USING EXTRACTS FROM *Cissus quadrangularis* (CQ)

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Background: Herbs are famous for their natural quality which it is understood that, those using herbal products will benefit from their curative effects and are not probably affected by any side effects or so called adverse effects. This proves to be the reason for choosing a herbal capsule formulation for bodybuilding. Cissus quadrangularis was the chosen plant, and its selection was based on its wide variety of ethno-medicinal uses, presence of a number of phytosterols and traditional importance.

Methods: The present study was aimed at developing a capsule formulation from the ethanolic extracts of *Cissus quadrangularis* stem and evaluate its safety by determining the toxicity after acute administration in BALB/c mice. Solvent extraction with 70% ethanol was performed, followed by freeze drying to obtain a powder. Pre-formulation studies were performed and the following values obtained; Bulk density = 0.69, Tapped density = 0.81, Compressibility index = 14.81, Hausner's ratio = 1.17. The obtained values proved that the powder had good flow properties that are of importance when it comes to solid dosage forms. Acute oral toxicity tests were performed following OECD guidelines 423 in assessing the safety of CQ ethanol extract. In the test, CQ ethanol extract was administered to male and female BALB/c mice by oral gavage at single doses of 600, 800 and 1000 mg/kg body weight. Mice were observed for toxic signs for 14 days. At the end of the test, body weight changes, cage side observations (fur condition, gait, ptosis, subcutaneous swellings, eye opacities, pupil diameter, breathing abnormalities, colour of faeces) and mortality were observed.

Results: The powder was finally filled in capsule shell size 0 by hand filling. A total of 30 capsules were formulated successfully. In acute oral toxicity, no treatment-related death or toxic signs were observed. It revealed that the CQ ethanol extract could be well tolerated up to the dose 1000 mg/kg body weight. Food consumption, body weight, and cage side observations revealed no abnormalities.

Conclusions: This study demonstrates tolerability of CQ ethanol extract administered daily for 14 days up to 1000 mg/kg dose, and the development of safe, stable herbal capsule formulation.

Keywords: *CQ ethanol extract, Acute oral toxicity, Herbs, capsules, body building, Ethanolic extracts, Freeze dried, pre-formulation studies*

FORMULATION OF HERBAL CAPSULES INCORPORATING *Curcuma longa* FOR POTENTIAL USE IN PARKINSON'S DISEASE MANAGEMENT

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Parkinson's disease (PD) is a neurodegenerative disorder that affects about 1.5% of the global population over 65 years of age.

The present research has been undertaken with the aim to evaluate anti-Parkinson's activity of acetone extract of *Curcuma longa* rhizome in 6 hydroxydopamine (6-OHDA) induced experimental animal models and to formulate and evaluate the herbal capsules containing rhizome powder of *Curcuma longa* for potential use in the treatment of Parkinson's disease.

In this research, the organic extracts of *Curcuma longa* rhizome were obtained using a Soxhlet extractor. The preliminary phytochemical study of the ethanol extracts of the seed of *Curcuma longa* revealed the presence of Tannins and Phenolic compounds, Alkaloids, Terpenoids, Saponins, Glycosides, Carbohydrates and Amino Acid. The physicochemical parameters of formulations (pH, viscosity etc.) were determined. The effects of *Curcuma longa* (100, 200, and 400 mg/kg, p.o.) were studied using in vivo behavioral parameters like muscle rigidity, bradykinesia and locomotor activity in mice. The experiment was designed by giving selective catecholamine neurotoxin 6-OHDA to induce Parkinson's disease-like symptoms and the use of Levodopa/carbidopa tablets as control. 6-OHDA significantly induced motor dysfunction (muscle rigidity and hypo locomotion). Daily administration of *Curcuma longa* (400 mg/kg) significantly improved motor performance of the mice. The improvement of motor performance of the mice after administration of *Curcuma longa* (400 mg/kg) was comparable to levodopa/ carbidopa used as the control. Thus, the study has shown that *Curcuma longa* rhizome, apart from its use as food additives and supplements can also be utilized as effective and cheap source of anti-Parkinsonism agents.

Key words: *Parkinson's disease, Curcuma longa, 6 hydroxydopamine (6-OHDA)*

EVALUATION OF *ERYTHRINA ABYSSINICA* FOR POTENTIAL ACUTE ORAL TOXICITY AND LETHALITY IN RAT MODELS

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A poison can be any substance that is harmful to the body. A poison can be injected, swallowed, absorbed through the skin, inhaled, animal bites and exposure to radiation. There are two types of poisoning, acute and chronic poisoning. Acute poisoning is exposure to a poison for a short period of time or once and the symptoms thus develop in a very close relation to the degree of exposure. Chronic poisoning is exposure to a poison for a very long time and the symptoms do not occur immediately. Plant poisoning is usually a problem that is faced by young children who unintentionally ingest toxic plants. The *Erythrina abyssinica* seeds are well known for their ornamental use but they are toxic. The ingestion of a single seed, well chewed is said to be fatal to an adult. The seeds were

obtained from Chigodora village in Mutare and were sun dried and mechanically pulverised. Extraction of the seed oil and other components was done by ethanolic and N-hexane extraction. The crude extracts were fed to rats so as to determine their toxicity by behavioural changes and their ability to kill the rats. The rats were divided into three groups of five rats per group. One group was served as the control group. The feeding process was done using the OECD 423 guidelines. The tests proved that the extract caused behavioural changes that were noted by (Sheila M. Maregesi et al) as the signs and symptoms of toxicity in rat models. Phase 1 of the experiment had no fatalities but Phase 2 had a 40% fatality rate and this was attributed to the high doses of the extract that were administered to the rats. The tests were not conclusive to the fact that *Erythrina abyssinica* seeds extract can cause toxicity to rat models because of a few setbacks which included not being able to carry out animal necropsy for organ studies and comparison.

Key words: *LC-MS, Erythrina abyssinica, toxicity, necropsy*

INVESTIGATION OF THE LETHALITY AND ORAL TOXICITY POTENTIAL OF *CROCODYLUS NILOTICUS* BRAIN TISSUE

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The Nile crocodile (*C. niloticus*) is an African crocodile, the largest freshwater predator in Africa, and may be considered the second largest extant reptile in the world. The Nile crocodile is quite widespread throughout Sub-Saharan Africa. There is a profound belief in African communities that *C. niloticus* brain tissue is toxic, so much that it has to be destroyed in the presence of others to prove it will not be used for witchcraft.In some rural cultures it is said to be used by some individuals to poison foodstuffs with the intention of killing their victims. Despite the countless reported cases of food poisoning surrounding the *C. niloticus*, there have not been any scientific consensus on the oral toxicity of the brain tissue. The project sought to acquire and prepare a fresh sample of the *C. niloticus* brain tissue, screen the brain tissue for toxicity potential and carry out acute and subacute oral toxicity studies in laboratory animals. Fresh *C. niloticus* brain tissue was obtained from Binga Crocodile Farm. The brain tissue was homogenized, assayed by Liquid Chromatography-Mass Spectrometry and force-fed to laboratory mice. Six mice, that were force-fed the prepared sample were observed over a period of seven days as per OECD guideline 425. The LC-MS assay of the *C. niloticus* brain tissue showed no known toxic constituents. None of the laboratory mice used in the study succumbed to poisoning or exhibited any signs of toxicity after being force-fed the brain tissue sample. Sub-acute toxicity studies were done due to financial limitations. Based on the results of the study a conclusion was made that the *C. niloticus* brain tissue is not toxic.

Key words; *acute toxicity, Nile crocodile, Liquid Chromatography-Mass Spectrometry, brain tissue*

EVALUATION OF ANTICANCER ACTIVITY OF ANNONA SENEGALENSIS AND *BOBGUNNIA MADAGASCARIENSIS* EXTRACTS ON BREAST AND CERVICAL CANCER CELL LINES.

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Cancer is one of the leading cause of death worldwide and there is a sustained focus on development of novel anticancer agents from medicinal plants. Medicinal plants have been employed in various ways for the management, healing of, and treatment of different diseases. For many years, researchers have grown interest among the usage of different medicinal from folklore system of medicine for the treatment of different illness. The folklore system of medicine consists of enormous number of plants with a variety of medicinal, pharmacological and therapeutic importance and therefore represents a priceless reservoir of novel bioactive ingredients. Annona senegalensis and Bobgunnia madagascariensis are multipurpose plants with a high traditional and medicinal uses for the maintenance of free health life.

Traditionally these plants are used as stimulant, pain reliever etc. whereas the plant possess beneficial effects such as anti-oxidant, antimicrobial, Antidiarrheal, anti-inflammatory, antiparasitic, anticonvulsant, antimalarial, antitripasonal, antisnake venom and Antinociceptive and many other medicinal properties. In the current study the hydro-alcoholic extract of the roots of the plant have been tested for anticancer activity. The extract was prepared by cold maceration method, hydro alcohol was the solvent used. The in-vitro anticancer studies were performed against human cancer cell lines (breast and cervical cancer cell lines) and MTT assay was used to analyze the cell growth inhibition. The results obtained from the in-vitro cancer studies performed using the breast and cervical cancer cell lines reveals that the hydro-alcoholic root extract of Annona senegalensis has a moderate anticancer activity. Even though there was increase in the cell growth inhibition when concentration of sample was increased, the IC50 values were more than100 µg/ml for Bobgunnia madagascariensis for both the cell line and the IC50 values were less than100 µg/ml for Annona senegalensis for both cell lines. Hence the level of cytotoxicity of the hydroalcoholic extract of Annona senegalensis can be concluded to be more effective than that of Bobgunnia madagascariensis.

Keywords: *Annona senegalensis, cancer cell line, Bobgunnia madagascariensis, phytochemical, MTT assay.*

DEVELPOMENT OF CAPSULES FOR THE TREATMENT OF DIARRHEA INCORPERATING *TECLEA TRICHOCARPA* CRUDE EXTRACTS.

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Diarrhea is one of the diseases of major concern here in Zimbabwe and remains a major cause of morbidity and mortality namely due to interrupted water supplies in high-density suburbs and supply of unsafe water, unattended sewage bursts and mushrooming of unregulated urban areas. It is of great importance therefore that these new drugs that are developed have better therapeutic effects and lesser side effects from those currently found on the market. *Teclea trichocarpa* was chosen in this project because of its well-known traditional uses for treating diarrhea. The tests that were done in this project were phytochemical tests, MICs, drug release study, efficacy tests and antidiarrheal investigation. Phytochemical tests were done so as to find the presence of the secondary metabolites that would aid in the antidiarrheal activity of *Teclea trichocarpa*. For the sensitivity tests the ethanolic extract showed antimicrobial activity on the three bacteria chosen which were *S.aureus, E.coli and Salmonella.* For the antidiarrheal test the ethanolic extract showed antidiarrheal properties.

Formulation of a capsule was chosen because of its advantages that include capsules, because of their elongated shape, are easy to swallow, which is one reason for the number of capsule-shaped tablets manufactured today; flexibility of formulation is another advantage of the capsule dosage form. However the biggest formulation advantage of capsules is that there is less need for additional

excipients; since capsules are tasteless, they effectively mask any unpleasant taste or odor of their contents; they offer rapid release characteristics, due to the rapid dissolution rate of the capsules; the use of hard capsules is also a common feature in clinical trials, as the filling of tablets or even capsules themselves will blind the dosage forms studied (Podczeck, 2004); the manufacture of capsules also involves a much shorter process compared to that for other modern dosage forms (e.g. tablet) and controlled release can be achieved using capsules.

The results of the dissolution studies on *Teclea trichocarpa* capsules showed that *Teclea trichocarpa* capsule contents dissolved in the dissolution medium. These results are within the specification set in the British Pharmacopoeia (British Pharmacopoeia 2000) and indicated that the capsules were immediate release solid oral dosage forms with good in vitro bioavailability. The efficacy tests showed the capsules having a good reduction in diarrhea in rats at a dose of 400mg/kg po. The stability tests showed that the capsules are stable under room temperature following the ICH guidelines.

The results of the project show that *Teclea trichocarpa* capsules with an ethanolic extract are effective in alleviating diarrhea.

Key words: *Diarrhea, Teclea trichocarpa ethanolic extract, capsules*.

A COMPARATIVE STUDY OF THE EFFECTIVENESS OF ALLOPATHIC VERSUS HERBAL TREATMENT OF CANCER.

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Cancer is a disease of multicellular organisms in which there is an uncontrolled proliferation of cells. The cardinal features of cancer are growth, invasion and metastasis. When cancer develops, cells become more and more abnormal, old or damaged cells survive when they should die, and new cells form when they are not needed. Examples of cancers that begin in specific types of organs are liver cancer, lung cancer and thyroid cancer. Cancer can be diagnosed using imaging techniques such as X-ray, endoscopy for tumors in organs such as the stomach and tumor markers. Allopathic treatment of cancer include chemotherapy, radiation, surgery and monoclonal antibodies. Most chemotherapy and radiation therapy are genotoxic, meaning that it interacts with genes (DNA) and causes mutations. Herbal medicine uses plants, or mixtures of plant extracts, to treat illness and promote health. It aims to restore your body's ability to protect, regulate and heal itself. A comparative study of the effectiveness of allopathic versus herbal treatment of cancer that was done by Pamela Tsimba with the support of Harare Institute of Technology is to identify a cheap effective type of cancer treatment with less side effects.
The survival rate of herbal treatment and that of cancer treatment according to the number of deaths seen per year using the two aforementioned treatment types using the test of proportion. The results showed that most patients recovered using herbal treatment. They experienced no side effects which made the patient's recovery more quickly and easier. There was significant difference in the survival proportions of subjects on herbal treatment as compared to the ones on allopathic treatment. Therefore, survival proportion of patients on herbal treatment was greater than survival proportion of patients on allopathic treatment. With the economic hardships in Zimbabwe it also proved that herbal treatment is cheaper than allopathic treatment hence, easily affordable for the patients.

FORMULATION AND EVALUATION OF *Azadirachta indica* and *Allium sativum* CAPSULES EFFECTS ON FAT STORAGE AND ITS POTENTIAL USE IN OBESITY

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Obesity is an energy balance disorder which arises when energy input exceeds energy output. Obesity facilitates the development of metabolic disorders such as diabetes, stroke, osteoarthritis and hypertension. Treatment of obesity is complicated due to the multifactorial nature of the disease. The present study was conducted to evaluate the effectiveness of *Azadirachta indica* and *Allium sativum* on fat storage and its potential use in alleviating obesity. *A indica* and *A sativum* were chosen in this project because they are reported to have medicinal properties including anti-obesity properties. Phytochemical tests were done so as to find the presence of the secondary metabolites that would aid in the management of obesity. The administration of the *A.indica* and *A.sativum* ethanol extracts in the diet significantly reduced the amount of fat in the subcutaneous tissues in the rats, this being consistent with the reduced body weight gain of the experimental group. The results from the in-vitro drug release study showed the capsules only released the extract in alkaline environment so this will protect the phytochemicals from destruction by Hydrochloric acid found in the stomach. The efficacy tests showed that the capsules are effective at a dose of 200mg/kg when given orally. The stability tests showed that the capsules are stable at room temperature. The results of the project show that capsules formulated from ethanolic extracts of *Azadirachta indica* and *Allium sativum* are effective in the management of obesity.

Key words: *Obesity, capsules, Azadirachta indica ethanolic extract*

FORMULATION OF AN ANTIMICROBIAL AND ANTI-INFLAMMATORY EARDROPS INCORPORATING *ZANTEDESCHIA ALBOMACULATA* AND *ALBIZIA HARVEYI* FOR TREATMENT OF OTITIS MEDIA

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Otitis infections, common in young children, usually occur when a bacterial or viral infection affects the inner, middle and outer sections of the ear. There three types of otitis infections depending on location, these are otitis interna, otitis media and otitis externa. In otitis media, the Eustachian tube becomes swollen or blocked and fluids build up in the ear. The infections represent the most common childhood problem for which antibiotics are prescribed in Zimbabwe (Daly et al; 2009). Because of inflammation and fluid buildup, the infections are at most painful.

Minimum inhibitory concentration tests were carried out on the causative agents frequently extracted from infected individuals. The plant extracts were used separately on the microbes and the greatest zones of inhibitions with *Z. albomaculata* were 7mm and 4mm in *S. pneumonia* and *S. aureus*

respectively, with *A. harveyi,* 16mm and 4mm in *S. pneuoniae* and *S. aureus* respectively. The plant extracts were also combined to determine their combinatory effects. Zones of inhibition achieved by the commercially available antibiotics were greater as compared to the plant extracts in inhibiting *S. aureus* however the extracts showed an additive antibacterial effect which surpassed the effect of ciprofloxacillin in *S. pneumonia* species.

Ethanolic extracts of the *A. albomaculata* were investigated for analgesic activities. Administration of plant extract to acetic acid-induced writhing in mice was compared to placebo and diclofenac sodium (10 mg/kg) treated mice. Interestingly, results showed that plasma plant extracts were capable of reducing severity of pain comparable to diclofenac sodium. Test samples and vehicle were administered orally 30 minutes prior to intraperitoneal administration of 0.7% v/v acetic acid solution. Inhibition of licking response in mice due to the administration of the test drugs during acetic acid-induced writhing test was recorded.

Key words*: otitis media, antibiotics, minimum inhibitory concentrations, A. harveyi, Z. albomaculata, analgesia*

FORMULATION AND EVALUATION OF THE MOSQUITO REPELLENT PROPERTIES OF A TOPICAL LOTION INCORPORATING EXTRACTS FROM *LIPPIA JAVANICA*

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There is a strong perception that natural actives are safer than synthetics. A research by Sarah J Moore on [multiple] continents (North and South America, South-east Asia and Africa) has highlighted this same perception. Perhaps more importantly, insect repellents derived from plants can be an inexpensive, sustainable method of preventing disease in high-risk regions of the world. Therefore, the aim of my study was to formulate and evaluate the mosquito repellent properties of a topical lotion incorporating extracts from *Lippia javanica*. Of the insect repellents used in Zimbawe most of them contain d- trans allethrin, imiprothrin and d- phenothrin which can be harmful if inhaled. Allethrin is a potent insecticide and is widely used as a mosquito repellent. Direct skin contact with allethrin causes itching, burning and tingling feeling. When inhaled, it may worsen asthma in individuals who suffer from the disease. In others, it may cause nausea, vomiting, and diarrhoea and coordination difficulties. The method used for crude extraction of *Lippia javanica* stem and leaf oil was steam distillation, the active constituents in *Lippia javanica* that act as mosquito repellents being alloparinol, camphor, limonene, α –terpeneol and verbenone. Testing the effectiveness of the botanical extracts as repellents against identified mosquito species (*Anopheles arabiensis*) was done at the National Institute of Health Research according to WHO guidelines. Skin sensitivity and irritation tests were carried out on albino rates to determine the safety of the crude extracts. *Lippia javanica* stem and leaf oil provided 100% repellence upon initial application at 0.00071429ml/cm² which was the minimum effective dose per cm² and reduced to 34.3% within 1 hour. The formulated product maintained repellence above 70% upon initial application for the 1 hour, in literature the repellence of 24% DEET remained over 90% for 6 hours and the skin sensitivity tests proved that the product is safe for human use after monitoring the rats at regular intervals of 30 minutes.

Keywords: *Lippia javanica, stem and leaf oil, mosquito repellence, DEET, steam distillation, safety, alloparinol, camphor, limonene, α –terpeneol and verbenone*

DEVELOPMENT OF A PHARMACEUTICAL CARE MODEL TO INTERVENE IN THE FACTORS LEADING TO POOR DRUG ADHERENCE AMONGST MENTALLY-ILL PATIENTS IN HARARE

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The aim of this study was to develop a pharmaceutical care model to intervene in the factors leading to poor drug adherence amongst mentally-ill patients living in Harare. In treatment and management of psychotic disorders, maximum benefit that a patient derives from medications is highly dependent on adherence to treatment. According to WHO, adherence rates to anti-psychotic medication is in the range of 40-65%. Poor adherence therefore remains one of the greatest challenges in mental-healthcare. Role of a pharmacist has recently grown beyond just dispensing and is mainly concerned with patient care. Establishing factors leading to poor adherence might lead to better understanding of reasons for non-adherence and lay groundwork for interventions. Cross sectional study was conducted and sites of study were Mbare and Highfield which are both places located in Harare. Adherence was measured using 8 item Morisky Medication Adherence Scale and a questionnaire was given to understand reasons for non-adherence. Descriptive and inferential statistical analysis through use of Pearson chi-square was done. Value of p was considered significant at p<0,05. 17(65,4%) out of 26 participants who participated in the study, matched definition of poor adherence according to MMAS score. Significant relationships were noted between poor adherence and gender (0.045), forgetfulness (0.017), fear of side effects (0.005), fear to become dependent (0.025), fear of stigmatisation (0.014), long waiting hours (0,006) and lack of explanation about the condition by healthcare provider (0,001). The study indicated that adherence is still a problem hence there is need for pharmacists to provide guidance and counselling to patients about adherence and consequences of discontinuing medication, develop a set of adherence focused activities, use a multi-disciplinary approach to promote mental health, where necessary provide adherence tools such as written calendars of medications and pill boxes and also encourage use of alarm clocks as reminders.

Keywords: adherence, medication, mental health, pharmaceutical care, pharmacist

THE DEVELOPMENT OF AN ALTERNATIVE SUPPLY CHAIN MODEL THAT IMPROVES THE PROCUREMENT PROCESS OF ESSENTIAL MEDICINES IN CENTRAL HOSPITALS IN HARARE

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This research study sought to determine the factors that influence the effectiveness of procurement process of essential medicines and hence to develop an alternative supply chain model for essential medicines for public hospitals in Harare, Zimbabwe. The study was done due to an observation done by researcher during internship period from June-August 2016, and January 2017. The observed shortages in essential medicines at Harare Central Hospital which caused suffering to patients. The study adopted a descriptive type of study design with purposive sampling method being used to select a sample of the target population. From purposive the sampling technique, a sample of 15 pharmacy staff directly or in directly involved in the procurement of essential medicines answered the questionnaires. The target population was to include all pharmacists, pharmacy technicians, and dispensary assistants from all pharmacy departments was estimated to 24 participants. Data was collected using the designed questionnaires delivered to the study participants by the researcher. Data analysis was done using descriptive statistics and also Pearson correlation coefficient was used for hypothesis testing using SPSS package. The study found that the supply chain is sometimes inconsistent that essential medicines are not delivered on time. This is as a result of manual recording of data and lack of training of staff. Therefore the study recommendations that; the public hospital management should ensure training of all personnel involved in the procurement of essential medicines. Due to high staff turn-over in the pharmacies, training seminars should be conducted every quarter or every half yearly. The government should encourage and fund for ICT based supply chain models in order to accelerate data transmission and transmit data to various stake holders simultaneously as procurement is done centrally to reduce reporting burdens. There is need to ensure regular inventory control by staff so as to increase guarantee accuracy and completeness in record management

Key words*: supply chain, procurement process, essential medicines, descriptive study, ICT, staff training, record management*

PHARMACEUTICAL FORMULATION OF AN OINTMENT FOR THE MANAGEMENT OF DECUBITUS ULCERS INCORPORATING *XIMENIA CAFFRA* AND *ZIZIPHUS MUCRONATA* CRUDE EXTRACTS.

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This study has investigated the phytochemicals present in, the antibacterial and anti-inflammatory properties of the crude extracts obtained from the *X. caffra* and the *Z. mucronata* plant roots and the efficacy of the ointment formulated incorporating these extracts for the management of decubitus ulcers. A solvent extraction method was used for the extraction process-using methanol and solid extracts were obtained. Phytochemical screening tests carried out revealed that in the *X. caffra* extract, phytochemicals present include flavonoides, flavanones, tannins, terpenoids and alkaloids. The phytochemical tests done on the *Z. mucronata* extract showed the presence of tannins, saponins, glycosides, alkaloids and flavonoids. Minimum inhibitory concentration (MIC) tests were successfully carried out for three bacterial species namely the *Staphylococccus aureus, Escherecia coli* and *Pseudomonas aerugnosa.* It was determined that both the plants have antibacterial properties and have a synergistic effect on each other. The minimum inhibitory tests showed that a concentration of 8% *w/w* of the combined extracts of *X. caffra* and *Z. mucronata* had the following MIC values, 24mm, 26mm and 24mm for *S. aureas, E. coli* and *P. aeruginosa* respectively showing susceptibility of all bacteria in the study. Further investigations established that both plant extracts have anti-inflammatory properties. The protein denaturation inhibition method was used to determine the anti-inflammatory properties of the extracts. Efficacy tests of the final product were carried out on albino rates on which wounds were incised and treated using the product. The results showed that the wound treated with the herbal ointment continued to heal as evidenced by granulation and reducing wound size from a diameter of 10mm on day 0 to about 8mm on 7th day. In the study an ointment incorporating the combined extracts of *X. caffra* and *Z. mucronata* was successfully formulated.

DEVELOPMENT AND EVALUATION OF A RANGE OF TOPICAL PRODUCTS FOR WOUND HEALING INCORPORATING *CEIBA PENTENDRA and ERYTHRINA LYSISTEMON*

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Wound healing is process that enables tissue repair after an injury while inflammation is a pathophysiological response of living tissue to injuries (*Murphy et al 2001)*. Different medications are used in the treatment of wounds. There is a growing interest in the use of traditional wound dressing agents. *Erythrina lysistemon and Ceiba pentendra* were used in traditional medicines for treating various infections and they have been found to have antibacterial activity against number pathogens. The wound healing activities of whole extract and fractions of *Ceiba pentendra and erythrina lysistemon* were investigated using excision and incision wound models (Knowlton et al 1997). *Ceiba pentendra and erythrina lysistemon* extracts shows significantly ($p < 0.05$) accelerated wound healing with is *Ceiba pentendra and erythrina lysistemon* -45% extracts having the highest percentage wound contraction and rate of epithelialization, with wound healing effects being seen from day 4 with total healing occurring at day 20 (100%). In excision wound healing activities involving the fractions. All fractions showed significantly ($p<0.05$) accelerated wound healing and total healing occurring at the 16th day (100%). Nevertheless inhibition was still observed at six hours after administration at all dose level. The results obtained showed that *Ceiba pentendra and erythrina lysistemon* has good wound healing and antibacterial activities.

Keywords: *Antibacterial activity, Ceiba pentendra, Erythrina lysistemon, Minimum Inhibition Concentration (MIC) and zone of inhibition.*

IN VITRO ANTIOXIDANT ASSAY OF *BRASSICA OLERACEA* AND *SOLANUM INCANUM* METHANOLIC EXTRACTS FOR POTENTIAL USE IN THE MANAGEMENT OF SKIN CANCER.

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The study was concerned with at carrying out antioxidant assays on *Brassica oleracea* and *Solanum incanum* extracts and determine if they can yield phytochemicals with novel medicinal components that can be useful in the management of skin cancer wounds and promote healing. *Solanum incanum* and *Brassica oleracea* have been accredited a number of beneficial role in management of conditions like cancer, hypertension, cardiovascular disease etc.; as also supported by traditional used of the plants. Phytochemicals identified upon extraction in both extracts were flavonoids, tannins, alkaloids and saponins; with the exception of reducing sugars, anthraquinones, steroids, glycosides and reducing sugars for *Solanum* in addition to the above. Presence of phytochemicals suggested that the extracts possess antioxidant potential. The effect of temperature on extraction was evaluated of *Brassica oleracea* as it was divided into air-dried and oven-dried samples. The fruits of *Solanum incanum* were separated as ripe and unripe to identify which contains a higher antioxidant potential. In vitro assays carried out included nitric oxide assay, reducing power assay as well as the hydrogen peroxide assay using UV-Vis spectrophotometer (Spectro UV-63PC). Ascorbic acid was used as a positive control. *Brassica oleracea* methanolic extracts were analysed at concentrations of 20, 40 and 60µg/ml in all assays whilst a range of 10-100mg/ml for *Solanum incanum.* The results showed significant correlation between the antioxidant activity of air-dried *Brassica oleracea* and *Solanum incanum* ripe fruits. Results were comparable to those of ascorbic acid, thus confirming its potential use in managing skin cancer.

Key words: *antioxidant activity, Solanum incanum, Brassica oleracea*

INVESTIGATION OF THE ANALGESIC EFFECTS OF EXTRACTS FROM Peltophorum africanum AND Ricinus communis FOR POTENCIAL FORMULATION OF TOOTHACHE DROPS

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Toothache also known as dental pain refers to pain in the teeth and their supporting structures. The treatment of diseases using medicinal plants has been part of human culture since a long time ago. Available treatments are not specific for toothache and they have longer onset of action with more side

effects. The research question is on whether toothache drops formulated with extracts of *Ricinus communis* and *Peltophorum africanum* will be effective for the relief toothache. The aim is to formulate a stable and efficacious solution for the relief of toothache. The extraction of phytoconstituents of R communis roots was done using 80% alcohol. Extraction of phytoconstituents from Peltophorum africanum root bark was done using acetone. The formulated solution was tested for analgesic effect using the Tail immersion test in Swiss albino mice. Stability studies of the solution were done and these include window ledge, freeze thaw, thermal test, cooling and heating. Acute oral toxicity studies using OECD 423 guidelines were done for both extracts. The results revealed that the solution is stable in an amber glass bottle. There were no observed toxicities or mortality in the rats after administration of 3000 mg/kg of Peltophorum africanum extract. A dose of 3000mg/kg of Ricinus communis root extract did not induce any toxicity symptoms and mortality in the rats. The formulated solution showed analgesic effects that are comparable with Paracetalmol which is the most common drug used for toothache. Further toxicity studies may need to be done in human models since animal models are not an accurate measure of the toxicity that might be elicited in humans.

Key words: *toxicity, analgesic, mortality, stability, solution, Ricinus communis, Peltophorum africanum, extracts*

A COMPARISON OF THE KNOWLEDGE, ATTITUDES AND PERCEPTIONS OF PRIVATE AND PUBLIC SECTOR HEALTH CARE PROVIDERS IN ZIMBABWE ON THE PRE-EXPOSURE PROPHYLAXIS OF HIV.

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A combination of Tenofovir disoproxil fumarate 300mg and Emtricitabine 300 mg was approved by the FDA for use as prophylaxis against sexually transmitted human immunodeficiency virus. Patients and members of the public may require valuable information regarding pre-exposure prophylaxis from both, the public and private sector healthcare providers. The aim of the study was to compare the knowledge, attitudes and perceptions of private and public sector healthcare providers regarding the pre-exposure prophylaxis of HV. This was a descriptive cross-sectional study in which healthcare providers comprising of doctors, pharmacists, nurses and nurse-aides from private and public health institutions in Kadoma and Harare Central Business District were interviewed using a standard questionnaire during the period between February and April 2018. Data obtained was analyzed using descriptive statistics and Microsoft excel built-in statistical parameters. The overall response rate was 95%. About 82% of private sector healthcare providers were more than willing to initiate the pre-exposure prophylaxis regimen to the susceptible individuals while 85% of public sector healthcare providers were willing to adopt and initiate it. There was no any significant difference between the two sectors as far as their knowledge of HIV pre-exposure prophylaxis was concerned. Among the interviewed public sector healthcare providers, 64% were found to be well knowledgeable about the HIV Pre-exposure prophylaxis while 66% of the interviewed private sector healthcare providers were found to be well knowledgeable about the HIV Pre-exposure prophylaxis. However, there still exists a need for the government to improve and implement viable awareness strategies for the HIV pre-exposure prophylaxis to both public and private sector healthcare providers.

Key words: *healthcare providers, HIV pre-exposure prophylaxis, perception, knowledge*

FORMULATION OF A MOUTH GARGLE AND ORAL CARE STRIPS TO MANAGE HALITOSIS USING EXTRACTS OF *ERYTHRINA ABYSSINICA AND MENTHA PIPERITA*

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Halitosis is a condition where the breath is altered in an unpleasant manner for the affected individuals and impairs them socially as well as psychologically. Halitosis can be of intra-oral or extra-oral causes. In nearly 85% of all halitosis cases, the origin is found in the oral cavity. The male gender is affected the most. The odor emanating from the oral cavity is produced by microbial putrefaction of the debris left in the mouth, resulting in the production of malodorous volatile sulfur compounds. Some standard dental treatments and mouthwashes have no antibacterial effects and preparations containing chlorhexidine discolor teeth. EDLIZ offers no treatment for halitosis. As a result a mouth gargle and oral care strips were formulated with extracts *of Erythrina abyssinica and Mentha piperita* to target both bacteria that release volatile sulphur compounds and also to freshen the bad breath. Oral strips were formulated using polyvinyl alcohol as the film forming polymer using the solvent casting method. The films were yellow, smooth, non-sticky, homogenous, transparent and flexible. Accelerated stability studies were also performed on the two products and observed for color change, odor, pH and folding endurance. The uniformity of weight of all the films were found to be in the range of (0.0423-0.0433g) ±0.002, folding endurance ranged between(281-286), thickness(45-55)micrometers, disintegration time(24.6-28.6) seconds, surface pH was an average of 6.8 which was within the mouth pH range of (6.7 -7.3).Minimum inhibitory concentrations were18mm and 19mm respectively for Prevotella intermedia and Fusobacterium nucleatum respectively compared to standard values of 21.33mm and 25.30mm for Prevotella intermedia and Fusobacterium nucleatum respectively. Mouth gargle is a liquid solution used to help promote oral hygiene and sometimes contain an antibiotic and an anti-inflammatory agent to treat inflammatory conditions and throat infections. The formulation was subjected to preservative challenge test using Staphylococcus aureus and E coli over a 28 day period. A reduction in the number of colony forming units were observed. No increase from the initial calculated count at 14 and 28 days is observed samples. The stability tests performed showed that the oral films and mouth gargle where of high quality. The proposed shelf life was 2 years pending the results of real time stability tests.

Keywords: *Erythrina abyssinica, Mentha piperita, halitosis, mouth gargle, oral care strips*

EVALUATION OF ANTIBACTERIAL ACTIVITIES OF *AZADIRACTA INDICA* LEAF EXTRACT AND *ALLIUM AMPELLOPRASUM BULB EXTRACT* AND FORMULATION OF HERBAL CAPSULES FOR POTENTIAL USE AGAINST DIARRHEA.

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Herbal medicines have been used traditionally for a large number of health concerns and maintenance. *Azadiracta Indica* and *Allium Ampelloprasum* are the two plants that had their medicinal benefits investigated in this study. The plants were collected, plant metabolites were extracted from them and phytochemical screening was done on the extracts *A. Indica* extract had tannins, flavonoids and phenolic compounds present whilst in *A. Ampelloprasum* extract tannins, flavonoids, saponins, alkaloids and glycosides were present. The drive for the investigation was the absence of cheaper alternatives of a natural variety with antimicrobial activity. The plant extracts had their antibacterial activities tested against *E. coli, P.aeruginosa* and *S.aureus* which are common bacteria in developing countries that can cause diarrhea. Positive results were obtained for the antimicrobial activity of both *A. Indica and A. Ampelloprasum*. This led to the formulation of a product made of hard gelatin capsules encapsulating both herbal products. The product went under some quality control tests and it was observed as resistant to moisture permeation, able to release all its ingredients and of a uniform mass nature.

Key Words: *phytochemicals; antimicrobial; E. Coli, extract; diarrhea*

EVALUATION OF THE USE AND ACCURACY OF POINT OF CARE DEVICES IN MONITORING BLOOD GLUCOSE LEVEL IN DIABETIC PATIENTS

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Diabetes mellitus is one of the leading non-communicable disease affecting millions globally. The incidence of diabetes mellitus and the associated complications in Zimbabwe is rising significantly. There is need to regularly monitor the glycemic levels in diabetic patients to avoid complications due to uncontrolled diabetes. The use of point of care devices commonly known as glucometers is on the rise due to the need to carefully monitor the glycemic levels. Point of care (POC) devices and the Self-monitoring blood glucose (SMBG) technique were introduced to make routine blood glucose monitoring more timely and easier for diabetic patients. SMBG devices are used routinely in various settings as a replacement for conventional laboratory as method for checking glycemic control and as a diagnostic tool.

The investigation was carried out to determine the accuracy of blood glucose measurements with glucoplus and codefree meters compared to lab methods in patients requiring blood glucose value. Patient blood samples were tested in triplicate for glucose level using the Glucoplus^{R} and Codefree glucose testing devices and laboratory hexokinase technique. The values obtained were then compared to laboratory reference point

A p-value of 0.182 was obtained using One-way ANOVA to test for statistical significance. There was no statistically significant difference among the three mean values for laboratory, Glucoplus^{R} and Codefree devices blood glucose values

Key words: *glycemic, hexokinease, diabetes, glucoplus, codefree*

DEVELOPMENT, EFFICACY AND SAFETY EVALUATION OF ANTI-INFLAMMATORY PROPERTIES OF *CISSUS QUADRANGULARIS LINNAS:* A POTENTIAL ANTI-RHEUMATIC HERBAL MEDICINE

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Rheumatoid arthritis is a chronic autoimmune disease. Experimental studies have shown that *Cissus quadrangularis linnas* has anti–inflammatory, analgesic and gastro-protective activities through reduction of the serum levels of these cytokines. This study was therefore aimed at formulating capsules incorporating the active extracts of this plant, in order to alleviate symptoms of Rheumatoid arthritis as well as protect Rheumatoid arthritis patients that are on chronic treatment with NSAIDs against development of gastric ulcers. *Cissus quadrangularis* stems, leaves and roots were collected, identified and dried. The dried material obtained was used for the preparation of the ethanolic crude extract. A yiels of 5.5% was obtained. Following extraction, Wet granulation of the powder was carried out. Powder flow properties were characterized. From the pre-formulation and physicochemical studies performed gave the following results, Bulk density was 0.7143g/ml, Tapped density was 0.7692g/ml, Carr's index was 4.22% and Hausner's ratio was 1.07. Capsules were then formulated using the crude extract. Each capsule contained 50mg of *Cissus quadrangularis linnas* ethanolic extract. The cruse extract showed significant anti-inflammatory properties when compared against indomethacin.The acute oral toxicity tests were carried out as per OECD 420 guidelines. Mortality was observed at 8%v/v of Cissus quadrangularis extract and this was group four. However in the other three groups there were no abnormal clinical signs that were observed.

KEY WORDS: *Rheumatoid arthritis, Cissus quadrangularis linnas, bulk density, Carr's index, Hausner's ratio, tapped density*

IN VITRO ASSESSMENT OF ANGIOTENSIN CONVERTING ENZYME INHIBITION ACTIVITY OF *MORUS NIGRA*

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Angiotensin converting enzyme (ACE) inhibitors plays a critical role in treating hypertension. The purpose of the present investigation was to evaluate ACE inhibition activity of *Morus nigra* (black mulberry) using an in vitro assay. The ACE activity was evaluated by determining the hydrolysis rate of substrate, hippuryl-L-histidyl-L-leucine (HHL), using Ultra Violet visible spectroscopy. The amount of HA (Hippuric Acid) represented ACE activity and it was measured using a spectrophotometer at 228 nm. Then, ACE inhibitor activity was determined by % ACE inhibitor value. Antioxidant activity was determined by Hydrogen Peroxide radical scavenging assay. The plant extract revealed an ACE inhibition activity that was concentration dependent with a percentage inhibition of 20%, 33%, 63%, 73% and 80% for 20, 40, 60, 80 and 100µg/ml respectively. *Morus nigra* can therefore be studied further and developed for potential use in hypertension.

Key words: *ACE inhibition; Morus nigra; antioxidant activity; Angiotensin Converting Enzyme*

FORMULATION OF HERBAL CAPSULES FOR POTENTIAL USE IN DIARRHEA TREATMENT INCORPORATING MANGIFERA INDICA EXTRACTS.

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Diarrhea is the fourth highest cause of death for children under five in Zimbabwe, and is the reason for 12% of its child hospital admissions. Hence they is need to find new remedies which are potent and effective in diarrheal treatment. I chose *Mangifera indica* in my project because of its well-known traditional uses for treating diarrhoea. In my project I used 70% ethanol for extraction of the bark and leaves in the *Mangifera indica*.70% ethanol was used because according to literature it has a higher yield value. The tests that were done in this project were phytochemical tests, minimum inhibitory tests ,atomic absorption spectrum, safety and stability tests. Phytochemical tests were done so as to find the presence of the secondary metabolites that would aid in the antidiarrheal activity of *Mangifera indica*. From the results of the phytochemical tests, the ethanolic extract showed greater number of secondary metabolites. This is due to the fact that ethanol is a better extraction solvent. For the sensitivity tests the ethanolic combined extract also showed greater activity on the three bacteria chosen which were Shigella, E.coli and Salmonella. The antibacterial effect of the ethanolic extract bark was more effective compared to that of the ethanoic leave extracts ,this is might be because the bark had more of the secondary metabolites than in the leaves. AAS was done so as to note the amount of trace

elements in *Mangifera indica*. This was done because trace elements like zinc are known to have antimicrobial properties. The results of AAS showed that *Mangifera indica* has a high concentration of magnesium ions. *Mangifera inidica* ethanolic extract is effective in alleviating symptoms of diarrheal.Positive results were obtained for the antimicrobial and antidiarrheal activity of *Mangifera indica*.This led to the formulation of a product made of hard gelatin capsules encapsulating *Mangifera indica extracts*. The product went under some quality control tests and it was observed as resistant to moisture permeation, able to release all its ingredients and of a uniform mass nature.

Keywords*: Diarrheal, Mangifera indica, ethanolic extracts, phytoconstituents , Salmonella ,E coli , Shigella sps*

AN INVESTIGATION OF THE ORAL TOXICITY POTENTIAL OF *CROCODYLUS NILOTICUS* BILE

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The Nile crocodile (*C.niloticus*) is the largest freshwater predator found across Sub-Saharan Africa. The bile of the Nile crocodile is implicated in numerous cases of food poisoning death, typically at beer drinking events, funerals or other public events.It is speculated and believed among African communities that the bile from this predator is highly toxic and causes death within 24hours of oral ingestion. Despite numerous recorded cases of food poisoning surrounding the bile (*ndurui***Sh***/inyongo***Nd***)* of the Nile crocodile, there is no scientific consensus on the oral toxicity of the bile.

Aims and Objectives: The project sought to acquire and prepare a fresh sample of the bile of the *C.niloticus,* screen the bile for toxicity potential, carry out sub-acute and acute oral toxicity tests on laboratory animals.

Methods: Fresh *C.niloticus* bile was obtained from a crocodile farm in Binga. The bile and gallbladder were homogenised, assayed by Liquid Chromatography-Mass Spectrometry and force-fed to laboratory rats. Six rats, that were force-fed the prepared sample were observed over a period of seven days as per OECD oral toxicity guidelines.

Results and Observations: The LC-MS assay of the *C. niloticus* bile showed no known toxic constituents compared to the inbuilt standards. None of the laboratory rats used in the study succumbed to poisoning or exhibited noticeable signs of toxicity after being force-fed the bile sample. No sub-acute toxicity studies were done owing to resource constraints.

Conclusion: From the foregoing it is hereby concluded that the bile of the Nile crocodile in its crude form is not toxic to laboratory rats. The findings of the study, though using different methods, concur with the results of the study carried out by Nyazema N.Z, in 1984.

Key words: *acute toxicity, Nile crocodile bile, Liquid Chromatography-Mass Spectrometry*

EVALUATION OF ANTI-OBESITY PROPERTIES OF *MANGIFERA INDICA* LEAVES FOR POTENTIAL INCORPORATION INTO AN ANTI-OBESITY REMEDY

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The prevalence of obesity is increasing at a frightening rate, but, sadly, only few medications are currently on the market. Currently it is estimated that there are more than 1.9 billion adults aged 18 years and older are overweight and 650 million adults obese. Overweight and obesity is the risk factor for many health problems like diabetes, heart disease, osteoarthritis and certain cancers. Obesity is largely regarded as lipid metabolism disorder and enzymes involved in this process can be selectively targeted to develop anti-obesity drugs. However, most of the anti-obesity drugs that were approved on the market have now been withdrawn due to serious adverse effects. Available approaches for the treatment of obesity involve inhibition of dietary triglyceride absorption via inhibition of pancreatic lipase (PL) as this is the major source of excess calories and natural products have a potential to provide a vast pool of PL inhibitors that can possibly be developed into clinical products. In this project the inhibitory effect of on lipase enzyme was determined using titration techinique. The % inhibition of the extracts was found to be 40 %.The lipase enzyme inhibition effect of *Mangifera indica* leaves ethanol extract was ascribed to be due to the presents of phytochemials such as phenolic compounds like flavonoids, phenolic acid and polyphenols which were conformed to be present by phytochemical analysis performed.

Key words: *Obesity, Inhibition, absorption, extracts, metabolism, Lipid*

FORMULATION AND EVALUATION OF ANTI - DIABETIC POLYHERBAL PHOSPHOLIPID SUSPENSION OF *OPUNTIA FICUS-INDICA, COMBRETUM HEREROENSE, CARICA PAPAYA,* AND *SCLEROCARYA BIRREA EXTRACTS*

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Phospholipids encapsulation incorporates plant water-soluble phytoconstituents into phospholipids to produce lipid compatible molecular complexes and improve bioactivity of phytoconstituents. This study aims to show that phospholipid encapsulation improves the absorption and bioavailability of polyherbal phytoconstituents of *Opuntia ficus-indica, Combretum hereroense, Carica papaya, and Sclerocarya birrea* plant extracts in lowering blood glucose level in rats. Four polyherbal phospholipid complexes of combining 4 herbal extracts (*Opuntia ficus-indica, Combretum hereroense, Carica papaya, and Sclerocarya birrea* extracts); F1, F2, F3 & F4; containing molar ratio of 1:1, 1:2, 2:1 and 2:2 of soya lecithin to herb were prepared by the antisolvent precipitation technique. Phytosome herbal formulation F1 to F4 were given to glucose loaded rats in the glucose intolerance test. They were found to lower blood glucose level compared to the group that was given distilled water as a control. Formulation F1 to F4 were also given to diabetes induced rats on a 14 day course and was found to lower blood glucose levels. Results were compared against the glucose lowering effect of crude extracts from HIT 300 project. From all four combined herbal extract phytosome complexes, F1, the 1:1 molar complex of 4 herbal extracts and phospholipid, lowered blood glucose the most compared to F2, F3 and F4. Results showed that phospholipid encapsulation increase bioavailability of crude extracts therefore lowering blood glucose the most.

Key words: *phospholipid, soya lecithin, polyherbal, encapsulation, hypoglycemic*

CHIWARA MEMORY H140251W

HIT 400 PROJECT 2018

FORMULATION OF PESSARIES FOR BIRTH CANAL DILATION INCORPORATING *POUZOLZIA HYPOLEUCA AND RHUS LONGIPES*

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Delivery is one of the most natural events in each woman`s life. It is considered a special period physically and physiologically which is followed by physical activity, stress and pain with some potential hidden risks. The history of oxytocin reflects the struggle of physicians and midwives to reduce complications of birth which were threatening lives of women and infants throughout history. Early midwives would provide pregnant women with herbal teas and mixtures of roots and they remained helpless watching patients die from stalled labour and postpartum bleeding. Reports indicate that about 70-80% of the women use folk medicine during pregnancy to promote uterine muscle contractility and prevent postpartum hemorrhage. During pregnancy and childbirth traditional medicine relies on the use of certain herbs for their beneficial effects to tone the uterus muscle, induce labour, in the removal of retained placenta and management of post-partum bleeding. During labour, many women experience protracted labour, which a cervix dilated to over four centimetre in diameter is dilating slower than **1 cm/hr**. Protracted labour during childbirth is experienced in up to 50% of all deliveries, often resulting in emergency interventions such as caesarian section or instrumental assistance, and often pose serious complications for both mothers and babies. Such interventions are reported in 20 to 25% of all deliveries in high income countries. Researchers have a belief that the causes of the purple line is due to vasocongestion in the sacrum. Usually when the baby descends into the birth canal the baby exert more pressure on the pelvis and the sacral veins thereby causing swelling to occur which eventually lead to the purple line appearance. The purple line was fully seen appearing on the top of the natal cleft of the guinea pigs which showed the fully dilatation of the birth canal. The present study was designed to investigate the contractile effects of *R.longipes* and *P.hypouleca extracts* in vivo in an effort to establish their potential uterotonic effects. The findings indicate that both the crude extracts and bioactive compounds of *R.longipes* and *P.hypouleca* possess uterotonic activity in the experimented guinea pigs.

KEY WORDS: *effacement, dilatation, parturition, labour, prostaglandin, pessary*

EVALUATION OF ANTIDEPRESSANT EFFECTS OF *Peltophorum africanum IN LABORATORY MICE*.

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Background: Depression is a multifactorial disorder that affects a significant proportion of the society. It affects the quality of life, well-being as well as the physical health of affected individuals. In the present study the antidepressant effects of *Peltophorum africanum* were evaluated.

Methods: Acetone extracts were administered orally to laboratory mice at doses of 100 and 200 mg/kg body weight. Fluoxetine was administered orally at a dose of 15mg/kg, and the control group was given saline water at a dose of 1ml/kg. The tail suspension test and the forced swim test were used to assess the struggling behaviour of the animals following acute and chronic dosing of the animals. The animals were also investigated for changes in brain structure and mass.

Results: Administration of acetone extracts to mice resulted in a significant decrease in immobility time when the animals were assessed for struggling behaviour in the forced swim test and the tail suspension test. The extracts also increased swimming time of the animals to an extent that is comparable to the standard drug. Administration of the plant extracts also resulted in a significant increase in the hippocampal weight of the experimental animals.

Conclusion: The present study revealed the antidepressant effects of *Peltophorum africanum.* When compared to a standard antidepressant drug, the extracts have comparable antidepressant effects to the antidepressant drug.

Keywords*:* *antidepressant, immobility, hippocampus, P. africanum*

DEVELOPMENT, EFFICACY AND SAFETY EVALUATION OF CREAM FOR NON- SCARING ALOPECIA INCOOPERATING EXTRACTS FROM *GUAZUMA ULMIFOLIA* BARK AND *ROSEMARINUS OFFICINALISE.*

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Looks are increasingly becoming every individual's concern. Clothes, jewellery, and even makeup contribute to the 'beauty' look of an individual. Despite all that, the natural appearance of an individual highly determines how good looking a person can be regarded as, and this highly constitutes the hair. The looks and comments to an individual, especially the females, affect self-confidence of the person, and hence probably performance in society. If the hair is unintended lost, the overall look of the individual is tarnished. The purpose of this project is more of the aesthetic value, rather than pain relieving.

Alopecia, which is the unintended loss of hair, has many different causes, some are self-afflicting, and some are the body itself. The main cause being the damage to the hair follicle. Either way, it leads to either permanent hair growth retardation, called scaring alopecia, or temporary hair growth retardation, called non-scaring alopecia. The course of this project will deal with non-scaring alopecia, where the hair follicle will still be able to be revived by non-systemic solutions.

The solution should also be cheap, hence the use of locally available plants as the active ingredients in the formulation of the medicament.

The plants used were the *Guazuma ulmifolia*, commonly known as Mutamba and *Rosemarinus officinalis* commonly known as rosemary. The bark of *Guazuma ulminofila* was used and the leaves of *Rosemarinus officinalis*. Mutamba has Procyanidin B_2 whilst Rosemary has essential oils. Both of these have hair stimulating properties, with antibacterial, anti-inflammatory and smoothening properties, that make them the perfect combination of the API's in the formulation. Procyanidin B_2 was extracted by using 1:1 90% methanol: chloroform by making a tincture.

A hair cream was made in the HIT Pharmacy laboratory. A hair cream has emollient properties and is also easily absorbed through the skin.

Keywords: *temporary (non-scaring); Alopecia; aesthetic; Guazuma ulmifolia; Rosemarinus officinalis*

FORMULATION AND EVALUATION OF DISINFECTANT FROM BIDENS *PILOSA* AND *LIPPIA JAVANICA* PLANT EXTRACTS FOR SURFACES

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Most microbes are becoming resistant to the commonly used disinfectants therefore considering a natural disinfectant with natural aroma will assist in reducing hospital acquired infections to both the patients and health worker and this has lead in this study and formulation of a multipurpose gel suitable for all surfaces. Phytochemical components extracted from *bidens pilosa* and *lippia javanica* collected from Harare central in Zimbabwe, was extracted using acetone , analysed for phytochemical metabolites and minimum inhibitory concentration was done(MIC).the extract was concentrated using the rotary evaporator at 77 degrees Celsius. Antimicrobial activity were done using candida albicans(fungi), staphylococcus aureus (grams positive) and pseudomonas aeruginosa (grams negative) with methylated spirit as the control with susceptibility of 18% w/v, 22% w/v and 14% w/v of the combined plant extract(synergism) respectively. The microorganisms were cultured in nutrient broth-agar plates according to the manufactures specifications. It was found that all the plants have a moderated inhibitory activities against grams positive and negative in low concentrations, high concentrations are needed against candida albicans. The gel was prepared by using Carbopol 934, Propylene glycol 400, Methyl paraban, Propyl paraben and required amount of distilled water. Triethanol amine was used to maintain a pH of 6.8.Stability studies have carried out as per ICH guidelines for 3 months at different temperatures (4 and 37 degrees Celsius). The preliminary studies physicochemical components of appearance (yellow lemon-like thick gel), viscosity, spreadability (20mg*sm/sec) and uniformity (no changes were seen for a period of 3months). SurfCare gel(product name) was packaged in wide open jars for domestic use and dispensing bottles for industrial use to prevent contamination Microbial evaluation of the gel showed that greater diffusion and inhibition was observed for gel formulation composed of 90 % herbal extract with less than 1 log reduction of microbial colon forming units after 14 days. The formulation and evaluation of a disinfectant gel was successful

according to literature there is no best disinfectants therefore it has to be used together with other potent disinfectants

Key words: *Lippia javanica, bidens pilosa, traditional use, surface, microorganisms, gel*

EVALUATION OF THE EFFECT OF *AZADIRACHTA INDICA* SEED EXTRACT ON HAIR GROWTH FOR POTENTIAL USE IN THE MANAGEMENT OF CHEMOTHERAPY INDUCED ALOPECIA.

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The major devastating adverse effects of cancer chemotherapy include bone marrow suppression, gastrointestinal disturbances, and alopecia. Chemotherapy induced alopecia affects approximately 65% of all cancer patients. CIA affects perception of physical appearance and body image which however go beyond a cosmetic problem because it has negative impact on sexuality, self-esteem and deprives patients of privacy. Women value their hair as it is a reflection of their identity hence this difficult and emotionally painful side effect causes patients to refuse chemotherapy. It has been observed that approximately 8% of patients reject chemotherapy. Due to these disturbing side effects people are afraid of conventional medicines hence this project seeks to evaluate the effect of *Azadirachta indica* seed extract on hair growth for potential use in the management of chemotherapy induced alopecia. The ethanolic extract of *A indica* had a percentage yield of 16% and phytochemical screening tests proved the flavonoids, coumarin, cardiac glycoside, alkaloids, tannins and phenolic acids. The group that received distilled water only revealed no sign alopecia was observed during the course of the study. The group of rats that were given cyclophosphamide hair growth was inhibited in most of the rats by day 16th after hair growth time and significant hair loss was observed on day 20 of the study. The group of rats that received cyclophosphamide and *A indica* seed extract, hair regrowth was slow until day 16 and hair completion time was observed on day 20 of the study ant there was no significant hair loss observed. This project found out that *A indica* have impact on hair regrowth.

Key words: *Azadirachta indica, chemotherapy induced alopecia, devastating, identity, cyclophosphamide, hair regrowth*

DEPARTMENT OF BIOTECHNOLOGY

AN ASSESSMENT OF BLUE-GREEN ALGAE EFFECTIVENESS IN THE BIOREMEDIATION OF MUNICIPAL WASTE WATER

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Blue-green algae have become noteworthy bioremediation agents for waste water as they are a substantial low-cost alternative to complex and inadequate conventional treatment systems like biological nutrient reactors, trickling filters and lagoon systems which are currently being used in Zimbabwe. Therefore the research project was done so as to assess the efficacy and time taken by *Oscillatoria spp* to bioremediate waste water to acceptable effluent disposal standards with lower operational costs. In order to evaluate its efficacy, *Oscillatoria spp* was propagated in Allen's blue-green algae media for 14 days until a concentration of 1500 to 2000mg/l was obtained. After that, different concentrations were inoculated in 3 waste water samples. The COD , nitrates-N, phosphorus, turbidity, temperature and pH of the water samples were analysed after every 48 hours for 14 days in order to evaluate the retention time and effect of *Oscillatoria* on each characteristic with time. This bioremediation method proved to be effective in the absence of any heat or oxygen supply as there was a total reduction in soluble COD of 26.6%, 54.11%, 72.47%, 90.82% and dissolved phosphorus of 38.11%, 45.35%, 73.53%, 97.41% and nitrate-N of 48.09%, 50.14%, 71.42%, 86.23% and turbidity of 9.05%, 24.76%, 61.71%, 75.74% for control 2, experiment 1, 2 and 3 respectively. The effluent from experiment 3 was found to fulfil the effluent disposal regulation standards and was classified under the blue polluter pay principles. It can be concluded that the concentration of *Oscillatoria* was proportional to the rate and time taken to bioremediate the waste water as the maximum reduction was from the highest concentration of algae. However there is need to assess the bioremediation ability of other algae types so as to find effective alternative bioremediation agents and improve the conventional treatment technologies.

PRODUCTION OF SINGLE CELL PROTEIN FROM WHEY FOR USE AS AN ANIMAL FEED SUPPLEMENT USING *BACILLUS SUBTILIS* AND *SACCHAROMYCES CEREVISIAE*

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The aim of this work was to produce Single Cell Protein (SCP) from whey using Bacillus subtilis and Saccharomyces cerevisiae. Whey was heated treated with acid and sterilised, it was then used as a substrate for Bacillus subtilis and Saccharomyces cerevisiae in 30 hours long fermentation. SCP was successfully made from whey using Bacillus subtilis and Saccharomyces cerevisiae. The highest amount of biomass, 23.14 g/l dry weight was produced using a mixed culture of Bacillus subtilis and Saccharomyces cerevisiae. COD was reduced in the final treated whey by 57.85% from 76.8g O2/l to 32.37g O2/l in the mixed culture fermentation which was the greatest percentage reduction in whey COD. The optimum growth conditions determined from the fermentations for SCP production (mixed culture: Bacillus subtilis and Saccharomyces cerevisiae) is 30o C and pH 4.15 – 6.9. Single cell protein is a valuable product and was produced successfully from a waste product - cheese whey, whilst significantly reducing the COD of waste whey by 57.85%.

Keywords: *Single cell protein, Bacillus subtilis, Saccharomyces cerevisiae, animal feed*

INVESTIGATION OF THE EFFECT OF CACTUS EXTRACT AND COAL ASH ON BIOLOGICAL OXYGEN DEMAND, TOTAL SUSPENDED SOLIDS, CHEMICAL OXYGEN DEMAND AND PH OF BREWERY AND DAIRY WASTEWATER, TO DESIGN A BIOREMEDIATION MODEL

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The capstone project mainly focussed on the comparative study of cactus powder, activated coal ash and aluminium sulphate on the wastewater treatment. The release of wastewater from industries into the environment, has led to high risks of water pollution in water bodies. The cactus powder was used as a biocoagulant and activated coal ash was used as an adsorbent. The combination of cactus powder and activated coal ash allowed for the reduction of Total suspended solids (TSS), biological oxygen demand (BOD), and chemical oxygen demand (COD) in the wastewater. The percentage changes of the physiochemical parameters were 92.95%, 82.4% and 77.4% respectively. The pH was increased from 4.065 to 5.47. The experiment showed that the coal ash and cactus powder were effective in the wastewater treatment. The results obtained led to the design of a bioremediation model using 20g/L activated coal ash and 4g/L cactus powder. The cactus plant and activated coal ash were seen to be effective in the wastewater treatment, and are more biofriendly as compared to the use of chemical substances.

DEVELOPMENT AND EVALUATION THE EFFECTIVENESS OF A MYCORRHIZAL FUNGI (GLOMUS SP) INOCULANT COMBINED WITH RHIZOBIUM ON THE GROWTH OF GROUNDNUT (*ARACHIS HYPOGEA VAR NATAL* COMMON)

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Groundnut production has been fluctuating over the years in Zimbabwe and biofertilizers like Rhizobium inoculants were introduced in a bid to enhance growth and yields of groundnut and also as a means to control the over use of chemical fertilizers. However, the response of groundnut to Rhizobial inoculation proved to be poor due to failure to characterize strains that are specific in infecting groundnut. The aim of this study was to develop and evaluate the effectiveness of mycorrhizal fungi (Glomus sp) combined with Rhizobium on the growth of groundnut. This is because legume plants are reported to form a tripartite association with the fungi and Rhizobium in a symbiotic manner. Mycorrhizal fungi were isolated from native Zimbabwean soil and this was also used in conjunction with a pure mycorrhizal inoculant as a standard. Evaluation of the combined effects was carried out under greenhouse conditions on the Natal common groundnut variety and two Rhizobial strains were also used to evaluate which strain performed better. Results were collected at 60 and 80 days after planting. There was a significant increase on the growth parameters (plant height, canopy length and fresh biomass) for plants with dual inoculation of mycorrhizae and Rhizobium. Results elicited that nitrogen content increased by 0.4% in plants inoculated with mycorrhiza and Rhizobium from that with Rhizobium inoculation only. This conforms to the reports by Thiagarajan and Ahmad, 2003, that mycorrhizal fungi release factors which stimulate Bradyrhizobial activity hence increasing plant yield. Therefore, it is evident from this study that the use of mycorrhizal fungi in combination with Rhizobium was found to enhance groundnut yield and the response to Rhizobium inoculation.

SOLID STATE FERMENTATION OF WHEAT BRAN WITH *ASPERGILLUS NIGER* AND *CANDIDA UTILIS* FOR FORMULATION OF POULTRY FEED

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The method of producing poultry feed in Zimbabwe has always involved the addition of feed ingredients and supplements such as protein supplements. The protein supplements are very expensive. The present study is concerned with solid state fermentation of wheat bran using *Aspergillus niger* and *Candida utilis* in formulation of poultry feed. The method of solid state

fermentation produces cell biomass that is rich in protein which can be used to replace the importation of expensive protein supplements. In the study, wheat bran substrate was inoculated with mixed and individual cultures of *A.niger* and *C.utilis* to make five different treatments namely A, B, C, D and E which was the control. There was no inoculum added to E. The solid state fermentation was carried out under controlled temperature and pH for a period of 21 days. The yeast cell biomass produced after fermentation was then weighed, dried and measured for protein content. The highest crude protein analysed, 44.29% was in treatment D which had mixed cultures of *A.niger* and *C.utilis.* The lowest protein content was 4.10% in treatment E with no inoculum. Temperature increased as fermentation progressed with the highest temperature recorded being 35.4°C. The pH decreased from 4.50 to 4.28 then increased to as high as 5.50. Poultry feed was formulated successfully and compared for nutritional analysis with the one already on the market. The results of this study showed that yeast and fungal solid state fermentation is effective for enhancing the nutritive value of formulated poultry feed through single cell protein enrichment. Thus this complements or substitutes the importation of protein supplements for formulation of poultry feed. The researcher recommends the incorporation of other microorganisms such as Lactobacillus (LAB) species in order to add value to the poultry feed and produce not only a fermented feed but also probiotic feeds in nature.

INVESTIGATION OF THE ANTIMICROBIAL EFFECTS OF *ERYTHRINA ABYSSINICA* (MUTITI) EXTRACTS ON COMMON ANIMAL PATHOGENIC BACTERIA

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In Zimbabwe agriculture plays a vital role in the economy. Over 70% of Zimbabwe's population rely on livestock production as a means of income. Livestock diseases have devastating outcomes on animal health and impact on national and international trade remain endemic in many parts of the world. The main objective of this study was to evaluate the in vitro antimicrobial activities of crude extract of *Erythrina abyssinica* using well diffusion method. Standard bacteria cultures of *Salmonella typhimurium*, *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* were used to determine the minimum inhibitory concentration (MIC) of the plants methanolic, through standard microbial techniques obtained from the Central Veterinary Laboratory, Harare. Zones of inhibition of *Erythrina abyssinica* methanolic extract at different concentrations of 25mg/ml, 20mg/ml, 15mg/ml, 10mg/ml, 7mg/ml, 5mg/ml, 2mg/ml and 1mg/ml was used to determine the zones of inhibition on different bacterial cultures. The solvent used for extraction (DMSO) was used as a negative control and gentamycin was used as a positive control. Comparison was computed for susceptibility of bacterial species and considered significant at $p<0.05$. The results were found to be significant with p value 0.005. Established phytochemical tests were performed to show the presence or absence of secondary metabolites. All the plant concentrations showed

activity against the test presumptive bacteria. *Erythrina abyssinica* was most active against the gram positive *Staphylococcus aureus* (21.833 mm) followed by gram negative bacteria Salmonella Dublin (19.333 mm) and *Pseudomonas aeruginosa* (16 mm). The MICs ranged from 1mg/,l-5 mg/ml. Phytochemical tests show the presence of tannis, saponins, alkaloids, terpernoids flavonoids and cardiac glycosides.

EXTRACTION OF CRUDE MUSHROOM ALCOHOL (1-OCTEN-3-OL) FROM *PLEUROTUS OSTREATUS* (OYSTER MUSHROOM) AND ASSESSING ITS ANTIBACTERIAL ACTIVITY AGAINST *STAPHYLOCOCCUS AUREUS*, *ESCHERICHIA COLI* H2599, *PSEUDOMONAS AERUGINOSA*, AND *SALMONELLA TYPHIMURIUM*

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The world of mushrooms is one of endless fascination and inexhaustible intrigues. Mushrooms are miniature chemical factories producing compounds of commercial value which have not been fully explored to benefit mankind. Oyster mushroom (*Pleurotus ostreatus*) is one such mushroom which was used in this study to successfully isolate 1-octen-3-ol commonly known as mushroom alcohol. The isolated compound was tested for antibacterial activity on most problematic bacteria in Zimbabwe and many sub-Saharan countries causing stomach problems and skin infections. The test microorganisms used in the study included *Staphylococcus aureus*, *Escherichia coli* H2599, *Pseudomonas aeruginosa*, and *Salmonella typhimurium*. The method used was the freeze separation technique and trans-fatty acid entrapment using ascorbic acid. An amount of 600grams of mushroom was used in this study which resulted in 84ml of crude 1-octen -3-ol from a total of 150ml liquid content translating to 80% extraction efficiency. Freezing was done to separate water content from the liquid extracts which resulted after mushroom pressing. Centrifugation was done at 1000rpm for 30mins to speed up the trans-fatty acid entrapment process. The disk diffusion method was used to determine the results while the analysis of variance and post hoc statistical analysis methods were used to authenticate the results of the research. Two commercially available antibiotics were used namely Streptomycin and Methicillin. All the test bacteria were none resistant to the control antibiotics The crude 1-octen-3-ol was partitioned into 3 concentrations of 25%,50%and 100% of which 25% was determined to be the minimum inhibitory concentration in the study. The highest sensitivity was noted on *Salmonella typhimurium* and lowest on *Staphylococcus aureus*. Furthermore 1-octen-3-ol showed more potency than Streptomycin in its bactericidal effect on *Staphylococcus aureus*. This research showed a greater promise for Oyster mushrooms for recommended use in pharmaceutical industry and in making healthy foods, flavours, or additives.

PLASMID PROFILING OF ANTIBIOTIC RESISTANT *STAPHYLOCOCCUS* AND *STREPTOCOCCUS* SPP AND DETERMINATION OF THEIR SUSCEPTIBILITY TO INHIBITION BY CHLORELLIN

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Mastitis is a crucial disease of cattle that has become difficult to treat due to the emergence of bacterial antibiotic resistance of the causative pathogens to inhibition by traditionally effective antibiotics. The aim of this study was to investigate the effect of *Chlorella vulgaris* against antibiotic resistant *Staphylococcus* and *Streptococcus spp* isolates from mastitic milk samples and to analyse their plasmid profiles to evaluate their resistance factors. *Staphylococcus aureus* and *Streptococcus agalactiae* were isolated from mastitic milk samples and presumptively identified using biochemical tests and morphology. Determination of resistance to commercially available antibiotics (Penicillin, Sulphamethoxazole, Gentamicin, Streptomycin, Ciproflaxin, Amoxicillin, Erythromycin, and Kanamycin) was done using the disc diffusion method. Plasmid profiling of the isolates was done using gel electrophoresis. Susceptibility to inhibition of the isolates by *C. vulgaris* was tested using the disc diffusion method at concentrations of 1, 1.25, 2.5,5 and 10mg/ml. *S. aureus* and *S. agalactiae* were concluded to be susceptible to10mg/ml *C.vulgaris* with respective diameters of the zones of inhibition being 40mm and 35.34mm. The plasmids for both isolates were found to be 7000bp size. It was found that *C. vulgaris* is a potential antibiotic for mastitis and that there is a high probability that *S. aureus* and *S. agalactiae* harboured resistance genes.

IN SILICO DESIGN OF A QUICK RESPONSE DIAGNOSTIC KIT FOR *VIBRIO CHOLERAE* DETECTION IN STOOL SAMPLES

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The maintenance of health and well-being is the main goal of many national healthcare systems with strategies employed for disease control and prevention. The rate and extent of spread of disease threatens this goal especially when dealing with infectious or communicable diseases such as cholera. Control and prevention largely depends on early diagnosis and detection followed by treatment. The aim of this project was to design a preliminary rapid diagnostic kit for cholera that is user friendly and that can be used with minimal expertise and equipment for domestic use while giving results within a short time frame of under 15 minutes. The kit was to be used on stool samples. The diagnostic kit was designed based on the enzymatic activity of the causative pathogen, *Vibrio cholerae*, and its enterotoxin. The test was designed on the biochemical tests- oxidase reaction using tetramethyl-p-phenylenediamine dihydrochloride (TMPD), and the nitrate reaction using Griess reagent. The design was developed based on

literature research and databases such as PubChem and PDB to gather data on characteristics and properties of the pathogen and the enterotoxin as well as structures used in validation of the design. The test was validated using molecular docking of the enterotoxin subunits with TMPD and showed binding affinity of -3.9 to -4.6 for subunit A of the enterotoxin and binding affinity of -4.5 to -4.7 for subunit B. Molecular docking also showed that there eight possible binding sites for each subunit within a small range of binding affinity values. These high binding affinities show that there is high interaction between the reagent and the enterotoxin which translates to the reagent being suitable for use as a diagnostic tool that gives a colour change within the intended 15 minutes. The diagnostic kit was determined to be used along with the colour of the stool to eliminate misdiagnosis due to presence of other Enterobacteriaceae. A biochemical reaction-based rapid diagnostic kit can be developed for cholera using the oxidase and nitrate reactions.

PRODUCTION OF ALPHA AMYLASE FROM *BACILLUS SUBTILIS* ISOLATED FROM INDIGENOUS SOIL USING POTATO STARCH UNDER SUBMERGED FERMENTATION

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Alpha amylase is one of the most utilized enzymes in the world, and its hydrolytic properties have seen it being used across various industries. It has application in textiles, detergents, food, and biofuel, making it a product on demand. In Zimbabwe, amylase among other enzymes are acquired through importing from developed countries, and the overall cost of enzyme imports was over USD 1 million in 2010 and is estimated to be much higher with the increase in demand over time. There is, therefore, an opportunity and a window to commercially produce alpha amylase in Zimbabwe for local consumers to meet the demand and eventually tap into the international market for enzymes that comprises of various countries in Africa with growing economies. *Bacillus subtilis* is a common bacterium used as a source of various commercial enzymes including alpha amylase making up 50% of the enzymes used in industry. *B. subtilis*, although being ubiquitous, has not been adopted for the production of enzymes of any kind in Zimbabwe, meaning that its viability and properties have not been identified in an indigenous study. In this research, *B. subtilis* was isolated from local soil samples collected from Greencroft in Harare. Isolates were screened for amylolytic activity on starch agar then subjected to submerged fermentation over 72 hours. The highest amylase activity was 12.5 U/ml, obtained after 72 hours at 50oC between pH 7 – 8 and 1% starch as the carbon source. The results indicated that the Greencroft *B. subtilis* isolate produces a thermostable amylase. This amylase can be used in biofuel production by companies like Green Fuel and equally the same in the production of alcoholic beverages as both require fermentation of sugars.

ISOLATION AND CHARACTERISATION OF INDIGENOUS *XANTHOMONAS CAMPESTRIS* ISOLATES ON *BRASSICA OLENACEA VAR CAPITATA L* FOR XANTHAN GUM PRODUCTION

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In industrial production stabilizers are some of the most expensive ingredients. Most fast moving consumer goods manufacturers in Zimbabwe are importing stabilizers from Europe and Asia at very high costs and there are shortages in foreign currency for importation resulting in compromised product quality. *Xanthomonas campestris* a source of one of the most common stabilizers, xanthan gum is locally available. The project seeks to initiate the production of xanthan gum in Zimbabwe through the determination of a competent starter culture. The objectives of this project were to isolate the *Xanthomonas campestris*, characterise the isolates, determine the growth kinetics and produce a competent starter culture. The infected cabbages were obtained from horticultural plots in the Midlands province of Zimbabwe and various techniques and tests were used in the isolation and characterisation of the isolates from the black rot. These included morphological and biochemical characterisation, biopolymer production tests, plasmid profiling and hrc gene tracking using the conventional polymerase chain reaction. The growth kinetics of the putative samples were determined and calculated using optical density results from light spectrophotometry. Biopolymer production levels were determined by fermentation for 72 hours and downstream processing using centrifugation, vacuum filtration and precipitation techniques. 5 isolates labelled number 1, 3, 4, 5 and 6 passed all the tests they were subjected to under characterisation and samples 4 and 6 qualified to be the best candidates for starter culture production. Sample 4 had a doubling time of 23 hours with the maximum biopolymer yield 86.7% of the established 4.75g/litre. Sample 6 had a doubling time of 10.7 hours, taking 25 hours to reach the stationary growth phase and had 83.4% biopolymer yield. Further molecular characterisation of the starter cultures (isolates numbers 4 and 6) through sequencing is highly recommended to establish their identity and for further research including genetic engineering. Research on the use of locally available cheap fermentation substrates can be carried out as yeast malt agar is relatively expensive.

THE EFFECT OF LIGNINOLYTIC ENZYMES EXTRACTED FROM *PLEUROTUS OSTREATUS* (OYSTER MUSHROOM) ON THE TREATMENT OF TANNERY WASTE WATER

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Tannery wastewater (TWW) is one of the most important sources of environmental pollution and when discharged into water bodies can pose threats to people's health. White rot fungi such as *P.ostreatus* has been reported to produce ligninolytic enzymes that play a significant role in the degradation of organic and inorganic pollutants. The purpose of the research project was to determine the efficacy of using ligninolytic enzymes (Lignin Peroxidase, Manganese peroxidase and Laccase) and the optimum time for the bioremediation of tannery waste water for it to reach acceptable effluent disposal standards. Tissue culture of *P.ostreatus* was first carried out and spawn was produced using wheat grain. Pottasium phosphate buffer was added to the ground spawn for crude extraction of ligninolytic enzymes. The filtrate was obtained and centrifuged to obtain the supernatant. The sample filtrate was assayed to determine for the presence of ligninolytic enzymes using different substrates for each enzyme. Spectrophotometer readings of the sample were taken and the increase in absorbance with respect to time determined the presence of ligninolytic enzymes. The enzyme filtrate was mixed with TWW followed by agitation on a magnetic stirrer for 1hr, 2hr, and 3hrs with respect to each sample. The TWW was characterized before and after treatment to note the changes in COD, BOD, pH, TSS, Microbial population, color and odor. ANOVA was carried out using SPSS. The significant value was $p<0.05$ for all the tested parameters, therefore showing that there was a statistically significant difference in the treatment method.2hours was the optimum time required for the treatment of Tannery waste water. The decrease in pH, Chemical oxygen demand (COD), Biochemical oxygen demand (BOD), Total suspended solids (TSS) and Total dissolved solids (TDS) was proof that the fungi *P.ostreatus* produced ligninolytic enzymes that utilised the oxidative organic compounds as substrates and degraded them into simple inorganic non-pollutant compounds.

Keywords: *Pleurotus ostreatus, Tannery waste water, Ligninolytic enzymes, COD, TDS, BOD, TSS, Ph*

EVALUATION OF FERMENTED LOCAL CREAM FLESHED *IPOMEA BATATAS* (SWEET POTATO) FOR THE DEVELOPMENT OF AN INFANT PUREE

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Ipomea batatas commonly known as sweet potatoes in English and mbambaira in Shona, is said to be the seventh important food crop after wheat, maize, cassava, rice, potato and barley. Fermentation is a biological process that entails conversion of large biomolecules into smaller mediated by microorganisms. Complementary foods, also known as 'weaning foods'

or 'baby foods', facilitate the transition from a liquid diet based on breast milk and/ or infant formula, to one which includes solid foods. According to WHO 2015 statistics annually 4.5 million children between the ages of 0-5 die annually and a third of the deaths are credited to malnutrition. Malnutrition is the lack of adequate nourishment in the body and this lead to deficiencies, which eventually lead to death. Producing a puree from local fermented sweet potato variety will help in providing an affordable food with improved nutritional quality. The aim of this study was to develop an infant puree from fermented local cream fleshed sweet potato variety. The sweet potatoes were cut into thin pieces, dried at 65^{o}C for 31 hours, and ground into flour. *Lactococcus lactis* was isolated from lacto (from Dairiboard) on MRS media, incubated for 48 hours at 37^{o}C. Solid state fermentation method was used and the sweet potato paste was fermented for 60 hours at room temperature. pH was measured at 24-hour intervals and the pH of the final product was 4.15 and the product was brownish, creamy and had a sweet smell and tangy taste. Fermented sweet potato puree was developed, though the process can be optimized for efficiency.

OPTIMIZATION OF THE POLYMERASE CHAIN REACTION - RESTRICTION FRAGMENT LENGTH POLYMORPHISM (PCR - RFLP) GENOTYPING METHOD FOR MYH9 GENE VARIANTS IN CHRONIC KIDNEY DISEASE AMONG ZIMBABWEAN ADULTS

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Polymerase Chain Reaction-Restriction Fragment Length Polymorphism (PCR-RFLP) relies on successful optimization of the reaction. Clinical studies mainly developed for Caucasian populations tend to differ or fail for African populations such as in the case of MYH9 gene polymorphism genotyping. Hence, genomic DNA was isolated from whole blood of 83 Zimbabwean adults. PCR-RFLP conditions were optimized for MYH9 variant rs11089788 based on the use of different concentrations of reagents and thermal cycling conditions. Optimal amplification resulted from 2mmol/l magnesium chloride, 0.2mM dNTPs, 1.0 µM each of forward and reverse primers, 0.1 units of *Taq* polymerase, annealing temperature of 55^{o}C for 45 seconds and 35 cycles. UV transillumination was used to view amplicons on ethidium bromide stained agarose gel electrophoresis of 2% and 3% before and after restriction endonuclease activity respectively. Reproducible amplifiable products using optimized conditions were observed in all rs11089788 PCR reactions. Thus, the results indicate the optimized protocol for PCR-RFLP of MYH9 gene variant rs11089788 from genomic DNA of Zimbabwean adult population is suitable for further work in allele frequency determination and relation to Chronic Kidney Disease (CKD) susceptibility.

PRODUCTION OF A-AMYLASE BY *ASPERGILLUS NIGER* UNDER SOLID-STATE FERMENTATION USING POTATO PEEL WASTE

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Currently in Zimbabwe there is no local enzyme production which forces companies to import enzymes such as α-amylase from other countries. The aim of this study was to produce α-amylase under solid state fermentation *by A.niger* using potato peel waste as carbon source. *A.niger* was isolated from soil and cultivated on PDA, a selective media for fungi. Morphological characteristics observed using LCB staining method helped in identifying the *A.niger*. Starch hydrolysis test was used to confirm if amylase was being produced by the fungal isolates. Solid state fermentation was done in conical flasks assessing parameters including pH, temperature and incubation period. The optimum temperature for α -amylase production was 30°C and pH 5. An incubation period of 72 hours was observed to be the best for maximal α -amylase production. Ammonium precipitation and dialysis were used to partially purify the enzyme and its activity was 1455U/ml. The final α-amylase produced was a brownish liquid. For further research studies a comparison of the enzyme's efficiency to the other α-amylase products available on the market needs to be done. The enzyme needs to be further purified as well to increase its activity.

IN SILICO BASED DESIGN AND FORMULATION OF A POSSIBLE BIOPESTICIDE AGAINST *SPODOPTERA FRUGIPERDA* AND *APHIS GOSSYPII* GLOVER PLANT PESTS DERIVED FROM PROTEIN AND NON-PROTEIN PLANT LEAF EXTRACTS OF *COLOCASIA GIGANTEAN*, *ROSMARINUS OFFICINALIS*, *ALOE VERA* AND *VIGNA UNGUICULATA*

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Three Major xenobiotic degrading enzymes of *Spodoptera frugiperda* (CP 450), *Aphis gossypii* (Glutathione S-transferase sigma-2), *Acyrthosiphon pisum* (Tyrosine 3 monooxygenase) and *Myzus persicae* (CP 450) were modelled and validated i*n silico*. Protein-ligand and protein-protein dockings were performed to investigate the molecular interactions of the target armyworm and aphid receptors with the studied ligands (calcium oxalate, aloe emodin and camphor) and cow pea (Cp) leaf thionin proteins respectively. Aloe emodin showed the strongest affinity towards

most of the target pest proteins with a binding affinity of (-8.9) kcal/mol (Tyrosin 3 monooxygenase receptor) while Cp thionin-3 protein showed a strong binding affinity of (-1840.5) kcal/mol towards *S. frugiperda* Peritrophin membrane protein-1. Most of the docking results reflected a high toxicity potential of the plant extracts toward the pests under study. Based on *in silico* and laboratory results, plant extracts from *Vigna unguiculata, Colocasia gigantean, Rosmarinus officinalis* and *Aloe vera*, from which the studies ligands are derived, showed to have pesticidal properties against the plant pests under study. In the performed assays, *Colocasia gigantean* leaf extract showed to be the most toxic towards the *Spodoptera frugiperda* larvae showing a toxicity percentage of 96.7 while the *Vigna unguiculata* leaf extract showed to be most toxic towards *Aphis gossypii* with a toxicity percentage of 94.9. Two pesticide products were formulated from the studied plant leaf extracts targeting *Spodoptera frugiperda* larvae and *Aphis gossypii*.

EXTRACTION AND PURIFICATION OF SOYBEAN PEROXIDASE FROM SOYBEAN (GLYCINE MAX) SEED COATS (HULLS) FOR THE TREATMENT OF INDUSTRIAL WASTEWATERS CONTAINING PHENOLS AND ITS DERIVATIVES

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Soybean peroxidase was extracted from soybean seed-hulls and partially purified using ammonium sulfate precipitate and dialysis and finally packaged. The removal of aqueous phenol and phenolic compounds (in tannery wastewater) using crude soybean peroxidase (SBP) in the presence of hydrogen peroxide was investigated. To assess the efficiency of removal of phenolic compounds glass vial reactors with 80ml of wastewater and different dosage combinations of hydrogen peroxide and crude enzyme extract were used, the treatment was done for 24hours. After extraction at pH 5 and 6, catalase inactivation was carried out, and the activity of the crude enzymes were 3.325 and 4.771U/ml respectively. Soybean peroxidase with an activity of 4.771U/ml was purified by ammonium sulfate (AS) precipitation and dialysis. Soybean peroxidase increased activity from 4.771U/ml to 9.84U/ml by purification. This was packaged as the final product. Efficient degradation of phenolic compounds was observed at 10ml H2O2 and 40ml crude SBP dosage combination in both wastewaters. From an initial of 4g/l in synthetic wastewater 68.75% phenol degradation was achieved whereas from an initial of 0.127mg/l of total phenolic compounds in tannery wastewater 79.53% degradation was achieved after 24hours of treatment. Crude soybean peroxidase can be applied as one of the cheap and fast methods for removal of phenolic compounds and dyes that maybe present in tannery wastewater.

OPTIMIZATION OF LIPASE PRODUCTION BY SUBMERGED FERMENTATION OF GROUNDNUT SHELLS USING *ASPERGILLUS NIGER* STRAINS FROM ZIMBABWEAN SOURCES

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This project was carried out in order to optimize lipase production by submerged fermentation of groundnut shells using *Aspergillus niger* strains from Zimbabwean sources. In this study, three (3) isolates of *A. niger* were obtained from soil contaminated with oil. Samples of soil contaminated with oil were collected randomly in different areas of Harare (Highlands and Belvedere) and were used to prepare serial dilutions of up to 10-4. Suspensions from each dilution were inoculated in Potato Dextrose Agar plates and then incubated. *A. niger* was identified with reference to the manuals of Barnett and Hunter (1972) and Mycology online of Ellis (2006). *A. niger* isolates were screened for lipase production on Tween 20-containing medium. The diameter of the white precipitate along the periphery of *A. niger* isolate 1 and isolate 2 in Tween 20-containing medium was found to be 17mm and 22mm respectively. The best lipase producer (isolate 2) was used to optimize fermentation process parameters (pH, temperature and inducer concentration) during lipase production. Lipase production was carried out at different pH conditions (4, 5, 6 and 7), incubation temperatures (25°C, 27°C, 30°C and 35°C) and olive oil concentrations (1%, 2% and 3%). Optimum conditions for lipase production by submerged fermentation of groundnut shells using *A. niger* were found to be pH 7.0, incubation temperature of 30°C and 2% olive oil concentration. Maximum lipase activity was found to be 17.66U/ml under the optimized fermentation conditions. Based on this study, it can be concluded that the overall lipase activity obtained was significantly higher when compared to other studies and can be considered for large scale production of lipases in Zimbabwe.

COMPARATIVE ASSESSMENT OF EFFECT OF GINGER EXTRACTS AND BACILLUS SUBTILIS AS METHODS OF BIOCONTROL OF SOFT ROT DISEASE IN IRISH POTATOES DURING STORAGE

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Irish potatoes are the fourth most important staple in the world and are becoming popular food crop in Zimbabwe and is being grown as a staple substitute in the country. However, most growers in the country a facing a challenge of significant post-harvest losses of tubers ranging from 20 to 80% leading to significant financial losses. This is due to soft rot disease caused by *Pectobacterium carotovora* (soft rot). The main objective of the study was to assess the effects of Bacillus subtilis and ginger extracts on the soft rot bacteria that causes the soft rot disease. *P. carotovora* was isolated from a tuber that showed signs of infection by the bacteria and the isolates obtained were confirmed and identified by the use of biochemical tests. An antagonistic bacteria (*Bacillus subtilis*) and plant extracts (ginger essential oil) were assessed as potential biological control methods. The agar disc diffusion test, tuber slice assay and storage experiment were used to assess the effects of *Bacillus subtilis* and ginger essential oils on soft rot bacteria. Zones of clearance created by ginger oils were wider with an average of 22.50mm as compared to those of *Bacillus subtilis* with an average of 16.25mm. The results obtained from the study show that *Bacillus subtilis* is more effective at reducing the incidence and severity of bacterial soft rot in potatoes in storage that ginger essential oils without leaving a residual smell. Change in mass was used as the parameter of choice to determine and assess the effect of ginger oil and *B. subtilis*. Percentage loss in mass of tubers with *B. subtilis* was 7.2% as compared to that of tubers treated with ginger oils which was 9.12% after incubation for 5weeks. It was concluded that both ginger essential oils and *B. subtilis* are effective methods of control against soft rot disease with *B. subtilis* being the most effective in storage. A bioformulation based on *Bacillus subtilis* was made as it showed the best results using vermiculite as an inorganic carrier to improve the shelf life of the biopesticide.

EVALUATING THE ANTIFUNGAL EFFICACY OF ALOE VERA (*A.BARBADENSIS MILLER*) AND MORINGA (*MORINGA OLEIFERA*) LEAF EXTRACTS ON INHIBITION OF AFLATOXIN PRODUCING FUNGI IN GROUNDNUTS

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Aspergillus flavus and *Aspergillus parasiticus* are fungi which produce aflatoxin as secondary metabolites. These toxins are found in a number of commodities especially those used for animal and human consumption. They have been a threat in human health as well as animal health because they cause aflatoxicosis and may lead to cancer especially aflatoxin B1. The aim of the experiment was to evaluate the antifungal efficacy of *aloe vera* and moringa leaf extracts on inhibition of aflatoxin producing fungi (*A. flavus* and *A. parasiticus*) in Zimbabwean groundnuts. Solvent extraction method using acetone, methanol, chloroform and distilled water was done to extract antifungal compounds in *aloe vera* and moringa leaves. *Aspergillus flavus* and *Aspergillus parasiticus* strains were isolated from infected groundnuts samples. The antifungal activities of extracts were determined using blotter method, disc diffusion and

well plate method. *Aloe vera* chloroform extract prove to be efficient in inhibiting the fungal growth on all the three methods. There was a significant difference ($p<0.05$) between solvents used and the antifungal activity of extracts using one way analysis of variance.

COMPARATIVE INVESTIGATION OF THE EFFECTIVENESS OF AZOSPIRILLUM SPP. AND ASPERGILLUS NIGER IN UTILIZING MOLASSES AND EICHHORNIA CRASSIPES (WATER HYACINTH) SUBSTRATES IN THE PRODUCTION OF A NITROGEN-PHOSPHORUS BASED BIOFERTILIZER

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The agricultural sector has been estimated to produce about 5.1 to 6.1 gigatonnes of carbon dioxide per annum, these amounts are to present the world with pollution problems. The use of chemical fertilizers promotes the growth of noxious weeds and algal blooms formation in lakes resulting in the death of aquatic life. Water hyacinth is a noxious weed that is causing problems to fisheries, hydropower plants and recreation in many tropical and subtropical lakes. This weed is currently a menace in Lake Chivero. The project is to produce a biofertilizer that is environmental friendly and also capable of suppressing the incidence of soil borne plant pathogens. *Aspergillus niger* and *Azospirillum spp*. were used for the production of the biofertilizer. A pure culture of A. niger was used and the *Azospirillum* was isolated from soil. For isolation of *Azospirillum*, soil samples were collected from the rhizosphere of the maize plants. Serial dilutions were conducted and the aliquot was cultured on Glucose Norris Nitrogen free media and white colonies were then cultured on *Azospirillum* media. Colonies from the *Azospirillum* media were on cultured on basal minimum salt media. Validation of the *Azospirillum* was done using the gram staining technique. The cultivation of *A. niger* was done on SDA+C. Starter cultures were prepared by culture of the two microorganisms in nutrient broth. Production of the biofertilizer was done by fermenting molasses and water hyacinth. The fermentation process was carried for 7 weeks. The pH values and, number of viable cells and spores were recorded on a weekly basis. The final product contains 1.12 × 1010 cells/500g of *Azospirillum spp*. and 3.40 × 109 spores/ 500g *Aspergillus niger*, and a pH of 5.35. Simple linear regression was used to compare if there is a relationship between increase in the number of microorganism and pH changes in the fermentation reactors. The statistical analysis showed that the two variables are related. From the experiment conducted it was concluded that there is a mutual relation between *Azospirillum spp*. and *A. niger* in the production of a biofertilizer as both microorganisms were able to utilize molasses and water hyacinth in the same fermentation reactor without the other suppressing the growth of another. Further studies can be carried out on field trials to determine the concentration of this biofertilizer can be applied for plant growth and increase soil fertility.

OPTIMIZATION OF YEAST (*SACCHAROMYCES CEREVISIAE*) FERMENTATION BY SELECTIVE SUPPRESSION OF WILD YEASTS, *LACTOBACILLI SPP* AND TOTAL BACTERIA

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Wild yeast, coliform and *Lactobacilli spp* contamination is a major problem in running fermentation of yeast cultivation. Yeast cultivation at an industrial scale produces different product lines such as brewers dried yeast, active dried yeast, ethanol yeast and fresh yeast. Selective suppression of contaminants during fermentation of *Saccharomyces cerevisiae* was done using sodium metabisulphate as an antimicrobial agent. Dilute molasses (28% Strong Wort) was used as the sole carbon source, with urea, phosphoric acid and yeast extract agar used as nitrogen, phosphate and vitamin sources. An automatic stirred tank bioreactor was designed using a 25litre polyvinyl chloride container, a speed controlled impeller, air lift pump and temperature controlled heating system. Yeast fermentations were run for 24 hours at 30ºC. Temperature, pH, alcohol content were the main controlled parameters to support maximum growth of yeast. Viability and budding index were checked at 2 hour intervals to check the activity of the culture yeast. Four fermentations were run, the first one for the optimization and validation of bioreactor, a control and the other two were the experimental trials. The first experimental trial was run using 4g sodium metabisulphate and there was significant suppression of contaminants during the fermentation. The concentration of sodium metabisulphate was increased to 4.5g in the last trial fermentation and this showed to be the best concentration for suppression of contaminants while supporting growth of culture yeast. The coliform microbial load decreased from 4.10E+02 to 3.3E+0.4, wild yeast from 3.10E+02 to 1.20E+02 and Lactobacilli 7.3E+03 to 3.3E+03. Microbial analysis was done using the pour plate technique. Nitrogen and phosphorus was analysed using kjedhal method and molybido-phosphoric acid method respectively. Yeast with highest fermentative power had the highest nitrogen content to phosphate showing high enzyme activity. Yeast can grow maximally under contaminants free environment. Fresh yeast, dried yeast and cream yeast were produced.

FORMULATION OF A FUNCTIONAL HEALTH AND WELLNESS CHOCOLATE BAR USING BIOACTIVE *LENTINULA EDODES* (SHIITAKE) WITH PROTECTIVE ACTION AGAINST PREVALENT GASTROINTESTINAL BACTERIA IN ZIMBABWE

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*Lentinula edodes (*shiitake) is an edible and medicinal mushroom that can be used to promote health and wellness. It possess antibacterial, antifungal properties among others. Chocolate can be used as medical carrier substance for facilitation of health as it contains functional properties that can work to reduce coronary heart disease. Drug resistance is a responsible for the difficulties in communicable disease treatment and management, thus new pharmacological strategies can be utilised as complementary medicine for the nation of Zimbabwe. The study aims were to screen the fungal (basidiocarp and spent substrate) extract against GI bacteria common in Zimbabwe as well as formulating a carrier material for the extract that can be used for the benefit of the nation. The screening was done using Kirby-Bauer diffusion test to verify and reward susceptibility of *Staphylococcus aureus 25923, Escherichia coli 25922* and *Escherichia coli 35218* to extracts. There was no significant relationship between basidiocarp extracts and inhibition of *E. coli* species. *S. aureus* had a significant relationship with both extracts, thus susceptible. Mycelia from Malt extract and Potato dextrose agar was used to ferment wheat bran in the presence of sodium phosphate buffer at pH 5. Solid substrate fermentation occurred for a period of 45-90 days and the spent substrate was used for extraction. The extract was used for sensitivity testing against the test microorganism. The spent substrate extract resulted in a different mechanism of action against bacterial species, though no clear zone of inhibition was observed. A chocolate bar with 4.6% *Lentinula* powder formula was formulated.

PRODUCTION OF SUPERABSORBENT PHYTOFORTIFIED *PLEUROTUS OSTREATUS* (OYSTER MUSHROOM) CHITOSAN HYDROGELS AS POTENTIAL GRAIN PROTECTANTS AGAINST TOXIGENIC STORAGE FUNGI OF PUBLIC HEALTH SIGNIFICANCE

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Toxigenic storage fungi rapidly colonize grain and seed repositories. By products of this metabolic activity include mycotoxins and micronutrients which attract secondary pests that accelerate seed spoilage. Most mycotoxins contribute to the rise in nutritional and gastrointestinal disorders that are turning into chronic ailments by the day. The spores of the mycotoxigenic fungi can also cause chronic obstructive pulmonary diseases in both humans and animals thus of public health significance. Conventional mitigation strategies solely depend on chemical control which has become an antagonistic solution to present environmental toxicology policies. The aim of this study was to use various principles of biotechnology for the bioprospecting of oyster mushroom, common botanicals and weed plants to produce a biopolymer gel that can be moulded to develop superabsorbent biostatic hydrogels as potential grain protectants towards preventing the

proliferation of these toxigenic fungi in agricultural grain and seed gene banking. Chitosan biopolymer was extracted by alkaline hydrolysis from oyster mushroom grown under solid state fermentation using wheat straw and cotton seed hulls as substrates. The highest yield was from the mushroom grown on cotton seed hulls and ranged from 84 to 88%. Phytogenic extracts from two common botanicals (*Lippia javanica* and *Ocimuum gratissimum*) and two common agricultural weeds (*Tagetes minuta* and *Bidens Pilosa*) were prepared through multivariant solvent extraction. Mycotoxigenic fungi were isolated from untreated *Penissetum glaucum*, *Sorghum bicolar* and *Archis Hypogea* incubated using the blotter and agar plate technique. Morphological characterization and microscopical examinations were carried out as confirmatory tests to screen for the case study mycotoxigenic gungi (*A. flavus* and *F. oxysporum*) that respond to sporulation. Chitosan hydrogels were produced using the radiation gelation treatment protocol, crosslinked with glutaraldehyde, stabilised with guar gum and fortified with the most potent phytogenic extract which was from *T. minuta*. It had the highest antifungal activity denoted through poisoned food method of hyphal inhibition tests (74,23% for *A. flavus* and 75.15% for *F. oxysporum*). The phytofortified hydrogels were subjected to efficacy tests to evaluate their moisture reduction extent, microbial growth inhibition level and pest inhibition capacity. The moisture content of hydrogel treated seeds dropped significantly to 10% from an initial of 30.34% after a 28-day period. The treated sample remained healthy with no pest detected contrary to the untreated samples that had a moisture content which rose from the initial by 20% and was fully infested with larger grain borer (LGB) a destructing secondary pest. It was found that the produced phytofortified oyster mushroom chitosan biopolymer hydrogels are water absorbing, antifungal and pest inhibiting making it a potential post-harvest grain and seed protectant.

Keywords: *Toxigenic, mycotoxins, gene banking, public health, chitosan, biostatic*

ISOLATION AND CHARACTERIZATION OF MICROBIAL RENNET FROM ASPERGILLUS NIGER AND ASPERGILLUS FLAVUS USING SOLID STATE AND SUBMERGED FERMENTATION AND IT'S USE IN COTTAGE CHEESE MAKING

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In the present study, a solid state and submerged fermentation of *Aspergillus niger* and *Aspergillus flavus* was carried out to produce microbial rennet for its use in the making of cottage cheese. The milk clotting activity of the microbial rennet was investigated after a 7-day incubation period. Effect of temperature and pH on the milk clotting activity was also determined. Proteolytic activity was assayed using gelatin as a substrate, through the formation of zones of clearance by the enzyme activity. The microbial rennet was then used to make cottage cheese and a sensory

evaluation of the cheese was done. After the fermentation process, milk clotting activity of microbial rennet produced by *A. niger* was 22.9 U/ml and 20 U/ml and by *A. flavus* was 21 U/ml and 19.2 U/ml in SSF and SmF respectively at 37℃ and pH 6.0. Milk clotting activity increased with increase in temperature however, an increase above 40℃ led to a decrease in the milk clotting activity and the same occurred for the effect of pH. The proteolytic assayed showed 6 and 4 mm zones of clearance for the microbial rennet produced *A. niger* and 5 and 3.5 mm for the microbial rennet produced by *A. flavus* in SSF and SmF respectively. The cottage cheese produced was relatively light and had a soft texture. The sensory evaluations indicated that all the microbial rennet samples produced a good cheese product. The study showed that *A. niger* was a better protease enzyme producer than *A. flavus*. SSF was more efficient in producing the microbial rennet compared to SmF.

ISOLATION AND IDENTIFICATION OF POTASSIUM SOLUBILIZING BACTERIA (*BACLLUS SUBTILIS*) AND TESTING ITS EFFECTIVENESS AS A BIOFERTILIZER ON LENTIL PLANT

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The purpose of this study was to test the effectiveness of *Bacillus subtilis* as a potassium solubilising bacteria on the growth of lentil plants on both sandy soil and field soil in the green house, and about 40 pots were used altogether, 20 had field soil and the other 20 were filled with sandy soil. *Bacillus subtilis* was first isolated from tobacco soil and grown on MRS and Nutrient agar for 7 days. On MRS media creamish colonise of *Bacillus subtilis* were observed and whitish were also observed in Nutrient agar and the colonies form a spore like projection in the media. The colonies of *Bacillus subtilis* were counted using a colony counter; MRS media was 8097.92 × 106 per gram whilst Nutrient agar had 2629.17 × 106 per gram. *Bacillus subtilis* culture was prepared and inoculated in both field and sandy soil and the plants were left to grow for about 6 weeks in the green house. The lentil plants were harvested from their pot and ground and dried in the oven from potassium and nitrogen analysis. The potassium content of the leaves, root and soil was determined using ammonium acetate extraction or titration and nitrogen using Keldar method. The leaves from the plants which were inoculated by *Bacillus subtilis* had highest nitrogen content (1.6% from field soil and 1.2% from inoculated sandy soil) as compared the control experiment which had the total nitrogen content of (0.4% field soil and 0.24 from the sandy soil). Nitrogen content of soil were also measured and there was an increase in the nitrogen content of the soil by 3% in field soil whereas in sandy soil it increased by 1.6%. Potassium content of leaves and roots was also measured; the roots had a total content of 37mg/l (ppm) in field soil and 33mg/l (ppm) from sandy soil while the control experiments had 25mg/l (ppm) field soil and 18mg/l (ppm) in sandy soil. The leaves from the lentils which were inoculated with *Bacillus subtilis* had highest potassium content of 68mg/l (ppm) and 62mg/l (ppm) in field and

soil respectively. The control experiment had the lowest potassium content of 47mg/l (ppm) and 28mg/l (ppm) from field and sandy soil respectively. Potassium content of the soil was also measured and there was an increase in the potassium content of the field soil by 45mg/l (ppm) and 40mg/l (ppm) in sandy soil. The experiment was successfully done hence *Bacillus subtilis* played an important role in solubilising potassium rock mineral in the soil to release potassium and therefore enhanced lentil growth.

ISOLATION AND EVALUATION OF THE EFFECTIVENESS OF *BACILLUS SUBTILIS* AS A PROBIOTIC IN POULTRY PRODUCTION AND ITS ANTIBACTERIAL ACTIVITY ON *SALMONELLA ENTERICA* AND *ESCHERICHIA COLI*

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The growing emergence of antimicrobial resistant bacteria has given rise to consumer fear that the use of antibiotics in the meat industry can lead to more antimicrobial resistant strains. As a result, alternative methods are being researched such as the use of direct-fed microbials (DFM), also known as probiotics. The use of probiotics in poultry has been shown to provide an intestinal ecosystem that benefits the bird by inhibiting the growth and colonization of pathogenic bacteria, such as *Salmonella* and *E. coli*. The aim of this study was to determine the ability of *Bacillus subtilis* to inhibit the growth of pathogenic bacteria, *E. coli* and *S. enterica* and to study its effectiveness as a poultry probiotic supplement. One important characteristic of *B. subtilis* that makes it a variable prospect as a probiotic is its ability to produce endospores. These endospores are capable of withstanding hostile environments such as high temperature and low pH. *B. subtilis* was successfully isolated from the pastoral soil. Gram staining and biochemical tests were used to identify the bacteria. Gram positive rods were observed under the light microscope and the expected biochemical tests were attained which indicated the presence of *B. subtilis*. Disk diffusion method was used to determine the sensitivity of *E. coli* and *S. enterica* to *B. subtilis* isolates. Results showed that E. coli is more sensitive to *B. subtilis* isolates than *S. enterica* because the diameter of the zone of inhibition was 12mm and 7mm respectively. Results also showed that sensitivity increase with the increase in concentration because more metabolites were present. In vitro tests showed that *B. subtilis* was able to survive in conditions found in the GIT of poultry which are temperature, pH, Nacl and bile concentrations. *In vivo* tests were performed in one day old layer chickens and the results recorded after 3 weeks showed that *B. subtilis* was able to decrease mortality rate as well as increase the weight of chickens as compared to the chickens that were not treated with the probiotic. We recommend that the *in vivo* research of the probiotic should be carried out for at least 8 weeks so as to ascertain the quality of meat and eggs of the layers chickens.

BIOCHEMICAL CHARACTERIZATION OF LACTIC ACID BACTERIA FROM NATURAL FERMENTATION PROCESS OF MILK FROM SELECTED PLACES IN ZIMBABWE FOR THE PRODUCTION OF A STARTER CULTURE

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The investigation was cariiied out so as to biochemically and physio-chemically characterize lactic acid bacteria (LAB) isolated from naturally fermented milk from selected parts of Zimbabwe for the production of starter cultures. Mother cultures were prepared from milk samples collected from Hwedza and Centenary, the curds and whey were then inoculated on MRS agar for isolation of *Lactobacillus sp* and on M16 agar for *Steptococci sp* isolation. The presumed LAB were then purified by further isolation and then characterized. The characterization was done by use of biochemical and physiochemical tests namely observation, methyl red test, vorges-praskauer's test, gelatin liquefaction test, sugar fermentation test, starch hydrolysis test as well as pH tolerance and temperature tolerance test. The results of these test were then analysed using the Bergey's manual of systematic bacteriology for the identification of the presumed LAB. After analysing the results using the Bergey's manual of Determinative Bacteriology the results suggested that the isolated bacteria were *S. thermophiles* (1), *L. bulgaricus* (2), *Lb. lactis* (3), *Lb. acidophilus* (4), *L.b delbreuckii sub lactis* (5), *Lb. delbreuckii* (10 presumed as starch hydrolysis tests were not clear) and *Lb. casei* (11). Three combinations of the bacteria (1) S. thermophiles and *Lb. bulgaricus*, (2) S. lactis ssp. *Diacetylactis, S. cremoris* and *Lb. lactis* and (3) *Lb. delbreuckii* were inoculated in milk and treated as per the ripening step in production of fermented milk products and combination (1) yielded a gelatinous yoghurt like consistency, (2) yielded curds with a solid consistency and cheese like aroma smell and combination (3) also yielded a semi-solid but crumbly curd.

OPTIMISATION OF STREPTOMYCIN PRODUCTION BY SUBMERGED FERMENTATION USING *STREPTOMYCES GRISEUS*

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The purpose of the investigation was biological synthesis of Streptomycin using *Streptomyces griseus* by submerged fermentation. This was meant to ensure local production of Streptomycin to reduce drug imports. *Streptomyces griseus* was isolated from soil samples obtained from Harare area and several biochemical tests were done to positively identify the bacteria. Several microbial strains were maintained in agar plates and used as control cultures for the biochemical tests. An airlift bioreactor was designed and provided controlled conditions for the fermentation process. Starter cultures of the Streptomyces *griseus* isolated and ATCC 10137 strains were prepared and used to inoculate the prepared fermentation media. Optimum conditions for Streptomycin yield were investigated based on glucose, starch and sucrose as carbon sources, temperature, KH_2PO_4, tween 40 concentration and the *Streptomyces griseus* strain inoculated. Streptomycin produced was recovered and purified using precipitation, filtration and crystallization. Produced Streptomycin was identified using HPLC analysis and potency was determined by bacterial susceptibility tests. Purified Streptomycin was formulated into a sulphate to increase its stability and as packaged for easy handling and protection from adverse conditions. Biomass produced was recovered, preserved and packaged to be used for organic fertilizer and feed production. A maximum yield of 1.62 g/l Streptomycin and 6.4 g biomass was expected, while an actual yield of 3.423 g/l and 3.261 g/l Streptomycin and 8.84 g/l and 9.24 g/l biomass was obtained by the researcher with the isolated and ATCC 10137 strain respectively. The optimum yield of Streptomycin was obtained with glucose as carbon source, 0.2 g/l KH_2PO_4, pH 6.5 to 7.5 and 4 ml/l tween 20. Optimum temperature was 27^{o}C and 25^{o}C for isolated and ATCC 10137 strain respectively. Isolated strain of *Streptomyces griseus* produced more Streptomycin than the ATCC 10137 strain. Streptomycin produced by isolated strain caused more bacterial inhibition than that produced by ATCC strain. The identity of the Streptomycin produced by the two strains was confirmed by HPLC. The study was a success and all objectives were met.

INVESTIGATION OF MEDIA EFFECT ON MYCELIAL GROWTH AND EFFECT OF GRAIN SUBSTRATE ON PRODUCTION OF *AGARICUS BISPORUS* SPAWN

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The production of *Agaricus bisporus* commonly known as button mushroom in Zimbabwe, is greatly affected by high cost incurred to purchase the imported spawn. The purpose of the research was to investigate media effect on mycelia growth and effect on substrate on production of *Agaricus bisporus* spawn, so as to develop a mycelia initiating protocol which

will be used local to produce spawn of this mushroom variety. To initiate spore cultures, spore prints for the button mushrooms at button and off button stage were collected aseptically in a sterile box and inoculated into the prepared Potato Dextrose Agar which is commonly used for germination. The mycelia that had been from the germinated spore was sub cultured in Malt Extract Agar, Potato Dextrose Agar, Nutrient Agar and Yeast Extract Agar to identify the most favourable media. Malt Extract Agar and Potato Dextrose Agar were the most favoured since they had the highest mean after statistically computing diameter of the mycelia in the different media formulations recorded in five consecutive days. Wheat was the mostly favoured grain substrate since it took 11 days to be fully colonized, while sorghum took 12 days to be fully colonized. However, there is need to obtain spore prints from button mushrooms at button stage to have a high probability of obtaining rhizomorphic mycelia structures with vigorous growth and to inoculate growth factors during media preparation to increase mycelia growth rate.

COMPUTER AIDED DRUG DESIGN OF THE INHIBITOR OF INFLUENZA A USING *ALOE EMODIN* AS A TARGET

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Influenza A is one of the deadliest diseases that affects both humans and animals killing both at unprecedented rates. Due to its capability of unexpectedly becoming a pandemic, research has been carried out to determine was to combat it and save lives. *Aloe Vera* has captured interest of scientists due to the discovery of its potential as a drug. Traditionally it was used to treat different illnesses without personnel knowing the mechanism by which it is healing the body. Scientists have come to call it the miracle plant as it has a myriad potential uses in medicine, cosmetics and food industry. In this study, the antiviral properties of one of its main exudates, *Aloe emodin*, was looked into on how it would treat influenza A. Since *Aloe emodin* is a ligand, it is to bind on the surface of the major surface proteins of influenza A thereby preventing it from manifesting in the host cells. Firstly, the major surface proteins responsible for penetration of the virus into the host cells were modelled using the appropriate Bioinformatics tools. After the models were obtained they underwent docking to determine the binding sites of *Aloe emodin* that required the least energy to efficiently bind and thereby prevent invasion of the virus into the host cell. The docking experiments were conducted and proved that *Aloe emodin* can successfully bind on to the viral proteins sufficiently enough to prevent penetration into the host cell. After this was proven possible certain properties of *Aloe emodin* were determined so as to check for toxicity of the ligand in the body, pharmacokinetic properties, Drug likeness and solubility. The results indicated that *Aloe emodin* was not toxic

to the body and has great potential of being used in the generation of an inhibitor of influenza A.
