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SCHOOOL OF INDUSTRIAL SCIENCES & TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

[COMPENDIUM OF HIT 300 DESIGN & INNOVATION PROJECTS ABSTRACTS 2015-2016]

The document captures the abstracts of HIT 300 Projects done by students in the School of Industrial Sciences & Technology and School of Engineering & Technology for the academic year 2015-2016

School of Engineering & Technology

Department of Chemical and Process Systems Engineering

DESIGN OF A PROCESS THAT PRODUCES 800KG PER DAY OF LITHIUM CARBONATE FROM SPODUMENE CONCENTRATE

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With the expected increase of lithium demand in the forthcoming years, an efficient management of all the available resources is necessary. Rock minerals like pegmatites and spodumene ores are important primary sources of lithium that are of great importance as they are found in large quantities in Zimbabwe. Minero-metallurgical processes have been developed for lithium recovery from spodumene ore deposits, involving physical concentration, thermal treatment, and leaching in order to obtain a lithium soluble species adequate to produce lithium carbonate by precipitation. Physical concentrations by froth flotation or by optical sorting are the two main alternative operations to produce the lithium concentrate. Metallurgical treatment starts by calcination where the silicate structure is transformed to a more reactive solid phase (β-spodumene) at a temperature of 10000C. Afterwards the concentrate is roasted with sulphuric acid at 2500C and water leached to allow the dissolution of lithium sulphate. At the same time, the solution was being stirred using a stirring speed of 400rev/min to prevent sedimentation and increase eddy diffusion. So a batch reactor was designed with a capacity of 1.5m3, stainless steel being the material of construction. The project has a payback period of 4.32 years, rate of return of 14.89% and an internal rate of return of 14.3%.

Key words: *Lithium carbonate, Spodumene concentrate, Leaching, Thermal treatment*

DESIGN OF A 1000 LITRE/DAY CONTINUOUS ADSORPTION SYSTEM FOR THE REMOVAL OF CHROMIUM IN TANNERY INDUSTRIAL EFFLUENT USING GROUNDNUT SHELL POWDER BLENDED WITH MAIZE BRAN.

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Adsorption of chromium ions from tannery effluent have been studied using groundnut shell powder blended with maize bran. The agricultural waste biomass was used in its natural form and batch adsorption experiments were performed for the removal of chromium in the effluent. Effects of pH, adsorbent dose and contact time were investigated. The metal ion removal was

dependent on the physico-chemical properties of the adsorbent, pH, adsorbent dose and other studied process parameters. The results of this study showed that adsorption of chromium using maize bran and groundnut shell reached equilibrium after 40 minutes of the experiment when the removal percentage was 99.24% and after that chromium removal efficiency decrease was observed. Maximum chromium removal was obtained at a pH value of 2 when the removal percentage reached 98.38%. A continuous addition of adsorbent dose to the solution resulted in an increase in the removal percentages of chromium until a time when any further increase would not cause much change. 50g/L was chosen as the optimum value which achieved a removal percentage of 99.236%. The adsorption of chromium by groundnut shell powder blended with maize bran was found to decrease with lower adsorbent doses, higher pH values and less contact time. The results of this study give an indication that groundnut shell powder blended with maize bran can be used as a low cost alternative to commercial adsorbents which are expensive in the removal of chromium.

Key words: *Chromium, Groundnut shell powder, Adsorbent, pH*

DESIGN OF A PROCESS FOR THE REMOVAL OF ZINC IN 4500M3 PER DAY OF LAKE WATER USING ACTIVATED CARBON FROM MAIZE TASSELS

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In this project, the design of a process for the removal of zinc in lake water using activated carbon from maize tassels is investigated. Zinc is a dietary requirement in human beings but when in excess it leads to health problems as anaemia, respiratory diseases, stomach cramps, vomiting and nausea. Lake Chivero is heavily polluted by the heavy metals and amongst them is zinc and zinc is disposed by industries that deal with galvanising of iron, paints, cosmetics and rubber. Currently there is removal of heavy metals in water using activated carbon made from other sources and this activated carbon is imported from other countries and statistics show that Morton Jaffrey uses about 3.8 tonnes of activated carbon per day. In Zimbabwe, the mostly grown crop is maize and the tassels are a waste material that lies idle after the harvesting of the maize crop. Hence this project focuses on activating the carbon in maize tassels so that they can be used as an adsorbent for removal of excess zinc in lake water. The maize tassels were chemically activated using phosphoric acid at temperatures ranging from 450 ^{0}C to 600 ^{0}C in the absence of oxygen and a yield of 44% of activated carbon from the maize tassels was obtained. The activated carbon produced was characterized in terms of pH and adsorption capacity. It was found that the above measured characteristics of the activated carbon produced compares favourably with those of some commercial grade activated carbons. A process was designed for the removal of zinc in lake water using activated carbon from maize tassels. A process control system was carried out for temperature, pressure and flow for the major equipment of the plant which is the adsorption column. An economic analysis for the process with a plant treating 4500m3 of water was conducted and it proved that the process is viable. The rate of return on investment was found to be 32.5% and the payback period of the project was found to be 3.08 years with the cost of water being $0.18 per kilolitre. In conclusion, this project is technically and economically viable as it also supports the ZimAsset agenda in providing a great benefit to the nation.

Key words: *Zinc, Activated carbon, Maize tassels, Phosphoric acid*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 60 TONS A DAY RUBBERISED ASPHALT FROM WASTE TYRES

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Permanent binders currently used in pavement overlays have a low crack resistance, noise resistance and rutting resistance, thus after cyclic loading and long exposure to sunlight, the asphalt becomes brittle due to oxidation. This results in the formation of potholes which are a sore sight and a contributor of road accidents in Zimbabwe. Concurrently, the bulky non-biodegradable waste tyre is becoming a problem both to the environmental and to the wellbeing of the society. This project seeks to present a paving binder that is modified by waste tyres thereby solving the two problems of high maintenance paving and waste tyre accumulation as it is apparent that maintenance costs are significantly reduced when paving resists cracks. Experiments were performed and a temperature of 177˚C at 30 minutes reaction time using 25% crumb rubber, were concluded as the optimum reaction conditions. The obtained results were scaled up to design an optimum process including a detailed design on the reactor. Therefore this report presents the designing of 20 cubic meter volume carbon steel reactors that modify 45 tons virgin asphalt into 60 tons a day rubberized asphalt. Process control and Hazard Operability studies (HAZOP) were done on the designed equipment to ensure safe operations. On completion of the project it was proved that it is possible to produce rubberized asphalt using this process. The economic analysis carried out showed that the project is a viable project with a payback period of 4.4 years and breakeven point of 35% capacity. Zimbabwe would benefit immensely from value addition of waste tyre.

Key words: Rubberized asphalt, Waste tyres, Non-biodegradable, Paving binder

DESIGN OF A SPINNING PACK FOR THE PRODUCTION OF DYED MICROFILAMENT POLYESTER YARN USING WASTE PET PLASTIC BOTTLES AS A SOURCE OF RAW MATERIAL.

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There is an increase in imports of synthetic yarn because of weak and bleeding of dyed yarn manufactured locally. This issue of imports of yarn raw material has resulted in high cost of production, which in turn has resulted in closure of textile companies. The objective of this project is to design a spinning pack and a unit operation of dying the molten polyester before it is spun into filaments. This will address the issue of colour bleeding in dyes and at the same time reduce both the energy expenditure and environmental effect of waste water associated with disperse dyeing. The spin pack has a capacity of 50kg/h and a total of 20 spinning packs are required to handle a capacity of 1000kg/h. Experiments were conducted to determine operating parameters of which an optimum inlet temperature of 290oC and an inlet pressure of 300psig (20.4 atm) where chosen from the analysis of experimental results. A comparison of the filter bed depth, surface area and mean surface-volume diameter of steel sands to the rate of filtration showed that a depth of 0.1m, a surface area of 0.1m2 and a surface-volume ratio of 0.4µm are favourable. Material of construction of stainless steel AISI 304 is chosen as it is cheaply available and is capable of meeting operating requirements. An economic analysis showed that the project is economical feasible with a payback period of 3.69 years and a rate of return of 27.13%.

Key words: Spinning pack, Polyester yarn, Waste pet plastic bottles, Disperse dyeing

DESIGN OF AN EXTRACTING VESSEL EXTRACTING 2500L OF PHENOLIC COMPOUNDS FROM MANGO LEAVES PER DAY

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Utilisation of mango leaves has resulted in being left for rotting and they had not yet being commercialised for value addition here Zimbabwe. Mango leaves are a rich source of phenolic compounds with an antioxidant activity. Phenolic compounds have varies application in the food,

cosmetic and pharmaceutical (cancer curing) industries. The project focuses on the design of extraction vessel with a production capacity of 2500L/day using supercritical fluid extraction. Literature has revealed various methods of extraction of phenolic compounds which include maceration, soxhlet, heated reflux, ultrasound/microwave assisted extraction, supercritical fluid extraction, and membrane filtration techniques, Kepner-Tregoe analysis was the decision matrix was used to come with best extraction method. Experiments was done in laboratory which include, the extraction of phenolic compounds using, effect of temperature and pH on extraction therefore ferric solution was used to test the presence of phenolic , 180oC and pH 4 was the best temperature and pH for extraction. The results lead to mass and energy balance carried out for the whole process. From mass and energy balance the extraction vessel of diameter 3.10m, thickness 0.455m, height 4.65m and number of plates 3 was designed. HAZOP was done which controlled the flow-rate, temperature and pressure. A detailed economic analysis was also done to access the economic feasibility of the project .The project has a payback period of 3.1 years and a return on investment of 31.93% which are acceptable financial indicators .It is conducted that it is feasible to design an economically viable and environmentally friendly process for extracting phenolic compound

Key words: *Phenolic, Mango leaves, Supercritical, Membrane filtration, pH*

DESIGN OF 75 TONNES PER DAY CARBON DIOXIDE (CO2) RECOVERY AND PURIFICATION PLANT FROM ETHANOL PRODUCTION INDUSTRY.

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Zimbabwe has no local supply of liquefied CO2 and is currently importing 27 000 tonnes annually from neighbouring South Africa, and this has proved to be expensive to the consumers of the product. In many regions of the world high quality CO2 is in short supply and a high price is paid by needy consumers. “Green CO2” recovered from the ethanol fermentation process is an ideal solution to close this CO2 gap, contribute to environment protection and generate an additional revenue stream. Ethanol is one alternative to the use of petroleum-based fuels. It is produced on a large scale in Zimbabwe from sugarcane to the magnitude of millions of litres per year. The

Chisumbanje Green Fuel ethanol plant is currently processing 5 000 tonnes of sugar cane, to produce 250 tonnes of ethanol and emitting 80 tonnes daily of carbon dioxide gas (CO2). The capital and operating costs for equipment to capture and liquefy CO2 from the ethanol plant were evaluated in this research project, and this helped to establish ethanol plant as an alternate source for CO2. Preliminary plant and equipment designs and major operating cost estimates

were determined for capture and liquefaction of 75 tons/day of CO2 for the local demand. The estimated total installed capital costs to install food/beverage grade CO2 liquefaction facilities were found to be $2.5 million for a 75-tonnes/day. In conclusion I was able to establish and characterize the amount of impurities in gas produced from sugar fermentation process. Furthermore the operating conditions for the scrubbing unit were established. The payback period was found to be 4.2 years and the return on investment was24%.

Key words: *Sugarcane, Carbon dioxide, Ethanol, Fermentation, Environment*

RECOVERY OF CYANIDE FROM MINE WASTEWATER EFFLUENTS

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Most Zimbabwe gold mines are using the cyanidation process to refine gold. This method achieves a high percentage of gold and has been in use since 1887in other countries (Korte et al. 2000).On the other hand, the process has resulted in high concentrations of cyanide being deposited into the environment. This poses dangers to humans, animals and aquatic life. Currently Zimbabwe is importing cyanide and employing a cyanide recovery method means cutting down costs on importing the chemical and at the same time reducing the amount of cyanide being deposited in mine waste water effluents. The purpose of this project is to come up with a feasible and effective method to recover cyanide from mine waste water effluents using the Acidification Volatilization Re-neutralization (AVR) process. In this process an alkaline solution is used to absorb cyanide gas from an HCN laden air. Experiments were carried out to determine the concentration of cyanide in a sample of the mine waste water effluents and most effective alkaline solution (NaOH, KOH and CaOH) to absorb cyanide gas at different pH values (3, 5 and 6).The obtained results were used to do a mass balance on the process and also do a design on the absorption column. Process control and a

HAZOP analysis were done on the designed equipment to ensure safe operations. An economic analysis was carried out and proved that the project is economically feasible with a payback period of 2.60 years and a return on investment of 38.43%.

Key words: *Cyanide, Wastewater, Acidification, Volatilization, Re-neutralization*

DESIGN OF A PROCESS FOR THE REMOVAL OF CADMIUM IONS FROM 3000L PER WEEK OF WASTE WATER USING NAOH TREATED SAWDUST AS AN ADSORBENT

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Saw dust modified with NaOH was prepared. The product was used as an absorption agent for the absorption of cadmium cations from wastewater. The uptake performance of modified saw dust (MSD) for removal of Cd (II) cations was investigated using continuous method. The influences of some experimental parameters like initial concentration of the cation, extraction time, and concentration of the saw dust, pH and temperature were studied. Three adsorption isotherms [Langmuir, Freundlich and Dubinin-Redushkevish (D-R)] were used to analyze the equilibrium data. The maximum removal efficiency of cadmium ions was found to be 72% at pH 4 and exposure to 60g of treated sawdust. The mean free energy calculated from D-R model was found to be 15.81 KJ/mol, indicating that chemisorption is involved in the extraction process. The breakeven point in dollars was US$458 630, payback period being 2,9years and the return on investment 34.5%. The present method has been compared with the previous methods.

Key words: Cadmium, Waste water, Sawdust, Adsorbent, Extraction

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EXTRACTION OF 2 TONS PER DAY OF AVOCADO OIL FROM AVOCADO PULP

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The extraction of avocado oil using the cold press method is a new technology which appears to be the most suitable and beneficial method to extract the avocado oil. It utilizes low temperatures which help retain the healthful properties of the oil, involves minimal processing and requires less capital investment. In this study three crucial experiments were carried out, the first one was the extraction of avocado oil by cold pressing with muslin cloth to determine the amount of oil extracted per kilogram of pears. The second experiment was the malaxation of avocado pulp at different temperatures to determine the optimum conditions for maximum yield of the avocado oil. The virgin oil obtained was polished using a laboratory spin tube centrifuge at 7000 revolutions per minute for five minutes to remove suspended solids and water. From the results 203.5 grams of virgin oil can be extracted per kilogram of pears. A disc bowl centrifuge with 24 conical discs and a diameter of 0.548m was designed. Economically the project is feasible with a 37.9% rate of return on investment, payback to investors can be made within 3 years. The break-even can be made at 38.7% after selling over 232 314 kg of extra virgin avocado oil.

Key words: *Avocado oil, Extraction, Cold pressing, Malaxation, Centrifuge*

A DESIGN OF A MICRO BIOLOGICAL TREATMENT PLANT OF WATER WITH A CAPACITY OF 25M^3 PER DAY

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Zimbabwe has an average sanitation coverage of 97% in the major urban centres that gives it high leverage in harnessing water as a water resource. The total annual freshwater resources withdrawal in Zimbabwe is estimated at 21.05% of total annual renewable water resources meaning that Zimbabwe is water-stressed in terms of a water intensity use index greater than 20% or per capita water availability of less than 17⟦00m⟧^3/year (Chiwira 2006). The severity of water stress or scarcity is more pronounced in the low rainfall areas where people are using run-off water straight from lakes and dams which is not safe for human consumption and might result in health hazards. E-Coli bacteria can be used to effectively treat water with many ions, this is so because of the negative charge they possess which attracts the irons in water thus absorbing the iron particles which will be in water as well as the dirt in it. Watermelon seeds on the other hand can also be used as an

effective water purifier because of their adsorbent properties. They treat water on two levels, acting as both a coagulant and an antimicrobial agent furthermore, they contain iron which act as a flocculent. As the watermelon seeds are amphoteric in nature they will attract any the E-Coli bacteria which would have passed by the water hence that purifying the water to about 80%.

Key words: *Micro biological, E- Coli bacteria, Watermelon seeds, Coagulant*

DESIGN OF A PROCESS TO TREAT 60 M^3/HR OF MINING WASTE WATER FROM GOLD ORE PROCESSING USING NANO-ZERO VALENT IRON.

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Looking at a possibility of removal of heavy metals that are found in the mining waste water the use of nano zero valent iron (NZVI) is increasingly more efficient. Lately fresh water has become scarce hence the need to look at treating mining effluent. Mining drainage contributes to pollution of the environment through the deposition of heavy metals in water. Treatment of water using zero valent iron can help reduce and in turn eradicate heavy metals from the water. Synthesis of nano-zero valent iron was done at laboratory level and its characterization was done using the XRD. Mining effluent at 1 atm and 25 ^{0}C was used in the experiments. Mining effluent characterization was done using the flame atomic absorption spectrophotometry (FAAS).The FAAS was used before water was used to ascertain heavy metals before and after treatment. The experimental results determined sizing and designing of the adsorption column, since it is the major equipment in the treatment of mining waste water. Plant layout and economics was done and it was found out that the return on investment would be (ROI) 24.23% whilst the payback period would be 4.13 years. Recommendations suggested that there is real need to adopt this technology and also to look at the application of nano zero valent iron in other forms of waste treatment different from mining waste.

Key words: *Mining, Waste water, Gold ore, Nano-zero valent iron.*

DESIGN OF AN EXTRACTOR FOR THE EXTRACTION OF OILS FROM VIGNA SUBTERRANEAN, CITRULLUS LANATUS AND PARINARI CURATELIFOLLIA SEEDS.

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There are many plants in Zimbabwe that are regarded as nutritious and underutilized but having the potential to serve the country economically. Mobola plums are wild tropical fruits whose trees are widely distributed in most parts of Zimbabwe and Bambara nuts and wild melons are indigenous African crops that have been cultivated for centuries in the semi-arid regions of Zimbabwe .These plant species have inherent nutritional advantages and produce their reserve food in form of oil. They are highly nutritious and serve as a complete food. These indigenous plant seeds will ensure the promoting of better health and aiding of treatment response in cancer patients. The extraction of these seed oils results in value addition and maximising the use of indigenous highly nutritive plants to benefit the local cancer patients. The project focuses on the design of a rotating disc column extractor with a production capacity of 100litres per day of seed oil which brings financial benefits to the nation. Comprehensive examination of the technological advances in the extraction of seed oil technology was done. Experiments were done to extract oil and to determine its content and the moisture content was also found. From the experimental results, the moisture content was obtained as 7.5 %, 6 %, and 7.1 % for Bambara Nuts, Mobola Plums and Wild Melon seeds respectively. The average oil composition in the seeds was found to be 2.7%. These results led to the design of an extraction column. Aspects of temperature control, flow control were also done and HAZOP analysis was done on the column. A detailed economic analysis was also done to assess the economic feasibility of the project .The project has a payback period of 2 years and a return on investment of 50.2 % which are acceptable financial indicators .It is concluded that it is feasible to design an economically viable and environmentally friendly process for extracting the seed oils to act as a therapeutic food supplement to alleviate acute malnutrition symptoms in cancer patients.

Key words: *Extractor, Oils, Vigna subterranean, Citrullus lanatus, Parinari curatelifollia*

DESIGN OF A PROCESS TO EXTRACT 6 TONNES/DAY OF XYLAN FROM A BLEND OF AGRO-WASTE

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In Zimbabwe there is over 2 million tonnes of agro-waste which is generated from the farming industry. The waste can be put used to generate revenue by the extraction of xylan. Extractions of xylan from agricultural wastes (bagasse and corn stalk) under alkaline conditions (NaOH) were performed. The agro-waste was milled into smaller particles to increase the surface area of extraction. NaOH was added to the milled agro-waste and stirred at 60oC for eight hours. The mixture was then filtered and HCL and centrifuged. HCL was added followed by 95% ethanol and the mixture dried in as oven to obtain xylan. Experiment two was to test the pH of buffer solution after adding HCL. The pH was found to be 5. A third experiment was conducted to verify the xylan produced. The maximum xylan recovery of the xylan from the blend of agro-waste was 38.8%. Mass and energy balances were done to check the conservation of mass and energy. A batch reactor was designed for the process of alkaline extraction at a temperature of 60oC. In this batch reactor process control was conducted monitoring temperature as the variable. The temperature was to be maintained hence temperature sensors where placed inside the reactor measuring the temperature with thermocouple. The HAZOP analysis was carried out around the batch reactor to anticipate the hazards hence take measures to minimise the hazards to prevent accidents. The economic analysis was carried out showed that the project is viable. The payback period was 1.78 years.

Key words: *Extract, Xylan, Agro-waste, pH*

REGENERATION OF 100 TONNES PER MONTH OF SPENT BLEACHING CLAYS IN OIL REFINERY INDUSTRIES USING SOLVENT EXTRACTION

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Regeneration of spent clay was done in a series of solid-liquid solvent extraction processes using different solvents. Firstly the amount of total oil content in the spent clay was determined by using calcination at 750oC and was determined to be 19.5g for every 60g that is 32.5%. After ascertaining the overall oil content in the spent clay, polar and non-polar solvents were then used in series to wash away the oil present in the spent clay. The extraction time used was 20minutes for all experiments. First, petroleum ether of boiling point (90oC-120oC) was used to extract the ideal oils from the spent clay and this process removed an average 10.2g of the total oil content in the spent clay, this was the amount of useful oils lost in the bleaching process. Secondly, the clay was extracted using a mixture of petroleum ether boiling point (90oC-120oC) and ethanol of 95v% to extract some of the remaining oils, Isopropyl extraction and finally washing with water. The total un-ideal oil was found to be 9.2g. After washing down the regenerated clay with water the clay was dried in a vertical turbo drier at 130oC to reduce the moisture to 0.5%. The total oil recovery in this project was 95.9wt% and the porosity regeneration of the clay was theoretically 95.9%. The clay that was used in the experiments was approximately 200mesh in particle size. To ensure safety of the operators there was an emergency shutdown system and alarms were put in place. An economic analysis was carried out and the pay-back period was found to be 3.5 years and the rate of return was 26.8years.

Key words: Bleaching, Oil refinery, Solvent extraction, Petroleum ether, Ethanol

DESIGNING OF A 5 000L PER DAY PROCESS OF NON-PETROLEUM CANDLES

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Toxic substances has become a major threat confronting the world therefore there is need to replace petroleum based candles which produces these toxic chemicals with non-petroleum (bees wax candles). This is because the use of petroleum based products produces toxic substances which cause serious health problems. Currently there is also an increase in the use of candles due to the power cuts faced by the citizens of Zimbabwe. The project focuses on the design of a leaf pressure filter with a production capacity of 5 000kg/day. This is due to the fact that beeswax candles currently used in Zimbabwe are being exported. This is expected to bring financial benefit to the nation through cutting down costs being incurred in importing the beeswax by the use of local produced honey combs. Experiments were done to extract the beeswax using different methods. The viscosity, density and the flash point of the beeswax were also determined experimentally. With all these experiment a candle was physically produced. These results lead to the design of the pressure filter on which all the design parameters where determined. Aspects of temperature control, flow control was also done and HAZOP analysis was done on the boiler and the pressure filter. A detailed economic analysis was also done to access the economic feasibility of the project .The project has a payback period of 2.97 years and a return on investment of 33.65% which are acceptable financial indicators. It was concluded that it is feasible to design an economically viable and environmental process to manufacture non-petroleum candles from honey combs in Zimbabwe.

Key words: *Non petroleum candles, Toxic, Bees wax candles, Filter, Viscosity*

DESIGN OF PROCESS THAT PRODUCES 880KG/DAY OF HYDROGEN FROM ORANGE PEELS

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Hydrogen is one of the most important substance which many chemical and process industries depend on. It acts as a raw material of very useful products which a nation cannot survive without. In Zimbabwe hydrogen is mainly used in the production of ammonia which is further processed into ammonium nitrate (fertilizer). Hydrogen is found in every organic substance which makes it the backbone of all hydrocarbons. In western countries hydrogen is mainly used as a fuel and its usage in different processes gives a global demand of 300 billion m3/yr. Due to the hardships of hydrogen production in Zimbabwe an energy efficient process will be more appreciated. This energy efficient project of producing hydrogen from orange peels is designed to produce 880kg/day. Two major experiments were done to determine the feasibility of the production of hydrogen from orange peels that is one for the production of hydrogen and the other for the ascertaining of the hydrogen

produced if any. Five repetitive experiments on the hydrogen production were done and an average yield of 80% was achieved. The yield was slightly lower than the theoretical due to the systematic errors of the laboratory equipment. The second experiment was done to ascertain the presence hydrogen and a pop sound was observed when a burning splint was introduced showing its presence. A detailed economic analysis was done to determine the economic feasibility of this project. The return on investment of this project was 26.7% making up a payback period of 3.75 years. The profitability indicators showed that project is economically viable and beneficial. Certainly this project will be able to sustain the hydrogen industry and minimize power shortages in our country if it is put an industrial scale.

Key words: *Hydrogen, Orange peels, Ammonia, Hydrocarbons, Yield*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 1500KG/HR OF ROSIN FROM PINE RESINS

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The project focuses on the design of a distillation column with an output capacity of 1500kg/hr of rosin. This is due to the fact that currently our country has low production capacity of adhesives because of limited raw materials, there is high dependence on imports and hence there is need to use other materials like rosin to produce adhesives and which has also other various uses. This brings financial benefit to the nation through cutting down costs being incurred in importing adhesives. Experimental work was undertaken to clean the crude resins using filtration and distillation of the pine resins to produce rosin. The pine resins were found to contain 74.6% of rosin. A distillation column was designed to help achieve the desired capacity of 1500kg/hr of rosin using material balances and experiments. The parameters obtained for the distillation column included a height of 27.6m, column diameter of 2.76m, 12trays and a reflux ratio of 2.48.Aspects of temperature control, pressure control, and flow control using the cascade control system was also done. The cascade control system was employed to control the temperature at the top or bottom of a distillation column where the secondary loop was used to compensate flow rate changes. A HAZOP analysis was done on the distillation column to identify any potential deviations that may lead to hazards such as high pressures and their migratory measurements were formulated. A detailed economic analysis was also done to access the economic feasibility of the project .The project has a payback period of 4 years and a return on investment of 25.37% which are acceptable financial indicators. It is conducted that it is feasible to design an economically viable and environmentally friendly process for the distillation pine resins.

Key words: *Rosin, Pine resins, Adhesives, Filtration, Distillation*

DESIGN OF A PROCESS THAT PRODUCES 450KG/DAY OF FLOUR USING SWEET POTATO AS A RAW MATERIAL

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The socio economic, agronomic potential for the production of flour from sweet potato has been discovered and identified. Utilisation of sweet potato, better controls of spoilage of the material to be processed, during process, conversion rate, were the technical problems that required solutions before marketable flour could be manufactured. In developing countries, processing the sweet potato (Ipomoea batatas) into flour provides an alternative to the difficulties associated with storage and transport of the raw tubers. The objectives of this project involved to process sweet potato tubers into fine powder (flour), to evaluate the proximate nutritive composition and the colour of the processed sweet potato flour during storage. This project mainly determined the design of 450kg per day of flour using sweet potato as a raw material. Washing, slicing, drying, crushing and packaging are the main stages in the designed process. Drying was done using solar energy and a range of temperature from 500C to 600C is to be maintained. The experiments were done to determine the moisture content, ash content, fat content, protein content and carbohydrate content of the sweet potato flour. The sweet potato tubers were processed into flour and stored for five months at room temperatures. The sweet potato flour was found to contain proximate values of 7.9%±0.2 moisture content, 4.5%± 0.3 ash content, 0.52%±0.3fat content, 1.0% protein content, 3.5%±0.5 fibre content, 89.6%±0.5 carbohydrate content, with no significant changes during storage. These experiments were used as a basis in the material balances and energy balances to obtain information on the equipment designed, conditions of operation and the quantity of materials used. The equipment design was done and the equipment designed was a solar powered tray dryer. The Hazop analysis was done to check for the deviations that may be encountered in the flour manufacturing plant. Economic analysis for the design was done. The project indicated to be economically feasible having a payback period of 2 years. The return on investment was calculated to be 62.7%. The production cost per ton was calculated to be US$18 698.24 and the selling price per ton was calculated to be US$24 307.71.The total annual profit was calculated to be US$15 145 56.90.From both the process design and equipment design, it can be deduced that there possibility of producing 450 per day of flour using sweet potato material as raw material.

Key words: *Sweet potato, Processing, Nutritive, Flour, Proximate*.

DESIGN OF A PROCESS FOR HEAVY METAL ION CONTAINMENT FROM 5000L INDUSTRIAL EFFLUENT USING MAGNESIUM OXIDE NANOPARTICLES

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An experimental approach was taken in the design of a process for the containment of heavy metals from industrial effluent using magnesium oxide and zinc oxide nanoparticles. Experimental work was done to synthesize magnesium and zinc oxide nanoparticles, heavy metal analysis of fresh water and waste water, removal of heavy metals and regeneration of nanoparticles for reuse. Maximum removal of heavy metals was found to be 86%. The vertical fluidised bed adsorption column was designed to help achieve high removal of heavy metals. An average feed flow rate of 5000l/day effluent was used to design the adsorption column. With US$ 203 400, producing return on investment of 40% and payback period of 2, 5 years. Installation of the column reduces the concentration of complexes to EMA regulations.

Key words: *Heavy metal, Containment, Industrial effluent, Magnesium oxide, Nanoparticles*

DESIGN OF A PROCESS TO EXTRACT 12 TONNES OF CALCIUM OXIDE PER DAY FROM COAL ASH

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Calcium oxide is one of the major raw materials used in many industries nowadays. It is required for various purposes in sugar cane refinery, metallurgical industries, as well as agricultural industries where it is used as agricultural lime for neutralizing the excess acidity of the soil. This project aimed to recover this calcium oxide from coal ash which is produced in abundance, about 100 thousand tonnes each year, by local power generating plants. The major equipment designed is a 20,05m3 CSTR for extracting 12 tonnes of calcium oxide per day from coal ash by leaching in a continuous production system. Prior to the design a number of experiments were conducted to determine the most suitable and economic operating conditions. The determination of the calcium oxide content of coal ash was done and a value of 24% by mass was found. The temperature for optimum leaching was found to be 80 degrees Celsius and with the maximum leachable amount being 89%. It was also found out that pressure has no appreciable impact on the leachability of calcium oxide. The

optimum pH for leaching was also determined to be 2. For safety at work it was also necessary to carry out hazard and operability analysis to determine the safe operating standards in the process. An economic analysis of the project was done to determine its profitability and it was found to have a return on investment of 46% and a payback period of 2.15 year

Key words: *Calcium oxide, Coal ash, Recover, Leaching, Optimum*

DESIGN OF A PROCESS THAT PRODUCES ONE MEGAWATT OF ELECTRICITY FROM A SORGHUM BREWER'S SPENT GRAIN FIRED BOILER UNIT FOR DELTA BEVERAGES

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The ever increasing human need for electricity coupled with the demand for greener, environmentally friendlier of electricity generation technologies have driven research in alternative fuels for electricity generation. Greener electricity generation technologies are more preferred because they help reduce the global climate change problems while at the same reducing fossil fuel depletion. The study was conducted to assess the techno- economic feasibility of a sorghum brewers spent grain fired boiler unit to generate 1megawatt of electricity for Delta Beverages. Delta Beverages , who are currently getting electricity at a premium price of USD$0.13/KWHr , which is above the national average of USD$0.09/KWHr from are generating 24 tonnes per day of sorghum brewers spent grain biomass waste which was used as a source of boiler fuel for the research project. After a full proximate analysis the sorghum brewers spent grain had an average heating value of 12.6MJ/kg whilst coal had 19.9MJ/kg, so this, and a summary of the ANOVA results showed that it is feasible to generate electricity using sorghum brewers spent grain as a source of fuel, and that sorghum brewers spent grains can be used as an alternative to coal. A biomass boiler unit consuming 1100kg/hr feedstock, operating at 86% efficiency, maximum pressure of 9bar and steam output of 1689kg/hr was designed to supply a 1megawatt turbine generator. Pressure, temperature and flow control mechanisms were assessed as a safety consideration. An economic analysis was done with a total investment cost of USD$ 3.4 million, a payback period of 3.7 years, and a return on investment of 27.4%.

Key words: *Electricity, Sorghum, Boiler, Climate change*

DESIGNING A 6000 TPD ESCAPED CARBON CATCH SCREEN THAT WOULD REDUCE CARBON AND GOLD LOSS FROM THE CARBON-IN-PULP CIRCUIT: CASE STUDY - FREDA REBECCA GOLD MINE PLANT

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Freda Rebecca Gold Mine Company has been experiencing gold and carbon losses from its Carbon-In-Pulp circuit. This design and innovation project investigates on the causes of such losses in order to come up with solutions to the problems. Freda Rebecca Gold Mine is the leading company in the country which produces high output of gold. This project seeks to find a suitable design of a vibratory escaped carbon catch screen that would suit the increasing tonnage/throughput at Freda Rebecca Gold Mine Carbon-In-Pulp circuit. The experiments that were conducted in this research project which include; manual sampling of the tailings stream and particle size distribution showed that carbon and gold losses were reduced to the value that is within the best practice for CIL/CIP circuits (20 – 40 g/t) due to the new escaped carbon catch screen that was installed. Hazard operability study has been analyzed in trying to monitor deviations that may rise in the processing plant, especially flow, vibration and pressure. An economic analysis for the project was carried out, the selling price obtained was US$1089.00/oz. The units produced satisfies the market and the project proved to be economically viable with a payback period of 1,3 years, the return on investment is high at 79%, therefore the project is economically feasible. The researcher recommends a schedule for checking the efficiency of the screen and also to purchase interstage screens on a monthly basis and prioritize installing them in the last adsorption tank to reduce the losses to an insignificant value.

Key words: *Carbon, Carbon-In-Pulp, Gold, Tailings*

DESIGN OF A PROCESS FOR THE SYNTHESIS OF 0.3 TONNES PER DAY OF SILVER NANOPARTICLES

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This project focuses on the design of a process for the synthesis of 0.3 tonnes per day of silver nanoparticles using sodium borohydride (NaBH_4) and silver nitrate (〖AgNO〗 _3) as reagents. The aim is to design a process to synthesise silver nanoparticles thereby providing a chemical to be used in the textile and clothing industries as a bactericidal agent. Silver nanoparticles can be manufactured using chemical, biological and green methods of production. They possess very high surface to volume ratios, they show bactericidal effects these essential qualities have been attributed to silver nanoparticles (AgNPs). Therefore, in nano-biotechnological research, AgNPs have received significant attention because of their unique physical, chemical, biological properties, and because of their applicability in textile engineering and medicine. The chemical method of synthesis was used to produce the silver nanoparticles. The designed process is focused on one main stage which involves the reaction of sodium borohydride in aqueous solution with distilled water and silver nitrate also in aqueous solution. The silver nanoparticles produced absorbed scatted light with a wavelength between 200 – 1100nm because of their optical properties which are sensitive to shape and size of the nanoparticles. The wavelength of light which was absorbed was 386nm which confirms that the nanoparticles synthesised in the range between 1-100nm in diameter. The use of silver nanoparticles is an introduction of a new technology in Zimbabwe and it also brings about creation of employment.

Key words: *Silver nanoparticles, Sodium borohydride, Bactericidal agent, Textile*

Design of an industrial gold extraction process via chlorine leaching step an ion exchange adsorption process

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This is a hydrometallurgical recovery process of gold from refractory ores in which chlorine-leaching techniques and ion exchange adsorption process is utilized. During the experiments, chlorine dissolved gold in the presence of HCl to form a chloroauric complex ion. The complex ion was then stripped from the solution by microporous polymer called a resin. It is a basic type resins (resin with quaternary ammonium or tertiary ammonium ions) which is selective towards chloroauric complex ion called AMBERLITE ® IRA-400 manufactured by Rohm & Haas. The gold-containing solution was passed through the bed under its own weight at different temperatures. At 200C, peaks of gold concentration in the effluent were observed approximately 200 minutes later and after 250 minutes at 30oC. However, the total time to extract more than 99% gold in the influent at 30oC was approximately half the time taken at 20oC. Therefore, it was deduced that the process can be optimized at temperatures above 30oC. By optimizing the Breakthrough curves that were obtained, a 1m x 5m column was designed which has an allowable effluent concentration of only less than or

equal to 5 % of the initial concentration and has volume of exhaustion of 1,128,643.30 liters during a seven-day full working period. Thus, an average charge of 102meq gold/L flowing at 80,000L/day, the yield is approximately 1.517kg gold per total working period. This yield is 40% more than what is already achieved by the standard extraction methods that most companies in Zimbabwe are getting. The chlorine resin in pulp process (CRIP) has proved to be financially viable by calculating profitability indicators such as return on investment (ROI), payback period (PP) and break-even point (BE) analysis which are usually used. The estimated total equipment cost was $538,400.00, and the fixed capital investment was estimated to be $2,315,120.00. the production cost was also calculated to be $3,387.66/ kg gold. Year. However, with the gold price on the world market at $40.00 per gram, the net profit per year were a staggering $13,347,394.36, thus, a payback period calculated was just 64 full working day.

Key words: *Gold extraction, Chlorine, Leaching, Ion exchange, Adsorption, Microporous polymer*

DESIGN OF A PROCESS FOR CAPTURING 500KG PER DAY OF CARBON DIOXIDE FROM POWER PLANTS FLUE GAS USING CALCIUM OXIDE

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Carbon dioxide concentration in the atmosphere as led to global warming and unpredictable weather patterns. Carbon dioxide sequestration has been designed as a way of lowering these emissions especially at power plants as they contribute about 40% to emissions worldwide. A dual set of fluidised bed reactors can be employed to capture the carbon dioxide with an overall capture efficiency of 95% according to experiments. The designed reactor has a bed height of 10m with a cross sectional area of 19.63m2.The superficial gas velocity is 0.1m/s and the minimum fluidising velocity is 0.018m/s. The most desirable material of construction is stainless steel and it will be jacketed with a firebrick material. According to the cost analysis carried out, the rate on investment is estimated to be 81.5%with a resulting break-even point of 1.227 years. Concepts were generated and screened in relation to the project focus of an economic plant that can meet the market demand. The overall process was designed and analysed to ensure that environmental degradation is kept to a minimum. Control systems were also evaluated to provide a safe working environment for all workers and to see to it that all ergonomic principles are applied.

Key words: Carbon dioxide, Calcium oxide, Sequestration, Fluidized bed, Superficial gas velocity

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DESIGN OF A SPINNING PACK FOR THE PRODUCTION OF DYED MICROFILAMENT POLYESTER YARN USING WASTE PET PLASTIC BOTTLES AS A SOURCE OF RAW MATERIAL.

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There is an increase in imports of synthetic yarn because of weak and bleeding of dyed yarn manufactured locally. This issue of imports of yarn raw material has resulted in high cost of production, which in turn has resulted in closure of textile companies. The objective of this project is to design a spinning pack and a unit operation of dying the molten polyester before it is spun into filaments. This will address the issue of colour bleeding in dyes and at the same time reduce both the energy expenditure and environmental effect of waste water associated with disperse dyeing. The spin pack has a capacity of 50kg/h and a total of 20 spinning packs are required to handle a capacity of 1000kg/h. Experiments were conducted to determine operating parameters of which an optimum inlet temperature of 290oC and an inlet pressure of 300psig (20.4 atm) where chosen from the analysis of experimental results. A comparison of the filter bed depth, surface area and mean surface-volume diameter of steel sands to the rate of filtration showed that a depth of 0.1m, a surface area of 0.1m2 and a surface-volume ratio of 0.4µm are favourable. Material of construction of stainless steel AISI 304 is chosen as it is cheaply available and is capable of meeting operating requirements. An economic analysis showed that the project is economical feasible with a payback period of 3.69 years and a rate of return of 27.13%.

Key words: *Spinning pack, Microfilament, Polyester yarn, Waste pet plastic, Operating parameters*

DESIGNING OF A SYSTEM TO RECYCLE 500 M^3/DAY OF WASTEWATER FROM THE BEVERAGE INDUSTRY USING BIOFILM CARRIERS AS THE CLEANING AGENT

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Processes and systems using water today are being subjected to increasingly stringent environmental regulations on effluents and there is growing demand for fresh water. These changes have increased the need for better water management and wastewater minimization, for which industries are facing challenges in treating their wastewater to standard consuming bulk of fresh water. The beverage industry is one of the major industries in Zimbabwe and the following study was conducted at the beverage Industry at Delta Beverages, Kwekwe, Zimbabwe to assess the techno-economic feasibility of reuse of wastewater using the Moving Bed Biofilm Reactor Process. The malting plant Delta Beverages, Kwekwe uses up to 350000 cubic meters of fresh water a year (140000 US dollars) discharging about +75% of the biologically contaminated water as effluent which is discharged into the ecosystem. A biological water treatment approach was done using Moving Bed Biofilm reactor, with use of Mutag bio chips which showed BOD_5 removal of 630mg, pH 7.8, COD

removal of 534mg and a combined mass removal of 0.05% at 12 hours at prolonged hours it was suggested that though removal was efficiently done there was waste of energy hence the optimum time chosen was 12 hours. The plant and equipment designs were done prior to the experiments done, that detailed two moving bed biofilm reactors with a combined capacity of 500m^3.A prototype of the system was made to demonstrate the aerated biological treatment. An economic analysis was done with a payback period of 2.09 years and return on investment of 49%.

Key words: *Recycle, Wastewater, Beverage industry, Biofilm carriers, Cleaning agent*

THE DESIGN OF A 1 710 CUBIC METERS PER DAY HYDROGEN RECOVERY PROCESS FROM CRUDE GLYCEROL USING STEAM REFORMING PROCESS OVER NICKEL CATALYST

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Crude Glycerol, by-product of biodiesel synthesis, is a bio-renewable substrate used for sustainable production of hydrogen. However, with the increase in production of biodiesel, there would be a glut of glycerol in the world market. Crude Glycerol is a potential feed stock for hydrogen production because one mole of crude glycerol on steam reforming produces 7 moles of hydrogen. As hydrogen is a clean energy carrier, conversion of crude glycerol to hydrogen is one among the most attractive ways to make use of glycerol. Steam reforming is a promising way to utilize the diluted crude glycerol aqueous solution to produce hydrogen over Ni/ Al2O3 catalyst .In this work; a response surface methodology (RSM) was implemented to investigate the process variables in a hydrogen production system. Under these conditions crude glycerol was reformed to H2, CO, CO2 and CH4 gas products that were measured by gas chromatography. There was a variation in temperature, flow rate and catalyst weight to come up with an optimum yield of Hydrogen from glycerol which resulted as 600°C, 0.05ml/min and 0.2g respectively. Using multiple regression analysis; the experimental results of the hydrogen yield and the crude glycerol conversion to product gases were fit to quadratic polynomial models. The hydrogen yield was predicted to be 57.6% and the conversion of crude glycerol was predicted to be 75%. A detailed design was done for the fixed bed reactor which is the steam reformer reactor of volume 0.887m3. Hazard operability was analyzed in trying to monitor deviations that may rise in the plant. An economic analysis for the project was

carried out and the project proved to be economically viable with a payback period of 3 years and a return on investment of 33.5%. The selling price was calculated to be $36.50/kg of liquefied hydrogen. The total cost of production was $956 803.67 and a net profit of US$320 674.40. From the process and equipment design it can be concluded that it is possible to produce 1 710m3/day of hydrogen from crude glycerol.

Key words: *Hydrogen, Recovery, Crude, Glycerol, Steam reforming, Nickel catalyst*

DESIGN OF A PROCESS TO PRODUCE 25000KGS/DAY OF LIQUID PETROLEUM GAS FROM THE PROCESSING OF NATURAL GAS

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Zimbabwe has been facing a challenge of power shortage over the past decade which has resulted in the increased consumption of liquid petroleum gas as an alternative energy source. According to the statistics provided by the Zimbabwe Energy Regulation Authority (ZERA), the country imports an average of 20 million metric tons of LPG every year. This valuable commodity is not produced locally and is being imported from other countries in the region, Zambia and South Africa to be specific. This situation has motivated the researcher to work on designing a process that can produce LPG making use of the abundant and unexploited coal bed methane reserves which amounts to 765 billion cubic meters that have been confirmed to be available in the Lupane-Hwange basin. Local production of LPG will result in employment creation, reduction of imports of this commodity thereby reducing the negative balance of payment. With the available demand of LPG and the abundant raw materials the researcher has proposed a plant with a throughput of 25 tons per day which satisfy a 35% market share based on the current demand. A deep literature review was conducted which assisted the researcher with the best technology which can be employed to produce LPG from natural gas making using the USY-Zeolite hybrid catalyst. Experimental work was done to obtain data which assisted the researcher in carrying out material balances and designing a packed bed reactor which is the major equipment in the process. Experimental work revealed that the local natural gas consists of over 90% methane .The design of equipment provided important parameters which were essential to determine the cost of the required reactor. A packed bed

reactor with a diameter of 2.0m,a height of 3,75m and 20 tubes were the fixed bed of the zeolite catalyst will be placed will be required to produce the required output of LPG. A HAZOP analysis was carried out for the designed equipment to ensure that it will function safely and efficiently. From the material and energy balances conducted it was established that 20tons of natural gas and 18 tons of steam are required to produce the proposed throughput. To determine the economic viability of the process an economic and profitability analysis was done. The project has a payback period of 2.6 year and Return on Investment of 38% which shows that the project is highly profitable .Zimbabwe being a net importer of liquid petroleum gas would benefit from undertaking this project.

Key words: *Liquid petroleum gas, Natural gas, Power shortage, Coal bed methane*

DESIGN OF A PROCESS TO PRODUCE 1000KG/DAY OF ACTIVATED CARBON FROM PEANUT SHELLS.

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The efficient commercial refining of cooking oil at reduced production costs has become a priority for the edible oil manufacturing industry. Bleaching of seed oil is of major concern to the edible oil manufacturing industry as it maximizes value and improves quality of the final product. The country pumps out around $2 million every year importing the expensive bleaching agents Tonsil and Trysil. This contributes to the increase in production costs. Agricultural waste that is dumped can be used as a precursor for the production of activated carbon which can be used as a bleaching agent in the refining process of cooking oil. This project focuses on the design of a process that produces 1000kg/day of activated carbon which will give a financial benefit to oil refining industry by cutting bleaching costs. The major equipment designed in this project is a fluidized bed reactor which was utilized as the activation reactor, due to its superior heat and mass transfer properties. Experiments done prior to the production were determination of ash content that was 95% at 400°C, adsorption capacity was 40mg/g and carbon yield content was 98% at 400°C and moisture content was 5% after drying in oven for 3 hrs at 400-500°C. Experiments done for bleaching of cooking oil to test activated carbon were, percentage reduction of free fatty acid using blending ratio of 1BE:2AC was 56%, ratio of1BE:2AC was 64%. Percentage color reduction using blending ratio of 1BE:2AC was 8.1 and 8.7 for blending ratio of 2BE:1AC. Higher temperature above 700°C reduces the yield content and

temperatures below 500°C reduces the ash content. Aspects of temperature control, flow control and pressure control were also done and HAZOP analysis was done on the fluid bed reactor to determine the possible hazards and operability standards on the major designed equipment. A detailed economic analysis was done to assess the economic feasibility of the project. From the calculations and estimations made an economic evaluation of the project was done and found to have a payback period and return on investment of 1.5 years and 60% respectively.

Key words: *Activated carbon, Peanut shells, Bleaching, Tonsil, Oil refining, fluidized bed reactor*

DESIGN OF A 0.8 TONNE/DAY PROCESS FOR CASSAVA STARCH BASED ADHESIVE FOR CARDBOARD BOXES AND BOOK INDUSTRY

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Synthetic adhesive have been a cause of concern due to their toxicity and non-biodegradability. Utilization of natural starch becomes highly necessary as a substitute. In Zimbabwe cassava is grown by smallholder farmers either by horticulture Honde valley or in dry regions of the country. 40-60 tonnes per hectare are harvested which cost $400-$600per tonne .216000 tonnes of cassava are harvested annually and 941 tonnes are required for the project. Improvement of functional properties was investigated on temperature, mass concentration and gelatinizer modifier used. Increase in temperature resulted in decrease in viscosity from 13.8 - 3 centipoise, slight decrease in density 1.029-1.022g/cm3and decrease in pH 8-1.9 on varying mass concentration of borax from 0.2-0.4 .Drying time for HCL as modifier was 6minutes and NaOH was 9minutes.A HAZOP analysis was carried out looking at deviations in parameters such as temperature, flow, pH, pressure and level their causes, possible consequence and also mitigations. Temperature control system and a cascade system were employed so as to control and eradicate any inconsistencies. Payback period of 3.2 years and a return on investment of 31.34% was calculated. It requires 72912.86 units to break even which translates to $39706.08

Key words: *Cassava, Adhesive, Synthetic, Toxicity, Gelatinizer*

DESIGN OF A 110TONNES PER DAY CIRCULATORY FLUIDISED BOILER FOR THE MINIMIZATION OF POLLUTANT FORMATION FROM THE COMBUSTION PROCESS (CASE STUDY: HWANGE THERMAL POWER PLANT

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The main project objective was to come up with a design that reduces formation of pollutant gases in the combustion whilst minimizing costs. This project served to incorporate the use of a circulatory fluidised bed boiler in the combustion of coal at a 220MW thermal power plant so as to minimise pollutant formation during the combustion process. Samples of the large coal deposits from the Hwange Colliery were studied ascertain the type of coal available at our disposal. Experiments were done in order to find out the properties of coal that is, volatile matter ash content, sulphur content etc. The samples investigated had the following average properties: the volatile matter was 6.35%, the ash content was 8.16%, and the Sulphur content was 1.62%. The mass balances were carried out which show that the boiler capacity is 110tonnes/day of coal to heat 165tonnes/day of water. The boiler operates at an average temperature of 870°C. The energy balances were also carried out. The equipment design was done on the CFB boiler with a height of 8m and 4m diameter. The material suitable for the boiler was also selected according to its ability to overcome corrosion and other considerations of materials (ductility, strength, brittleness etc.). The HAZOP analysis was done on the CFB boiler and also the control system for the equipment. The economic analysis was done and the ROI was 46%; total capital investment was $679 668 and payback period was 2.15 years. To conclude this project is technically and economically feasible and it promotes minimisation of pollutant formation in combustion processes

Key words: *Fluidised boiler, Pollutant, Combustion, Thermal power*

DESIGN OF 40TPD TANNERY SOLID WASTE GASIFICATION PROCESS

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The conventional leather tanning technology is highly polluting as it produces large amounts of organic and chemical pollutants. About 100000 tonnes of tannery waste are dumped each year in Zimbabwe, poising a major challenge to the environment. This project focuses on the utilization of this waste in electricity power generation. The main aim of the project is to design a 40t/day gasifier

for the gasification of tannery solid waste. Prior to the design a number a number of experiments were conducted to determine the optimum conditions for carrying out the process. It was established that temperature of above 850°C promote the production of light hydrocarbons. The moisture content of tannery waste was determined experimentally and found to be 10.1%, a high bulk density of 525.20 kg / m3 and the corresponding ash content as 4.39 %. The calorific value of the solid waste was determined and found to be 17.86 MJ/ kg with the volatility matter as 66.44%. Based on the experiments 600000kWh of energy be produced from the gasification process. The major equipment for the gasification process, the gasifier was designed, a volume of 11 .12m3, diameter of 2.19m, and height of 2.92m was established as the key parameters for optimum gasification. The hazard analysis and operability (HAZOP) study on the gasifier was done to ensure equipment operability and safety. A detailed economic analysis of the whole process was done to assess its profitability and from the calculations and the estimations done, a payback of 1.966 years and a breakeven point of 50% and return on investment of 50.8566% was determined.

Key words: *Tannery, Solid waste, Gasification, Moisture content, Calorific value*

DESIGN OF A PROCESS TO PRODUCE 10TONNES PER DAY OF BIO BASED SUCCINIC ACID

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Zimbabwe is endowed with large scale sugarcane plantations namely Hippo Valley, Triangle and Chisumbanje. The sugarcane is used in sugarcane refineries. The waste product is bagasse which is incinerated as a fuel and the rest dumped in landfills. Succinic acid is a chemical that is employed in various applications both industrially and pharmaceutically. Currently Zimbabwe is importing 5000 tonnes of succinic acid annually. This definitely results in a strain in the country's already struggling economy. Following this problem the researcher designed an economically and environmentally friendly method to make bio based succinic acid as opposed to the conventional way which uses petrochemical methods posing a danger to the environment. Experiments were done to investigate the feasibility study of fermenting bagasse in the presence of Actinobaccilus Succinogene (a succinic acid producing bacteria) to produce succinic acid. Experiments done included the acid hydrolysis of the bagasse using dilute hydrochloric acid, the preparation of the growth medium, the preparation of the inoculum, the fermentation and finally the extraction of the succinic acid from the fermentation broth. The experiments yielded 32.8g of succinic acid from 40g of hydrolysed bagasse. The calculated yield was 82%. Mass balances were carried out on the basis that 4 500tonnes of bagasse will be obtained from the Hippo valley annually. A bio fermenter was designed for the fermentation of the bagasse to produce succinic acid. The project was proven to be economically viable with an estimated payback period of 2.13years. From the process and the equipment design, it can be concluded that it is viable to produce 10tonnes of succinic acid per day.

Key words: *Succinic acid, Sugarcane, Petrochemical, Actinobaccilus Succinogene*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 600KG PER MONTH OF MONETITE CEMENT USING EGG-SHELLS AND SAND SYNTHESIZED NANOSILICA REINFORCEMENTS.

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Musculoskeletal disorders or osteoporosis are serious traumas caused by accidents and aging. The osteoporosis defects are bone disorders or bone fracturing. The development of calcium phosphate cements has come a long way of material technology to replace fractured bone. Since the 1980s, calcium phosphate cements have been used during surgeries. This documented project focuses on the development of the calcium phosphate cements by reinforcing them with nanosilicates particles. The calcium phosphate cement of specific type is Monetite calcium phosphate developed from egg shell. Experiments were done to study the feasibility of using egg shells and blending with nanosilicates. The nanosilicates were synthesized using the Alkalifussion method and the sizes of 22nm were characterized. The SME method showed the culture of the nanosilicates with 8 – 80nm particle size range. The Monetite cement was then tested for compressive strength and settling time, the results were positive with 7.56 ± 2.33 Mpa and 37 ± 7 minutes, respectively. The process of the plant was designed and the HAZOP analysis was done for major equipment, including process instrumentation and control mechanisms. The process was then analyzed for economic analysis and it was viable with approximately 3 years' payback period and 31% return on investment.

Key words: *Monetite cement, Egg-shells, Nanosilica, Alkalifussion*

DESIGN OF A HYDROTHERMAL PROCESS FOR THE CONVERSION OF TOBACCO WASTES TO 1 067 TONS PER YEAR OF LEVULINIC ACID.

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Biomass symbolizes an abundant and comparatively low cost carbon resource that can be utilized to produce platform chemicals such as levulinic acid. Existing manufacturing technology limits the cost-effective production of levulinic acid in commercial capacities from biomass such as tobacco waste. The key to refining the yield and efficiency of levulinic acid production from waste biomass lies in the ability to optimize and separate the intermediate products at each step of the reaction pathway and

decrease re-polymerization and side reactions. The experimental work for the conversion of tobacco waste to levulinic acid at different temperatures were conducted to obtain an optimum temperature of 98oC.Five other experiments were carried out for this conversion at the optimum temperature of 98oC to obtain an average yield of 86.6% for 120 minutes. Results of the mass balances were used to draw up raw material usage ratios in the sizing up of equipment. A detailed design was done for the major equipment; Continuous Stirred Tank Reactor. The HAZOP study on the designed equipment was done to ensure equipment operatability and safety. The control system of this equipment was automated. An Environmental Impact Assessment was carried out and put in place in order to mitigate the impacts of waste effluents. The project requires a total capital investment of about $453,909.60 and the projected sales volume of levulinic acid from tobacco waste was considered viable with a payback of 2.5 years.

Key words: *Hydrothermal, Tobacco wastes, Levulinic acid, Optimize, Temperatures*

DESIGN OF A JACKETED ACETALIZATION REACTOR FOR THE MANUFACTURE OF 11.4 TONNES PER DAY OF CELLULOSE ACETATE BIODEGRADABLE PLASTIC FROM COTTON LINTER

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The process focuses on the production of a biodegradable plastic which is a concept whose range of use has been widening over the years. The bio-plastic has the potential to replace the non-biodegradable plastics as its properties compare very well with the non-biodegradable plastic. Experiments were carried out to analyse effects of salts at different concentration on cellulose acetate and the results showed no effect thus cellulose acetate plastic can be used as salt storage containers. Also biodegradable tests were performed which showed that cellulose acetate formed can degrade under composting conditions. The conversion of cotton linters to cellulose was achieved using acetic anhydride, acetic acid, sulphuric acid and glacial acetic as well as glycerol as a plasticizer. The acetalization reaction occurred in a jacketed reactor in order to maintain the reaction temperature and drying of final product was done at atmospheric pressure and at a temperature of 60oC. The obtained results were scaled up to design an optimum process including a detailed design on the acetalization reactor. A yield of 75% was obtained. Process control and hazard operability studies (HAZOP) were done on the designed equipment in order to ensure safe operations. After all was done it was seen that it is possible to produce biodegradable plastic using cotton linters as raw material. The economic analysis carried out showed that the project is economically feasible with a payback period of only 4 months as the major raw material (cotton linter) is purchased at a

considerably low price of $200/MT. Zimbabwe therefore will benefit from this project as it adds value to cotton which is grown in most parts of the country and is very economic since the raw material is regarded as waste in the ginning industry.

Key words: *Acetalization, Cellulose Acetate, Biodegradable, Cotton linter*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 1217, 2 MT PER ANNUM OF POWDERED CELLULOSE FROM COTTON LINTER

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The production of powder cellulose from cotton linter is such a new concept and its range of use of the product has been widening ever since it has been discovered, (20th JECFA (1976)). Powdered cellulose is an insoluble dietary fibre that is tasteless, odourless and colourless powder produced from naturally occurring plants (www.mdpi.com/journal/polymers). The purpose of this project was to come up with a cost effective, efficient and innovative process for the production of powder cellulose from waste of cotton that is cotton linter as a competitive alternative to food and pharmaceutical industry. Experiments were carried to determine yield of powder cellulose using different type of acids. The complete conversion of cotton linter was achieved by using 0.1 M Sulphuric acid and NaOH solution for neutralisation. All the experiments were carried out at atmospheric pressure and at a temperature of 100oC. The obtained results were scaled up to design an optimum process including a detailed design on the depolymerisation reactor. . Process control and hazard operability studies (HAZOP) were done on the designed equipment to ensure safe operations. On completion of the project it was proved that it is possible to produce powder cellulose using this process. The economic analysis carried out showed that the project is a viable project with a payback period of 1.4years and return on investment of 86%. Zimbabwe being an agro-based economy and is one of the major cotton producing country and has 25 producing areas having five ginneries with a combined capacity of 136 000 metric tons of cotton, located in Chiredzi (ginning capacity of 20,000 tonnes), Chinhoyi (ginning capacity of 40,000 tonnes), Gokwe (ginning capacity of 35,000 tonnes), Kadoma (ginning capacity of 20,000 tonnes) and Muzarabani (ginning

capacity of 21,000 tonnes) (Zimbabwe Country Report 2014) would benefit immensely from value addition of cotton linter which is the raw materials.

Key words: *Cellulose, Cotton linter, Pharmaceutical, Depolymerisation*

DESIGN OF A 10 000 LITER/DAY IMMOBILIZED CONTINUOUS FERMENTATION PROCESS AND OPTIMIZATION OF ITS PROCESS PARAMETERS FOR IMPROVED FERMENTATION PROCESS OUTPUTS IN LAGER BEER PRODUCTION.

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Fermentation is the most time consuming and effective step in the production of beer, thus the effective use of fermentation vessels is a crucial element in the brewing economy. One means of increasing productivity of a batch process is to convert it to a continuous one. Immobilization technique revitalized continuous fermentation led to industrial applications in the secondary fermentation and low-alcohol beer production. Fermentation was controlled by regulating the temperature, the oxygen content and the pitch rate; but the temperature plays a dominant role in the optimization of the fermentation process. The general purpose of this thesis was to focus on a particular industrial process (from the beer industry) which is to serve as a guidance example for optimal control using different algorithms/methods. Automation of fermentation processes has become a necessity for the brewery industry due to its capability to increase productivity, reduce wastage and provide consistent quality product to keep ahead of competitions. In this study, I am considering especially the lager fermentation process and for its optimization. In the fermenter the yeast and the wort undergo an exothermic reaction i.e. heat is generated. Since fermentation is desired at a specific temperature i.e. 25°C for lager temperature, control equipment is employed to constantly keep the temperature at the desired value. Using the same raw materials but different feed input variables and a slight change in parameter characteristics, experiments were conducted in the laboratory to bring up results for this project. Energy and mass balances proved this process to be highly economical. A Hazop analysis was conducted for the process. The economic analysis conducted showed high profits, a 4.3 years payback period and 34.36% rate of return on investment. At a production volume of 1 564 681.38L our company would have reached its break-even point.

Key words: *Continuous Fermentation, Optimization, Lager Beer, Temperature*

DESIGN OF A PROCESS THAT PRODUCES 300 KG PER DAY LEAD METAL FROM USED CUPELS USING METHANE SULPHONIC ACID.

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In Zimbabwe there are 61 gold mines and 4 platinum mines registered with the chamber of mines. Lead laden cupels from mining industries and also some industrial laboratories pose a danger to the environment on disposal. However these cupels contain metals which when extracted are beneficial. The project focuses on the design of a stirred batch reactor for the removal of lead from cupels with a capacity of 300 kg/day. The lead is extracted by a hydrometallurgical method using Methane Sulphonic Acid (MSA) in studying the leaching of the cupels. The parameters which include stirring speed, temperature, acid concentration and particle size had a significant influence on the kinetics under experimental conditions. The leaching results indicated that Methane Sulphonic Acid is favourable to treat the lead-laden cupels and the lead extraction could achieve the maximum conversion in 90 minutes at ambient conditions. These results were used to the design of the stirred batch reactor. A pressure control system was designed and a HAZOP analysis was done on the reactor. A detailed economic analysis was done to access the economic feasibility of the project. The project has a payback period of 3.5 years and a return on the investment of 28% which are acceptable financial indicators .It was concluded that it is feasible to design a process that will help in controlling lead disposal using an environmentally friendly method which is also economically viable.

Key words: *Lead, Cupels, Methane sulphonic acid, Environment, Extraction*

THE DESIGN OF A PROCESS TO PRODUCE 50 TONS PER HOUR SLAG BASED 'HYBRID' ALITE-CALCIUM SULFOALUMINATE CEMENT-CASE STUDY FOR LAFARGE CEMENT ZIMBABWE.

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Lafarge cement Zimbabwe is in the production of Ordinary Portland cement (OPC) which has low early day's strengths of 16.5Mpa compared to Alite Calcium Sulfoaluminate cement (ACSA) which has 22.8 Mpa at 2 days. High early day's strengths in cement enables efficiency in construction which is an advantage of alite calcium Sulfoaluminate cement over ordinary Portland cement. Alite calcium Sulfoaluminate based clinker is rich in Aluminium which results in lower formation temperatures of 1300-13500C resulting in low CO_2 emissions and decreased fuel consumption due to the incorporation of a counter current cooling system that has heat recovery. Alite calcium sulphoaluminate cement was produced from clinker synthesized in the laboratory from a mixture of limestone, gypsum, slag and kaolin at temperatures within the range of 1300 to 1350 °C. A high compression strengths of 50.64 MPa was produced after 28 days making the cement competitive on the market and rendering the innovative use of slag and gypsum (cheaper industrial wastes) in the raw materials for alite-calcium sulfoaluminate cement manufacturing. An efficient plant that produces 50 tons per hour has proved to be economically sustainable savings being realized from reduced limestone usage, reduced coal usage and low CO_2 footprints on the environmental side. Investment analysis resulted in return on investment of 25%, payback period of 9.6 months, and an internal rate of return of 45% and break even at 57% capacity utilization with a selling price of $10 per bag.

Key words: *Alite-calcium, Sulfoaluminate, Cement, Aluminium*

DESIGN OF A BIO SORPTION COLUMN FOR THE REMOVAL OF LEAD IONS FROM 9000L/DAY INDUSTRIAL EFFLUENT USING TREATED SUGARCANE BAGASSE AS AN ADSORBENT

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Adsorption of lead (II) ions from battery manufacturing plants effluents using treated bagasse as a bio sorbent was studied. Chemical activation was used to treat the bagasse using nitric acid. Experimental work was undertaken to determine the moisture content, determine the effect of pH, effect of contact time and the effect of adsorbent dosage on the adsorptive capacity. The maximum adsorptive capacity was found to be 97,7% at a pH of 5, 2% moisture content and a contact time of 60minutes .The equilibrium adsorption capacity of adsorbents used for lead were measured using Langmuir isotherms. A bio sorption column of 30.5m^3 was designed to help carry out adsorption and the control of this equipment was automated using micro-controllers. The total manufacturing cost of the process is US$ 525 720, it will break even at a sales of US$ 448 936 and will pay back after 4.32 years. Lead has a selling price of $2.00/kg. The return on investment of the lead recovery project is 23.1%. This study shows that it is technically and economically feasible to recover lead using bagasse.

Key words: *Bio sorption, Lead, Industrial effluent, Sugarcane bagasse, Adsorbent*

DESIGN OF A PROCESS WHICH PRODUCES 13 TONNES PER DAY OF NANOCOMPOSITE FERTILIZER.

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The agriculture sector in Zimbabwe is facing various challenges like climate changes, urbanisation sustainable use of resources and environmental issues such as runoff and accumulation of organic fertilizers. Zinc oxide Nano composite fertilizer has a potential to boost food production because of its efficiency in distributing nanoparticles with controlled high site specificity which reduces collateral damage. There is no nanofertiliser producing plant in Zimbabwe, this causes problems of high costs in chemical fertilizer. This project focuses on the design of a process to synthesize 13 tonnes per day of zinc oxide Nano composite fertilizer that uses zinc acetate (Zn〖(Ac)〗_2) and triethanolamine (TEA) as raw materials. The designed process is focused on one main stage which involves the reaction of zinc acetate in deionized water and TEA in ethanol solution. Experiments using zinc oxide Nano composite fertilizer were conducted on legumes (bean and soybean) and tomato from germination of seeds to flowering and on tobacco from germination of seeds to 2 weeks after sowing. Based on experimental results, zinc oxide nanoparticles in fertilizer have shown higher percentage germination on legumes and tobacco for plants that were panted with zinc oxide nanoparticles. 10.148 kg of nanoparticles are produced in 1 hour which is then used to form a Nano composite fertilizer. 3367 tonnes of Nano composite fertilizer are going to be produced annually at a selling price of $26 and the payback period is 1.45 years

Key words: *Nano composite, Fertilizer, Zinc oxide, Triethanolamine (TEA), Ethanol*

DESIGN OF A PROCESS OF MANUFACTURING AMMONIA USING HYDROGEN FROM COAL-BED METHANE

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Separation of the hydrogen needed for the ammonia synthesis reaction, from its source is difficult. Hydrogen production method is the main source of distinction between the various ammonia production routes. Most of the improvements in the technology regarding the ammonia synthesis were concerned with the hydrogen production step. Hydrogen can be produced by steam reforming, partial oxidation and water electrolysis. The bulk of the world ammonia production is based on steam reforming. The major hydrogen sources are natural gas, naphtha and coal. In this project different methods available for hydrogen separation from its source are analyzed and the best possible way to produce synthesis gas (which will form ammonia) from natural gas is found out. The number of reforming stages required for a plant capacity of 1500 tons per day of ammonia production is found out. The mass balance and energy balance calculations for the above said plant capacity is presented in this work. Then the conventional carbon dioxide removal process and methanation process are replaced by the advanced, economical pressure swing adsorption process. It was also found that two stages of shift converters required for this plant capacity. The number of reforming stages required is only one and nitrogen is obtained from oxygen pressure swing absorption units. The oxygen separated is also used as a fuel with natural gas for reforming. The carbon dioxide is separated in another PSA which can be used for the production of urea. On the experimental analysis hydrogen was present and from the literature CBM contents about 95% hydrogen gas. On the economic analysis there is a pay-back period of 3 years 9 months, ROI of 27%, and a break-even point of 0, 5 units. Therefore the project is feasible because from the literature there is scarcity of CBM.

Key words: *Ammonia, Hydrogen, Coal-bed methane, Steam reforming, Methanation*

EXTRACTION OF 500 KG/DAY OF XYLITOL FROM CORN STOVER

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There is a high demand for sugarless sweeteners locally and the only available imported. This study aims to develop an efficient technology of extracting xylitol from corn stover while retaining a high yield. Xylitol was extracted using membrane, after fermenting it to obtain it from d-xylose. The corn stover was dried, ground and hydrolyzed then overlimed. It was then fermented with candida tropicalis for 48 hours. The mixture was then filtered using a mutton cloth and then passed through a microfiltration paper. The xylitol obtain was 9% of the filtrate obtained after filtration. It may be concluded that xylitol production using microbial means may be the answer to the country's dependence on imported sugarless sweeteners. A detailed economic analysis was done and the project has a payback period of 3.65 years and a return on investment of 27.42% which means the project is economically feasibility. Therefore, from the analysis carried out, it was found that it is possible to produce 500kg/day of Xylitol per day from corn stover

Key words: *Xylitol, Corn stover, Membrane, Microbial*

DESIGN OF POLYMERIZATION BATCH REACTOR FOR THE MANUFACTURE OF 12TON/DAY OF BIO-DEGRADABLE LIGNIN BASED THERMOPLASTIC POLYMER FROM SAWDUST

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Waste petroleum based plastic has posed a lot of stress and pollution on the environment and the economic disposal of sawdust has not been fully realized at a larger scale also causing stress on the environment. This project's focus is to utilize sawdust which is basically a waste from timber processing industries to make biodegradable plastics which is also an environmental solution due to plastic waste, that's addressing ZIMASSET cluster 4 of value addition. This project also seeks to find the replacement for petroleum based thermoplastics which are not biodegradable with plastics from natural resources (sawdust) which are biodegradable. This project is focused on the design of a polymerization reactor with a capacity to produce 12ton/day of biodegradable thermoplastic polymer. Experiments were carried out to access the feasibility of the project and results obtained showed that this project is technically feasible. Process design was also carried out and the process was seen to produce 12ton/day plastics from 26tons of sawdust. Hazop analysis and process control

was also done on the polymerization batch reactor, digester and the dryer so as to enhance process safety and product quality. Economic analysis was also carried to determine the economic feasibility of the project. This project has a payback period of 2.23years and return on investment of 44.93%, this shows that this project is highly economically feasible

Key words: *Polymerization, Batch reactor, Lignin, Sawdust, Petroleum*

DESIGN OF A PROCESS TO EXTRACT 125L/DAY ALGAE OIL FROM ALGAE FOR PHARMACEUTICAL USES

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Due to lack of proper treatment or medication that either inhibit, suppress or lower the risk of getting chronic diseases, many people in Zimbabwe die or suffer from these chronic diseases such as Diabetes, Cancer, Asthma, Heart diseases, Osteoporosis and atherosclerosis. Algae oil have been found to possess chemical elements and properties that could suppress Cancers, Heart diseases and diabetes among others. At present algae oil is being imported from China and Japan and it is expensive costing $35/L therefore the main objective of this project is to design a more efficient and cost effective extraction process to extract 125L/day algae oil. Experimental work was carried out on the feasibility of algae oil extraction using the Soxhlet method using 80% ethanol as extracting solvent for 2 hours and 1,62ml of algae oil was obtained from 10g dry powder. Experimental results were used as a basis to do mass and energy balances and hence the design of the equipment as well as process design of Supercritical fluid extraction operating at 330C and 76 bars. Equipment design was done for the proposed extractor with a volume of 0,850m3, height 2,6m and diameter 0,646m. Material of construction is 304 stainless steel which has a higher resistance to corrosion and also can withstand higher internal pressures. Profitability of the project was accessed through an economic analysis. The total capital investment required was $484,000 with a payback period of 3, 3 years and a rate of return of 40% which show that the project is economically viable.

Key words: *Extract, Algae, Soxhlet method, Ethanol*

DESIGN OF A PROCESS FOR THE PRODUCTION OF 30TONS/DAY OF ETHYLENE FROM ANHYDROUS ETHANOL.

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The investigation of ethanol to ethylene process technology considers a means to mass produce ethylene. 15660 tonnes of 99.6% ethanol and 0.4% water feed was converted into 9000 tonnes of 99.6% pure ethylene using an adiabatic, fluidized bed reactor operating at 3980C and a pressure of 1bar.A fluidized bed reactor of diameter 0.914m operating with a superficial velocity of 0.0431m/s , a minimum fluidization velocity of 0.0129m/s and bubble size of 0.05m with a catalyst weight of 175kg was designed .A modified catalysts of alumina and potassium hydroxide was considered to increase yield and selectivity of ethylene to further increase the mass production. After the dehydration reaction, the product purified using an absorption column and finally two desiccant driers to obtain 99.96% purity of ethylene. The plant will be located near Chisumbanje Ethanol Plant for easy access of raw material. Since ethanol production is seasonal due to the climatic condition in Zimbabwe for sugarcane production, the plant will operate only 300 days per year at a very high capacity. After conducting an economic analysis, the return of investment of 34% and the payback period of 3years was obtained to break even. Therefore lot of the companies have started the production of ethylene especially in Brazil. The total production cost of $172956 proved to be low as compared to the Naphtha process for the same mass production of ethylene. The process is still producing a lesser mass of 9000tonnes ethylene compared to the naphtha cracking process which can produce mega millions of ethylene. Therefore, the development of cheap and sustainable conversion process of low cost lignocellulosic biomass is important in the future. The process also proved to be environmentally friendly since not much pollutant gases are being released to the environment compared to other processes.

Key words: *Ethylene, Anhydrous ethanol, fluidized bed reactor, Dehydration*

DESIGN OF A PROCESS THAT EXTRACT 2500KG/DAY OF GELATIN FROM ANIMAL BONES AND HIDES USING A HYBRID OF CHEMICAL AND BIOLOGICAL PROCESS.

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Due to the unavailability of a gelatin production plant in Zimbabwe, which causes high costs in gelatin and of products produced using gelatin since it is being imported from other countries. This project focuses on the design of a process that extract 2500kg per day of gelatin from animal bones and hides using hybrid of chemical and biological process. The design process has three main stages which are pretreatment of hides and bones using chemical and enzymes, hydrolysis extraction of gelatin and purification of extracted gelatin. Experiments were done to determine the effective and economical process between chemical, biological and hybrid process and also to determine the quality and yields of gelatin. These experiments were used in mass balance to determine the amount of raw materials needed and hence the size of equipment design. A detailed design was done for the major equipment; hydrolysis batch extractor which operate at 55°C, pressure of 1.8 atmosphere and pH of 5.5. Hazard operability has been analyzed in trying to monitor deviations that may rise in the process. An economic analysis for the project was carried out and the project proved to be economically viable with a payback period of 3.4 years. From the process and equipment design it can be concluded that it is possible to produce 2500kg/day of gelatin. The researcher recommends further optimization of the process to utilize waste fluids from the process.

Key words: Gelatin, Bones, Hides, Hybrid, Chemical, Biological, Purification

DESIGN OF GASIFIER FOR THE GASIFICATION OF 9 TONNES PER DAY OF WASTE TYRES

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It is important to note that gasification of biomass has been practiced for a long time and has played an important part in reducing the need for fuel imports in some countries as the prices of fuel are constantly increasing. This project is aimed at carrying out the technical and economic feasibility of setting up a 9 tonne per day waste tyre gasification unit, design the major process equipment and

construction of a prototype. The experimental work carried out proved that it is economically and technically feasible to gasify waste tyres.100grams of waste tyres required a residence time of 1hr for complete combustion under a temperature of 750 Degrees Celsius. The product gas was then condensed and the resultant liquid had a density of 0.885g/cm3and a viscosity of 2.2. The experimental results were used in coming up with a mass and energy balance having a feed flow of 375kg/hr and gas output of 240kg/hr. raw material usages ratios where then used in sizing up of the equipment. A Hazop analysis of the major equipment (gasifier) was done to ensure equipment operability and safety. The project requires a total capital investment of $952 315.31, total manufacturing cost of product was $ 0.41/L and the factory selling price of the product as $0.58/L. The projected sales are considered viable with a 3 years payback period and breakeven point of 199 813.21 units

Key words: Gasification, Waste tyres, Fuel imports, Residence time, Combustion

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THE DESIGN OF A PROCESS THAT PRODUCES 1000M3/DAY OF BIO HYDROGEN FROM MICROALGAE

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The world's energy markets rely heavily on fossil fuels (such as coal, petroleum, and natural gases). However, due to increasing energy demands, depleting reserves of fossil fuels, and increasing negative effects on the environment (such as global warming and climate changes), as well as growing political instability, the world is facing a major energy threat that needs to be solved by virtue of alternative energy sources utilizing renewable resources. The only natural, renewable carbon resource known with large enough capacity to substitute for fossil fuels is biomass. Among the existing biomass energy/biofuels, bio hydrogen has received considerable attention as it is clean, renewable, has high energy content, and does not contribute to the greenhouse effect. Technologies leading to more efficient and commercially viable production of bio hydrogen from biomass, one of the promising bio hydrogen production approaches are conversion from microalgae, which is abundant, clean, and renewable, unlike other well-developed. Therefore, this review examines the perspectives and state-of-the-art of algal hydrogen research in the context of pathways of hydrogen production, photo bioreactor design with a volume of 15.75m3 and its operation, economic evaluation. Prospects and challenges in algal hydrogen production are also outlined. Experiments were carried out to determine the amount of hydrogen produced per 6000kg of microalgae culture. From the experimental results, an input of 800g biomass algae produced 12g/day of bio hydrogen under sulphur deprivation environment. The obtained results were scaled up to design an optimum process including a detailed design on the photo bioreactor. 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 payback period of 2.4years and return on investment of 42.2%. On completion of the project it was proved that it is possible to produce high yield of hydrogen using bio photolytic process under sulphur deprived environment.

Key words: *Bio hydrogen, Microalgae, Fossil fuels, Environment, Conversion*

THE DESIGN OF A 5TONNE PER DAY ORGANO-MINERAL FERTILISER PRODUCTION PROCESS

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A process was designed with the intention of producing 5000kg of organomineral fertilizer per day from sugarcane filter cake which is a waste material at Tongaat Hullets. The desire was to reduce the amount of filter cake being discharged into the environment as well as providing an affordable fertilizer to the Zimbabwean farmer. Experiments were carried out to determine the amount of moisture in the filter cake as well as the nutrient composition. The NPK content was determined to be 23.1%, 7.1%, 9.3% respectively. A granulator was also designed using appropriate equations that will produce organomineral fertilizer. Aspects of temperature control and flow control were also considered and they gave enough information for the HAZOP analysis. A payback period of 3.5 years and a rate of return of 28.46% was also determined which are acceptable financial indicators

Key words: *Organo-mineral fertiliser, Filter cake, Environment, Moisture, Temperature control*

DESIGN OF A PROCESS THAT UPGRADES SAWDUST- BIOGAS TO 24M3 OF BIOMETHANE PER DAY (USING ACTI-ZYME AS BIO-CATALYST).

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Zimbabwe has some of the largest deposits of timber in southern Africa (about 500 000 tons per annum) such that most entrepreneurs venture into timber processing. The venture results in a lot of sawdust dumps that are of no economic use if they are left lying around. There is 10000 metric tons that go to waste each year. Research shows that it's feasible to produce biogas from the digestion of

the sawdust in an aerobic digestion process. The aim of this project is to digest 4000 metric tons per year to produce biogas. This is an economic way of disposing sawdust. Biogas produced will be approximately 31 m3 per day and it will be upgraded to 24 m3 per day using chemical scrubbing technique. Biogas production is growing and there is an increasing demand for upgraded bio- gas, to be used as vehicle fuel or injected to the natural gas grid and for power generation (electricity). To enable the efficient use of biogas in these applications the gas must be upgraded, i.e. the carbon dioxide, which constitutes a large part of the raw biogas from the digester, must be separated from the methane. Purified or "sweetened" biomethane has a higher calorific value of 99 % relative to the 77 % of raw biogas. The project is also economically viable since it takes two year to payback an investor with a return on investment of 48 cents on a dollar. Several methods of upgrading biogas to biomethane are discussed and in this project chemical scrubbing is used because of the high purity of methane achieved 97 % and low methane spills.

Key words: Sawdust, Biogas, Biomethane, Acti-zyme, Scrubbing

DESIGN OF 40TPD TANNERY SOLID WASTE GASIFICATION PROCESS

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The conventional leather tanning technology is highly polluting as it produces large amounts of organic and chemical pollutants. About 100000 tonnes of tannery waste are dumped each year in Zimbabwe, poising a major challenge to the environment. This project focuses on the utilization of this waste in electricity power generation. The main aim of the project is to design a 40t/day gasifier for the gasification of tannery solid waste. Prior to the design a number a number of experiments were conducted to determine the optimum conditions for carrying out the process. It was established that temperature of above 850°C promote the production of light hydrocarbons. The moisture content of tannery waste was determined experimentally and found to be 10.1%, a high bulk density of 525.20 kg / m3 and the corresponding ash content as 4.39 %. The calorific value of the solid waste was determined and found to be 17.86 MJ/ kg with the volatility matter as 66.44%. Based on the experiments 600000kWh of energy be produced from the gasification process. The major equipment for the gasification process, the gasifier was designed, a volume of 11 .12m3, diameter of 2.19m, and height of 2.92m was established as the key parameters for optimum gasification. The hazard analysis and operability (HAZOP) study on the gasifier was done to ensure equipment operability and safety. A detailed economic analysis of the whole process was done to assess its profitability and from the calculations and the estimations done, a payback of 1.966 years and a breakeven point of 50% and return on investment of 50.8566% was determined.

Key words: *Tannery, Gasification, Design, Moisture content, Calorific*

DESIGN OF 40T/DAY ALUM PRODUCING PROCESS PLANT FROM WASTE BEVERAGE CANS

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Turbidity and colour has been one of the major challenges facing most Water treatment plants in Zimbabwe. The effect of high levels of turbidity is the increase in the cost of production. The most efficient way of removing and reducing turbidity and colour is by the application of coagulants, which is mainly alum in Africa. Several methods have been established for the production of alum; the most efficient one has been determined to be the use of an acid to digest the bauxite waste. This method has been chosen to be the most efficient because it is simple and cost effective. It has been proven that a significant percentage of budgetary allocation for the treatment of water mostly in Africa and developing countries goes into the procurement of alum. The focus of this study is to determine a protocol that can be effective, efficient and cost less in the production of alum from waste beverage cans. The environmental friendliness of the process developed was also very important and vital to the work and duly investigated. One of the most important variables also investigated was the effectiveness of the product produced. This study developed a process, which leads to the production of alum from waste beverage cans. In this project a plant capacity of 40t/day of product was produced in a 8hr working plant operating 300days a year. The process would operate a total of four batches with batch cycle time lasting a total of 2hrs as determined by experiments. The project proved to be feasible economically. The production price was $4 122 235.513. The production cost of $0.34/kg .The project also has a quick payback period of 2years. The alum produced from the beverage can waste performed comparably well to the commercial Alum.

Key words: *Alum, Waste beverage cans, Turbidity, Coagulants,*

PRODUCTION OF 2 TONNES/DAY OF ORGANIC FERTILIZER FROM THE DEGRADATION OF WASTE CHICKEN FEATHERS: CASE STUDY OF IRVINES POULTRY INDUSTRY

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The significant growth in the poultry industry locally and globally has led to the generation of large amounts of waste chicken feathers which pose serious health hazards to the environment from the way they are being disposed. The major drive for this project was to minimize disposal and incineration of waste feathers through converting them into a useful, environmentally friendly and valuable product (organic fertilizer) at a rate of 2 tons per day. Keratinophilic bacteria were cultured and isolated from soil samples collected from a feather dumping site. From the keratinase assay, Bacillus Subtilis bacteria was identified to have preferable keratinolytic activity hence was used to obtain the enzyme keratinase which was used to degrade the waste feathers. The biodegradation process took place under anaerobic conditions, at a pH of 10 and temperature of 37°C. 95% feather degradation was noted after seven days and there was a temperature rise of 15°C. The nutrient value of the fertilizer was tested in the laboratory and found to contain 14% Nitrogen, 7% Potassium and 4% Phosphorus. A HAZOP analysis was carried out on the major equipment being the bioreactor and pH and pressure control measures were proposed to ensure safe and intended operation of the equipment and process parameters. An economic analysis was also carried out which indicated that the project is feasible as it results in profits of $183715.43,a break-even point of 109680.16 units and a payback period of 0.6 years.

Key words: *Organic fertilizer, Degradation, Chicken feathers, Keratinophilic, Biodegradation*

Industrial and Manufacturing Engineering Department

DESIGN AND PROTOTYPING OF A 6 AMP DEEP CYCLE BATTERY CHARGER

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With the increasing use of solar energy and power backup systems in Zimbabwe, a battery charger was designed for charging a 12V deep cycle sealed lead acid battery. The design was intended at developing a battery charger that is able to monitor and control battery charging and discharging voltage levels, reverse polarity protection and has infinity overcharge protection. The battery uses the Maximum Power Point Tracking (MPPT) charging technology which resulted in a charging efficiency of 86%. The deep cycle charger has a float voltage of 13.8V and a low voltage disconnect of 11.0V which protects the battery from both overcharging and over discharging. It consists of a circuit which performs charging, a circuit displaying battery charging level during charging and discharging. The LCD on the front panel of the charger displays the battery voltages. Design was simulated using Proteus simulation software, and then the prototype circuit was developed. Solutions were brought to problems that were noticed during tests. The brain of the circuit, the PIC16F877A which is the most advanced microcontroller nowadays was used to control the charging process. Detailed working drawings and calculations were made before manufacturing the prototype.

Keywords: *Deep cycle battery, Maximum power point tracking, Charge monitoring, Discharge monitoring.*

DESIGNING OF A PLUG AND PLAY UNINTERRUPTED POWER SUPPLY, HOME BACK-UP SYSTEM.

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The purpose of this project was to design and construct a 1KW 220 Volts Uninterupted Power Supply (UPS) at a frequency of 50Hz. This frequency would match the mains supply thus matching the load requirements in Zimbabwe. During the design of this device, material substitution was considered and hence it was constructed with locally sourced components and materials of regulated standards. The basic principle of its operation is a simple conversion of 12V DC from a battery using integrated circuits and semiconductors at a frequency of 50Hz, to a 220V AC across the windings of a transformer. An additional power supply to the public power supply with the same power output is thus provided at an affordable price.

Keywords*: Power backup, automatic switch ON, Material substitution.*

REVERSE ENGINEERING OF A WALL MOUNTED FIRE EXISTINGUISHER

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Fire disaster is a common threat to lives and property. An automatic fire fighting extinguishing strategy provides real time monitoring, exploration and programmed firefighting zone without human monitoring. This project presents the design of a low cost, robust, and secure fire protection system for property and buildings. It sends early fire detection signals and helps to reduce fire break outs and fire damages. This system consists of a smoke detector and outputs are connected to the controller. The system takes into account the density of smoke and thus the probability of false signals can be avoided. The researcher presents an overview of the design and the implementation of the automatic wall mounted fire-fighting extinguisher. The aim of the project was to assist in firefighting in cases of fire ground evolution. This is an essential tool towards the risk reduction that the fires can cause in buildings. The automatic fire fighting extinguisher was made and it's efficiency and fire detecting and extinguishing capabilities were tested in a simulated environment that took place in a small house model.

Keywords: *Real time monitoring, Fire protection, Automatic, Fire extinguisher*

DESIGN OF AN AUTOMATED VIBRATION MONITORING SYSTEM FOR CONDITION BASED MAINTENANCE OF A LATHE MACHINE (*CASE STUDY*).

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This article presents an automated vibration monitoring system for a lathe machine. This study was motivated by the fact that machine production time was wasted during planned maintenance when, most times, the machines did not require any maintenance at all. Also, the periodic intervals used did not depict the correct ageing of the machine components which resulted in unexpected failure of the machine. Planned maintenance schedules are done with the assumption that the machine is going to breakdown after a certain period of time. This research was carried out at Harare Institute of Technology in Industrial and Manufacturing Engineering workshop. The aim of this research was to come up with a vibration monitoring system for a lathe machine, which included integrating an

electronic circuit for the system, use of liquid crystal display (LCD) system for improved user interface and incorporation of vibration sensors to determine the vibration level of the machine. Experimental research design was used to determine the acceptable ranges of vibration amplitudes in order to classify the amplitude into 4 groups namely: extremely rough, rough, acceptable and smooth. The designed system produced consistent vibration amplitudes for both machining and non-machining operation. The system used different coloured lights connected to vibration sensors attached to the lathe machine to alert the user when the vibration is more than accepted and also to switch off the machine when the vibration threshold is exceeded. The vibration monitoring system helps in damage control and enables preventive measures to be taken before damage occurs.

Keywords: *Condition Based Maintenance, Lathe Machine, Machine Downtime, Vibration Monitoring, Vibration Sensors*

DESIGN AND DEVELOPMENT OF TELE-MANIPULATED PULSED MAGNETIC FLUX LEAKAGE WELD TESTING MACHINE

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This project was on the design of a tele-manipulated pulsed magnetic flux leakage weld defect testing machine. The design was prompted by the failure to test the quality of welds on manufacturing and production machines which resulted in unexpected breakdowns and production of substandard products. The aim of the project was to design a weld testing machine which is a non-destructive weld testing technique. The researcher carried out experiments and tests on a fabrication company. Interviews, observations and engineering softwares were used in coming up with the weld defect testing machine. The designed machine consists of a motorized traction system that eliminates human propulsion and an electrical circuit which induces an electromagnetic field in the test piece after welding. The same circuit incorporates a sensor for detecting changes in current settings after experiencing a weld defect. The strength of the current change signifies the degree or character of the defect. The stronger the current the bigger the defect is. The Test Meter on the front panel of the charger displays the changes in current. Implementation of the tele-manipulated magnetic flux leakage weld defect testing machine will result in improved weld quality, reduction in plant downtime and increase in productivity.

Keywords: *Breakdown, Magnetic Flux Productivity, Tele-manipulated, Welding, Weld defects*.

DESIGN OF A GASIFIER TO PRODUCE SYNTHESIS GAS TO BE USED AS ALTERNATIVE FUEL FOR GENERATORS AND ENGINES AND IN HEATING APPLICATIONS

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Synthesis gas is also known as synthetic, flue, producer, or fuel gas and it is a mixture of hydrogen, carbon dioxide and carbon monoxide. The gas finds application in electricity generation, used as alternative fuel for generators and engines and also used in heating and cooking applications. The project designed a biomass gasifier for the purpose of producing synthesis gas to be used as alternative fuel for generators and engines as well as application in heating and electricity generation. The gasifier had several units incorporated in it which included, the reactor, cyclone, tar collector and filter unit. The biomass fuel was fed through a hopper and channelled directly to the ash sieve for combustion. The burning biomass produced a mixture of gases that is, carbon monoxide, carbon dioxide and hydrogen which is also known as synthesis gas. This project managed to ensure environmental sustainability through production of fuel gas with high percentage of purity.

Keywords: *Synthesis gas, Fuel gas, Flue gas, Synthetic gas*

UTILITY MODELLING OF A HYDRAULIC RIG FOR LIGHT AIRCRAFT

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Hydraulic rigs are part of the ground support equipment used when servicing aircraft. These rigs are designed to conveniently service both military and commercial aircraft systems worldwide so as to save lifespan of the engine and reduce servicing costs. They can also be used as faulty finding equipment and it comprises of a hydraulic system and uses hydraulic oil as medium of operation.

This part of servicing can be done through test running of the aircraft but at a cost of loosing life hours of the engine and fuel consumption. This test running of the aircraft reduces the lifespan of the engine and costly in terms of fuel consumption, so as a way, to ease these costs, and improve standard of service associated with small Air force training aircraftt in Zimbabwe a portable hydraulic rig system comprising of a motor and a hydraulic system was designed. The incorporated hydraulic system employs enclosed fluid to transfer energy from one source to another, and subsequently creating rotary motion, linear motion, or force. Hydraulic power units apply the pressure that drives motors, cylinders, and other complementary parts of a hydraulic system. Unlike standard pumps, these power units use multi-stage pressurization networks to move fluid, and they often incorporate temperature control devices. The designed rig was prototyped and produced pressure of about 1000psi which enough to test the landing gear of small Zimbabwe air force aircrafts.

Keywords: *Hydraulic rig, hydraulic fluid, pressure, reservoir volume, power*

SUBMERGED ARC FURNACE FOR CALCIUM CARBIDE PLANT

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The shortage of calcium carbide has caused a monopoly in the gas producing industry, which has resulted in South Africa being the major supplier of calcium carbide in the whole of Africa despite the fact that there are large deposits of calcium carbide raw material (limestone) in Zimbabwe. Furthermore, acetylene that is a major gas used for oxy-acetylene welding, which does not rely much on electricity, making it the most common welding process in Zimbabwe comes from calcium carbide. Hence, lack of a calcium carbide plant has led to closing of a couple of companies that uses acetylene gas due to shortages and cost of importing the product. This project seeks to develop a calcium carbide submerge arc furnace to aid in the production of acetylene for the steel, agriculture and gas for the SME in Zimbabwe. The designed electric arc furnace consists of a refractory-lined vessel, that would be water-cooled covered with a retractable roof, and through which graphite electrodes enter the furnace. The designed furnace is primarily split into three sections namely shell, hearth, and roof. Design calculations were done to come up with the bill of material or quantities of the desired furnace that would be installed for the manufacture of acetylene gas.

Keywords: *Calcium carbide, acetylene, refractory lining, furnace operation*

DESIGN OF A SOLAR POWERED LEAF HUMIDIFICATION SYSTEM FOR SMALL SCALE TOBACCO FARMERS IN ZIMBABWE

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Environmentally friendly practices in all industries including the agriculture are the way to go this century to reduce carbon footprint production globally. This does not spare even small-scale tobacco farmers in Zimbabwe who uses traditional methods of tobacco leaf conditioning using firewood and drums. This has caused a great deal of deforestation and land degradation as well as accidents through bursts of drums since there is no measurement of the pressure in the drum. Hence, a safer and more reliable tobacco leaf conditioning system is the goal of this project. An environmentally friendly solar driven steam conditioning system was designed to help the small-scale tobacco farmer of Zimbabwe to minimise the rate of deforestation. The designed solar driven leaf conditioning system consists of steam pipes, solar stand, tube collectors, water tank pressure gauges, hygrometer and a reservoir. An experimentation using a prototype of the designed system was carried out producing the required energy and quality of steam for steaming; hence the system can be used as a safer substitute of several humidification technologies.

Keywords: *Humidification, solar collector, deforestation, leaf conditioning*

DESIGN OF A VAPOR COMPRESSION SYSTEM WATER HEATER

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In Zimbabwe water heating is a necessity in every life aspect. Locally the electricity is the major method used for water heating. However, the operation of an electrical water heater to heat water is very costly whether in domestic or commercial applications in terms of energy consumption. Hence, designing of a more efficient way of water heating is the aim of the project to reduce energy consumption. A vapour compression water heating system was designed as a solution to this

problem. The research of this project was based on literature review, surveys and experimentation through existing designs and mechanisms of vapour compression cycles. This vapour compression system comprised of a compressor, both a pre-cooler and an actual condenser. The designed system does have storage tank that stores water from the pre-cooling condenser.

Keywords: *condenser, refrigerant, water heating, compression, energy consumption*

OPTIMIZATION OF A HONEY EXTRACTOR

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Local beekeepers are using the old traditional methods of processing honey which leaves their product as a product of low quality. This results in the production of substandard honey, beeswax and reduced honey production by the bees, which eventually causes the country to import from other countries. Honey is at its maximum purity while in the sealed honey combs however once this have been broken as human are to collect the honey it starts to deteriorate. Therefore there is a great need for a hygienic process or machine which can be used in extracting the honey. The aim of this project was to the design and manufacture of an extracting machine, which can be powered either electrically or manually to counter power failure problems and to cater for those small scale farmers without access to electrical power hence compatible with the local small scale farmers' environment. Determination of the operating conditions was determined experimentally and also testing of the actual machine. An economic analysis of costing and evaluation was carried out and the total budget for the versatile machine was a reasonable. Although the designed process turned to be technically and economically feasible, there is need for improvements on the processing of honey which can be further improved filtering and packing. Therefore it is recommended that more research should be done on the further processing of honey.

Key Words: *Honey extractor, shape and design, optimisation, transmission structure*

DESIGN OF A MULTI CITRUS JUICE EXTRACTOR

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The aim of this research work is based on the design and fabrication of fruit juice extracting machine. This machine has the ability to extract juice from fruits such as lemons ,naartjies and lemons with the help of a screw shaft which acts as an auger .The machine has a sturdy construction, is portable in design and it is made to be a table top machine. Several varieties of juicy fruits are available in abundant quantities in many parts of Zimbabwe most especially during the harvesting seasons. Incidentally there is an increasing demand for fruits juices among people of all age groups due to the vitamins, mineral and fiber contents. These products are essential for human and animal growth, aid metabolic activities and improve health standards. The researcher designed, constructed and evaluated the performance of the extractor in the laboratory using orange fruits. The fruits were washed and weights (1kg, 1.5kg and 2kg respectively) of fruit slice (8 and 16 slices) were then processed using the extractor to extract the juice. A device of this nature can be manufactured in small machine shops in and is used for small scale commercial purposes only.

Keywords: *juice extractor, machine optimization, design and fabrication*

REVERSE ENGINEERING OF A SOLAR BASED CHARGING UNIT

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This project focused on the application of photovoltaic systems in charging usb based devices, considering their conveniences on cost effective, environment friendly and energy harvesting models. Unavailability of a consistent power supply in Harare Province has been a constant bane to users of electrical devices, such as laptops and cellphones, significantly reducing their productivity in terms of computer-based work done. The project aim therefore was to design and optimise a solar based charger system for the Zimbabwean market. Methods used included informal interviews, experimental analysis, concept generation techniques, modelling and testing. The result was the development of a functional prototype using mono-crystalline silicon PV Cells. The device is

recommended for further aesthetic development and for use by users of small laptops, notebooks and phones in Zimbabwe and sub-Saharan Africa.

Key words: *Solar charging, Mono-crystalline silicon, PhotovoItaics, Cost effectiveness*

DESIGN OF AN ICE THERMAL STORAGE SYSTEM FOR HOTEL AIR-CONDITIONING IN ZIMBABWE

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The cooling needs in hotels, like in a lot of buildings, are usually high during the day when they are mostly occupied. It is during this time of the day when consumers pay the higher tariffs for electricity consumption. This project is aimed at designing integrated ice storage and HVAC system which will have the storage system charged at night with the chiller running at maximum capacity with low electric energy costs and consequently having air conditioning services during the day. The objective of the system is to reduce electricity consumption and related costs by increasing power usage during low cost and demand periods. To design the refrigeration plant with an ice bank for air-conditioning purposes, the cooling needs were first considered on an hourly basis over several days. The cooling needs of hotels in the country were studied and an ice storage system was designed based on day maximum cooling load of 180kw and night maximum cooling load of 30kw. Duct sizing was done using the Ductula software. An economic analysis was done at the end to determine the feasibility of the project. The researcher recommends this design as it is advantageous to the electricity production and distribution companies since it tends to stabilize consumption in the national grid.

Keywords: *Electrical Energy Costs, Refrigeration, Ice Storage, Air-Conditioning*

DESIGN OF AN AIR CONDITIONING SYSTEM FOR PHAMARCEUTICAL LABORATORY

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Like in any other working environment, cooling is an essential element in pharmaceuticals laboratory. In a pharmaceutical laboratory there is as a requirement that the laboratory should be an enclosed space with two or more doors as to ensure that there is no outside air to enter the laboratory. The requirements of the laboratory to be a closed space gives rise to the room space that it need to be conditioned to be able to work in it and also to allow the desired standards. This research is based on the design of a laboratory air conditioning unit, a technology transfer approach. Data was collected on current systems in use. System pipng was done using Ductula software. A prototype was developed which was able to achieve cooling loads of 18^{o}C.

Key words: *Pharmacitical laboratory, Cooling, Air conditioning*

UTILITY MODELING OF AN EASY TO USE COMPACT HEAT EXCHANGER FOR HOSPITALS

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In order to ensure a constant supply of hot water in a hospital, the heating facilities should be in their best operating condition. For a boiler, one of the components that guarantee good system performance is the heat exchanger, which is precisely engineered to match the specific duty requirements, with a high efficiency and low volume to pressure ratio. This research is based on the design of a plate exchanger. The objective was to have water heating system with a high secondary temperature rise and large sudden load changes. The core unit occupied a maximum of 1.2 m^3 space and a range of domestic and process hot water duties from 110 kW to 1 800 kW. Experimental design produced the best results at 60ºC on secondary temperature with the corresponding pressure of 400psi at a flow rate of 380kw.

Keyword: Hospital, *Hot water, Boilers, Heat exchangers*

DESIGN OF A COLD CHAMBER INJECTION MOULDING MACHINE

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The project focused on the design of a cold chamber injecting system for Chazon Tec Company in pressure die casting aluminium. Chazon tech is a nonferrous casting company with new interests in pressure die cast products. A literature research was done on all the major areas with significant relevance to the project such as types of material used for the sleeve, plunger head, the pressures required to inject aluminium and the design principles. Software's programs such as Auto Desk Inventor 2015 and MD Solid were mainly used to come up with the working drawings and analysis of the pressures and the feasibility of the designs. Possible designs were evaluated against design specifications to select the most complete design. A working prototype was constructed and assembled for testing and further development.

Keywords: *Die-casting, injection, aluminium, moulding*

IMPROVEMENT OF THE CANNED FOOD PRODUCT SEAMS

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The project was focused on the improvement of the can seaming quality. A prototype canning machine was developed at HIT, and the results of the trials showed poor quality seams. This project sought to review literature on seam failures and causes and relate them to the prototype failures currently occurring .Secondly the project work focused on reverse engineering of the prototype with the intent to improve the performance of the prototype to recommended standards.

Keywords: *Canning, Seaming, Quality, Food*

REVERSE ENGINEERING OF AN EXTERNAL HYDRAULIC GEAR PUMP

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Geometrical Tolerances in gear machines have a significant impact on the performance of external gear pumps. Review of current indicates only a few studies that investigate the phenomena of geometrical micro details. This due to the complexity of the problem since it involves multiple domains and scales. This work will prove how it is possible to investigate the problem involving micro level details and the goal has been to study the effects with the aim of quantifying and proving the impact of a chamfer on the gears lateral side. The work has been performed by coupling the tooth space pressures solved by HYGESIM (Hydraulic Gear machines Simulator) with a numerical solver developed in an Open FOAM environment. The simulations are carried out by solving Reynolds equations which has been proven to give accurate solutions to problems involving fluid films. It was also found out that the generated hydrodynamic effects tend to increase with an increased chamfer. When it comes to the leakages, the chamfer has a positive effect. Comparison of the power losses for one of the chamfers, shows that the smaller one gives decreased losses while the bigger one generates increased losses.

Keywords: *Geometrical tolerances, Gear pump, Reynolds equation, Hydraulic*

UTILITY MODELLING OF A COMPACT EXCAVATOR

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The construction industry in Zimbabwe has huge potential for growth but is mainly composed of small scale companies. Since profitability and project timelines are highly dependent on mechanization, companies need to acquire machinery for operations. However, the absence of small scale machinery hampers efforts of growth in the industry. The project work seeks to design a small scale excavator for trenching operations. The excavator was designed using SolidWorks software and simulations were performed in the ANSYS environment. The compact excavator was designed with

an independent boom swing which can be locked in position.furthermore the excavator is mounted on a two wheel towing platform and has been designed to be towed by a 100 HP utility truck.

Keywords: *Excavator, Hydraulic, Compact, ANSYS, Solidworks*

DESIGN OF A TOBACCO STEAMING SYSTEM

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In Zimbabwe, an effort to provide tobacco farmers with better leaf processing technology is a necessity in order to promote ZimAsset. Tobacco leaves from the farm has to be cured but is too dry it results in breakage and low market price. Conversely, if is over conditioned, the tobacco becomes stained and discoloured and it too is penalized. This research is based on the design of a controlled tobacco leaf steaming system. The current steaming systems which are drum and tunnel steaming systems being used by farmers are not reliable because of manual wetness control resulting in over or under steaming resulting in moldy and reduced leaf quality. The aim of the research is to design a system which gives a moisture content of not greater than 18,7%. Information on current steaming systems across the globe was gathered. A steaming chamber with a relative humidity and temperature control was designed. Simulations were done using Autodesk Inventor were done to validate the functionality of the design. A prototype was then produced which can further be developed for use by Zimbabwean farmers.

Key words: *Tobacco leaves, Steaming system*

DESIGN OF A CONDITION BASED MAINTENANCE INSTRUMENT FOR ROTATING SYSTEMS

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The aim of the project was to come up with a condition based maintenance system for rotating equipment. Currently organisations are relying on breakdown and planned maintenance techniques

which are more expensive and do not give correct ageing of the machine. The condition based maintenance system designed can be applied on any device which contains sensors and is a rotating system. Experiments were carried out using MATLAB and Energy2D to ascertain the functionality of the control system. The system performance was validated by Proteus simulation software and set of parameters were obtained that exhibited a commendable improvement in the R.C.M capability, energy efficiency, ergonomics and safety and product quality of the design. The designed system was able to monitor the temperature, alignment and vibration using a combination of sensors working under a microcontroller. A variable resistor was used to enable the circuit to be used on any machine or system as long as there are known set parameters. This system also helps in anticipating and rectifying failures before they occur.

KEYWORDS: *Alignment, Condition based Maintenance, Microcontroller, Vibration sensors, MATLAB.*

DESIGN OF A CONDITION BASED MAINTENANCE SYSTEM OF HIGH VOLTAGE THREE PHASE TRANSFORMER.

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This project was aimed at developing a condition based maintenance system for monitoring high voltage three phase transformer. Over the years, increased calls has been made on reducing power usage. Emphasis has been placed in looking for alternative sources of energy in a quest to make the existing systems more reliable and have energy sufficiently supplied to everyone. This led to the development of the health monitoring system which enabled the transformer to be monitored online so as to reduce number of breakdowns and frequency of planned maintenance even when not necessary. The system included an electronic circuit for monitoring oil and temperature. A communication channel was also developed to enable communication between the micro controller and offsite maintenance team using the global mobile communication system (GSM). The designed system was able to predetermine the failures of transformer before they occur and resulted in reduction of costs of replacement and risks associated with breakdown of the transformer.

Keywords*: Breakdown, Condition based maintenance, GSM, Transformer, Temperature*

DESIGN OF A BLAST FREEZER

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Living organisms are all mostly comprised of water and it is this water inside that crystallizes into ice. The length of freezing time has a direct effect on the final quality of the product. In poultry production, most small to medium entrepreneurs make use of ordinary refrigerators which takes averagely 12 hours to freeze the whole bird and consequently reduce the quality. This research is based on a design of a blast freezer, a technology transfer approach. Current blast freezers are big and expensive, being beyond the reach of many farmers hence the need to design a compact blast freezer. Calculations were done on loading and Ductula software was used to size the pipes. The designed freezer takes 2-3 hours to wholely freeze 2kg bird to a temperature of about -40°C and with an air speed is of the order of 2–4 m/s. This design results in preservation of product quality due to shortened shock time.

Key Words: *Small to Medium Entrepreneurs, Poultry, Freezing Time, Blast Freeze*

DESIGN AND DEVELOPMENT OF A SORGHUM THRESHER FOR SMALL AND MEDIUM SCALE FARMERS IN BORROWDALE AND BANKET.

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Sorghum and millet as sources of malt to replace imported barley for the brewing industry has been a topical issue recently. Sorghum is needed in large quantities by Brewery companies as it is a primary resource in their product manufacturing. However these companies can only take sorghum which is clean for their product to be of good quality. Zimbabwe small and medium scale farmers in the case study area produce 40 to 90 tonnes of sorghum which is supplied to a brewing company. This paper aimed to design a low cost sorghum thresher machine, for the ease of threshing and cleaning of the sorghum, as well as reduce the cost of production and time frame. Literature surveys and work studies in the Agricultural sector industry were conducted to review use of various technologies available. Engineering tools such as Auto Cad and Inventor were used in producing and

analysing the model of the sorghum thresher machine. The machine is easy to use, affordable and can thresh sorghum with minimal damage.

Keywords : *Sorghum, threshing, malt, brewing companies*

DESIGN OPTIMISATION OF A SMALL SCALE GOLD CRUSHER

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A hammer mill is a machine consisting of a rotating head with free – swinging hammers that are used to reduce the gold ore in smaller grains of sand in order to liberate the gold from the rocks. This project is focused on the design optimisation, development and testing of a prototype hammer mill which is targeted to the small scale miners all over Zimbabwe. The methodology used was to analyse the important critical defects of the existing hammer mills which were causing large downtimes and provide solutions. The major components of the optimised hammer mill are the hammers, drive shaft, screen bearings, and the hammer mill body. The test carried out on the prototype proved that if the hammer mill is commercialised it will able to perform and satisfy the requirements of the small scale miners.

Keywords: *Gold crusher, Hammer mill, Optimisation, Downtime*

DESIGN OF A SEMI-AUTOMATED LABELLING MACHINE

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This project presents the design of a semi-automatic labelling machine. One of the most dynamic and fast changing elements of product packaging labels not only reflect the product manufacturer's brand, they differentiate product packaging and provide consumers with an abundance of information about the product itself. It can clearly be seen that labeling plays a major role on a product therefore there is need to make sure that products are labeled correctly and efficiently. The goal of this project was to design and fabricate a semi-automatic labelling machine that can be used

to label round bottle containers of up to 2litres. The background and what motivated the designer to come up with this design is the manual labelling that is done at Instifood's beverage products. A prototype was developed which uses self-adhesive labels which are winded on a label row. The prototype achieve desired results of labelling containers up to 750ml. Minor adjustments needed to be carried out on the feed and holding mechanism so that the containers don't fall over when moving along the conveyor belt and also for the design to be able to handle bigger containers.

Keywords: *Labelling, Semi-automatic, Holding mechanism, Feed*

DESIGNING A MEMBRANE FOR WATER PURIFICATION FROM WASTE POLYSTYRENE

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The main goal of this project was to prepare and characterize water filter membrane from waste polystyrene. The membrane has been synthesized by dissolving it in dichloromethane followed by sulphonation using sulphuric acid and washing it in distilled water then the precipitate is heated to obtain dry sulphonated resin. The degree of sulphonation of the dry sulphonated resin was determined using back titration method. Then systematically investigated the water uptake, water permeability and thickness of membrane produced under different design parameters in order to choose the most appropriate design concept.

Keywords: *Waste, Polystyrene, Sulphonation, Permeability*

DESIGN OF A HIGHWAY AERODYNAMIC TURBINE

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This project seeks to reduce the shortage of electricity in Zimbabwe by designing a highway aerodynamic turbine for power generation along Seke dual road. The working principle of the turbine is based on the concept of harnessing pressurised air produced by fast moving vehicles along

the highway which then turns the turbine and a generator converts rotational initiated by kinetic energy of induced wind into electrical energy. The turbines will be installed at the divider of Seke dual road which have enough space in-between to make the recapture of high pressure air effective. The power available from the wind varies as the cube of the wind speed, so twice the wind speed means eight times the power. This is why the site of Seke road was selected carefully, considering the high speed of vehicles travelling along that road. The shape of the turbine blades designed by the researcher did not take the aerofoil shape originally considered because it turned out that the C-shape of the blades capture maximum pressure of the wind energy induced by vehicles on the highway. Simulation of the turbine with ANSYS software was not carried out as planned however a prototype was developed and it showed that the project is feasible.

Keywords: *Highway, Aerodynamic, Turbine, Harnessing*

DESIGN OF FIBREGLASS SHREDDING MACHINE (OPTIMIZATION OF PLASTIC SHREDDER)

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This project involved the design and optimization of a fiberglass shredding machine to be used at Prodorite Pvt Ltd to minimize waste handling, cost, rate of injuries and environmental pollution. Fiberglass sheets production leaves considerable amount of off cuts during manufacturing varying in sizes between 50-100mm wide and 300-1000mm long. Most of the time waste handlers were forced to break the off cuts using bare hands resulting in injuries. Other costs incurred were failure to comply with the environmental legislation and high manpower for handling. The working environment was also filled up with off cuts causing a serious health hazard to the employees. The shredder designed was capable of shredding all grades of fiberglass sheets off cuts. Fiberglasses off cuts are fed into the machine through feeder hopper which directs them in the cutting chamber. Cutting chamber encompasses of stationary and rotating blades. Off cuts comes in contact with two members, one is a stationary blade and another is rotating shaft with blades. Cutting blades provides for the tensile force to cut off cuts whereas the stationary blades provide shearing force to push the uncut material. Those stationary blades are fixed at particular distance by means of studs. The shaft is rotating through electric motor by means of pulleys and is supported by means of bearings which are mounted on the cutting chamber housing. Pulley cover is provided to cover the pulley from a

safety point of view. The discharge hopper consists of concave screen with holes which shredded off cuts comes out of cutting chamber. The optimized design was subjected to various engineering tests, results were obtained and analyzed. A prototype was then produced and also tested for functionality.

Keywords: *Design, Optimization, Shredding, Fiberglass*

DESIGN OF A SOLAR PHOTOVOLTAIC SYSTEM SIZING APPLICATION FOR ZIMBABWE

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The world is about to face energy crisis which might threaten the existence of civilization and Zimbabwe is no exception but however, there is abundance of solar energy. This necessitated the development of a web based application that can effectively size solar photovoltaic systems. Solar power systems that are currently available are limited in their function due to the generic designs hence country wide application is ineffective. The system developed was able to reduce power losses due to generic designs by 20% and solar system design time by 20%. The application also managed to reduce cost due to over designing and under designing by at least 15%.

Keywords*: Solar energy, Generic designs, Sizing, Web based App*

DESIGN OF A SOLAR THERMAL ENERGY STORAGE MEDIUM

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In a bid to focus on the use of renewables particularly solar energy, there is a challenge of its intermittency. This makes the use of solar energy at night and during cloudy days a challenge. This research focuses on harnessing and storage of solar thermal energy using a rock bed filled with crushed granite. The designed rocked had a storage capacity of 5kWh$_{th}$ energy. The solar collector system was capable of harnessing solar energy at an efficiency of 53% and discharge it at an efficiency of 42%. The thermal storage unit cost was made minimal through material substitution. The product can be used in both domestic and industrial set ups where water heating is required. It

can also be integrated with a vapor absorption air conditioning system thus it can be used both for space heating and cooling.

Keywords: *Solar energy. Intermittency, Harnessing, Crushed granite, Solar collector*

DESIGN AND PROTOTYPE DEVELOPMENT OF A DIGITAL TURNING DYNAMOMETER

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The purpose of this project was to design and develop a digital turning dynamometer for the Harare Institute of Technology workshop. This was done in a bid to capacitate the workshop with equipment that enables efficient delivery of lectures especially in courses which include metal cutting and workshop technology. The digital dynamometer is a device for measuring forces during the use of machine tools in turning. The purpose of using a digital dynamometer is to accurately measure the turning force in order to optimize the machining process. The developed prototype was able to measure forces with a mean absolute error (MAE) of 5%. It had a relatively high degree of repeatability which was calculated through experiments and found to be 75%.

Keywords: *Dynamometer, Machine tools, Turning*

DESIGN OF A SEMI AUTOMATED MEAT SAW

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A meat saw is a meat cutting machine that uses the mechanism of a rotating blade which is motor driven that cuts meet as the operator manually pushes the meat into the blade. The purpose of this project is to design a semi-automated machine that will eliminate manual input by the operator. The researcher is hoping to accomplish this by automising the hold and feed mechanism of the machine. The only input by the operator will be to clamp the meat on the feed table and the machine

automatically feeds into the saw. The machine will be able to automatically adjust to the required sizes of meat to be cut. In order to facilitate all this, the researcher is going to use a micro-controller chip which will be used to input programs that will facilitate the movements of the table.

DESIGN OF A CHARCOAL MAKING KILN

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A charcoal making kiln is a device which produces charcoal from sawdust that is a waste product from sawmilling process. This machine was made after gathering all the necessary and relevant literature, from existing charcoal making methods and other similar ideas. After gathering the literature, i made a few possible solutions by incorporating new designs with already existing ideas. A best solution was then chosen amongst the three possible solutions, the best solution was developed further to come up with the best charcoal making kiln. Different design processes and criteria's were used in coming up with the best proposal. Detailed working drawings and calculations concerning the machine were made before manufacturing the prototype, a miniature of the real expected machine which should be able to make charcoal from bio waste.

Electronics Engineering Department

DESIGN AND DEVELOPMENT OF AN FPGA BASED LOW POWER MULTIPURPOSE DISPLAY BOARD USING 3 DIMENSIONAL LED CUBE

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An FPGA based project on the design of a low power multipurpose display board using a 3 dimensional LED cube was developed. In this project an Altera DE2 board was used to control the cube. Individual super bright blue LEDs were hand soldered to form an 8x8x8 cube to make a true volumetric display that actually occupy space, a total of 512 LEDs were used. A program was written in VHDL and downloaded into the Cyclone II that could render 3D effects on the cube. Both software and hardware multiplexing were used to address the cube using amazingly fewer data lines; hardware multiplexing was done by 3 to 8-line decoder. An application designed to run on a PC and written in C# language was also developed. It enabled the user to control the cube with his or her computer that is, one could actually run custom effects or even complex animations using the computer's processor and displaying on the cube. Furthermore, instant messaging could be achieved, the instant a key is stroke on the keyboard it is immediately displayed on the cube as a message or series of letters as one types on his or her PC. This feature was implemented using a USB to RS232 cable connecting the host computer to the DE2 board and UART communication protocol was used to transfer data between the two devices

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DESIGN AND DEVELOPMENT OF A COLOR RECOGNITION ROBOT

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The aim of this project was to develop a system that detected the colour of different objects then use this information to sort those objects using a robotic arm. The system was to be made up of two sections; the vision section and the sorting section. The vision section was to be comprised of a digital camera and a personal computer to provide the software based colour detection. MATLAB was used to detect the colour for each object. Through serial communication the MATLAB program would then communicate with the sorting section. The sorting section was made up of a microcontroller circuit and a servo based robotic arm with 4 degrees of freedom. Once an object has been detected and its colour identified, the robotic arm would pick the object and place it in a designated location. The microcontroller would control the robotic arm. The microcontroller program was written in C language using the MikroC compiler.

DESIGN OF A PROTOTYPE FOR A 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 indigenous liquid filling factories. This liquid filling machine prototype is the 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 machine uses a programmed microcontroller that function as the brain of the system. It has predefined program and instructions that are responsible for the liquid dispensing processes and conveyer belt movement that the machine will perform as directed by the user. When a bottle or beaker picked up by the infra-red sensor at the filling position, the motor will automatically stop and filling system will start. After the filling process, the motor will automatically operate enabling the conveyor to start moving.

LAPTOP THEFT DETECTION SYSTEM

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The aim of the project was to design and implement an RFID based theft detection system that can detect RFID tags of two laptops. An RFID reader would detect the presence of RFID tags and would send the unique identifier number of the tag to the microcontroller. The microcontroller would prompt the user to enter a password. The microcontroller would communicate with a database on a computer and verify if the password entered coincides with the RFID tag.

OPTIMAL POWER POINT TRACKING CHARGE CONTROLLER SYSTEM FOR OFF THE-GRID SOLAR ARRAY SYSTEMS

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As people are much concerned with the fossil fuel exhaustion and the environmental problems caused by the conventional power generation, renewable energy sources and among them photovoltaic panels and wind generators are now widely used. Photovoltaic sources are used today in many applications such as battery charging, water pumping, swimming-pool heating system, satellite power systems etc. Though it has the advantage of being maintenance and pollution-free but their installation cost is very high (Maheshappa et al 1998). Photovoltaic energy has been attracting more attention in the last few years as it meets the requirements of being environmentally compatible and resource conserving. They have the advantage of being maintenance and pollution-free. A solar cell may operate over a wide range of voltages and currents,

depending directly on the illumination. They require a power conditioner (dc/dc or dc/ac converter) for load interface. Since PV modules still have relatively low conversion efficiency, the overall system cost can be reduced using high efficiency power conditioners which, in addition, are designed to extract the maximum possible power from the PV module.

TRANSPORT TICKERTING SYSTEM

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The aim of this project was to design and implement a microcontroller based transport ticketing system. RFID cards have unique numbers that were used to distinguish the passengers on board. The RFID card was swiped upon entry. The pin of the RFID card was entered. A code in the microcontroller was used to check if the card was valid. It was also used to check if the passenger had sufficient number of units. Moreover, it was used to determine if the pin is correct. If these conditions were met the door would open for 5 min then close. The GPS module was used to give co-ordinates. The LCD would display the amount of units available and the co-ordinates at entry. The co-ordinates would be stored in the microcontroller. At the destination the passenger would swipe the card and enter the pin again. The LCD display the co-ordinates at the destination, distance travelled and remaining. The door open for 5min then it closes. A database was created which contains the details of the passengers. The amount of units where deducted from the database. The amount of units in the RFID card are recharged using the database.

Food Processing Technology Department

PRODUCTION OF CARBOXYMETHYL CELLULOSE FROM CELLULOSE EXTRACTED FROM MAIZE HUSKS

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The objective of this project was to produce carboxymethyl cellulose from cellulose extracted from maize husks. Maize husks were obtained from street maize vendors along Lomagundi road. The maize husks were washed dried and ground to a fine powder before extraction of cellulose using the acid detergent method of extraction.6g of ground maize husks yielded 5.2g of cellulose after reacting with NaOH and H2SO4 and delingifying with sodium hypochlorate. The colour of the cellulose was creamish yellow which is acceptable. 5g of cellulose was used in the production of carboxymethyl cellulose. The slurry method of CMC production was used with ethanol-NaOH-water mixture in the mercerization stage. The alkali cellulose was mixed with monochloroacetic acid to produce CMC and other by-products. The by-products sodium glucolate and sodium chloride were washed out using alcohol and water. The CMC produced was a light yellow. The CMC was incorporated in soy ice cream successfully reducing water crystalisation.

DEVELOPMENT OF A PROCESS FOR PRODUCING XYLITOL FROM THE FERMENTATION OF SUGARCANE BAGASSE HYDROLYSATES USING DEBARYOMYCES HANSENII.

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The aim of this project is to develop a process for producing xylitol from the fermentation of sugarcane bagasse hydrolysates using Debaryomyces hansenii. . Xylitol is a polyalcohol of five carbon atoms which is widely used in the food and chemical industry. In the study, various pre-treatment procedures on the raw material were investigated in order to determine their effect on the xylitol yield. The hydrolysates were obtained using acid of varying concentrations, varying time of hydrolsate extraction, concentration of liming agent, autoclaving time, effect of detoxifying agent used. These were found to influence the yield of hydrolysates and consequently influence the yield of xylitol produced, a comparison was also made between the yield of xylitol from corn fibre and sugar cane bagasse hydrolysates. The yield from corn fibre hydrolysates were observed to be more

than from sugar cane hydrolysates. Qualitative analysis of xylitol presence in samples was done using thin-layer chromatography. Quantification was done using visible spectrometry. D.hansenii can ferment sugar can bagasse to produce xylitol by utilising the sugar, xylose present in the bagasse. Pre-treatment improves the production of xylitol as it determines the amount of xylose present as well as influencing the fermentation process. Xylitol production can be improved by using dilute acid, controlling the time taken during hydrolysis as well as time taken during activated carbon detoxifying. D.hansenii produces the highest concentration of xylitol by using an acid that is 2% concentrated or less, autoclaving for approximately 1 hour, using calcium carbonate as neutralizing agent and detoxifying the hydrolysates for 1 hour using activated carbon. This process can be utilized for the production of xylitol in Zimbabwe and thus maximum yields can be obtained. This might solve the problem of importing xylitol in Zimbabwe.

DESIGN OF A PROCESS OF OPTIMISING EXTRACTION OF BETA CAROTENE FROM CARROTS (DAUCUS CAROTA)

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The objective of this experiment was to design a process of optimising extraction of beta carotene from Daucus carota L (carrots) by the use of an enzyme cellulase and co-solvent. Different trials were conducted using different solvent and at varying time and temperature intervals in order to obtain the maximum yield. Fresh carrots were washed and cut and then pickled in a solution of concentrated NaCl and acetic acid. The pickled carrots were then incubated in an enzyme solution until soggy. Hexane, ethanol, potassium hydroxide and vegetable oil were added to the soggy carrot and was then sonicated. After sonication the sample was homogenised and then refluxed. After refluxing the hexane extract was separated from the supernatant after re-extracting twice and then filtered. After filtration the solvent solution was removed from the carotenoids by means of a rotary evaporator and the residues were then analysed using a spectrophotometer and the solvent extraction hexane had the highest yield of 6.4mg/100g followed by petroleum ether with 6.0mg/100g and then 4.4mg/100g. During extraction whilst varying temperature, a temperature of 45°C had the greatest yield of 14.4mg/100g followed by 30°C which had a yield of 14.1mg/100g and both 15 and 60°C had a yield of 14mg/100g. Addition of acetic acid and sodium chloride increased the yield for all the temperature ranges. The highest yield of 16mg/100mg was obtained after 30minutes whilst refluxing at 45°C followed by refluxing for 45minutes and then for 60minutes. The least concentration was obtained after refluxing at 15minutes. From the results obtained, refluxing should be done at 45°C for 30minutes in order to optimise extraction. Pickling of the carrots with a solution of sodium chloride and acetic acid help in increasing the yield of beta carotene extracted.

PRODUCTION OF CARAMEL COLOUR FROM EXTRACTED SNOT APPLE (MATOHWE)

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The purpose of this study was to produce caramel colour from extracted snot apple (matohwe) mucilage as well as investigate the effect of pH and temperature on the development of the browning reactions. Mucilage was extracted from snot apple pulp using three methods; water extraction method, acidified water extraction method and alkaline water extraction method. Two samples were used, that is snot apple pulp powder and snot apple unprocessed pulp and the yield was then compared. Snot apple pulp was dried, grounded and sieved into a powder. Water extraction, acidified water extraction and alkaline water extraction methods were conducted. The methods were conducted at different pH levels and temperature time combinations. The obtained mucilage was left to sediment overnight and then filtered. The supernatant was then concentrated by evaporation using heat. Brix values were taken at different temperatures during evaporation stage. Apparent viscosity was measured against concentration of mucilage. The yield of mucilage extracted using snot apple powder for water, acidified water and alkaline water extraction method was 8.596%, 16.937%, 21.05% respectively. For all the samples and extraction method used the colour of the mucilage was light brown, brown and dark brown-black for water, acid and alkaline extraction methods. The browning was as a result of reaction of water soluble proteins and sugar residues in solution by maillard reaction and also in alkaline media there is fragmentation which results in brown polymers. Brix value increased with temperature. As mucilage concentration increased apparent viscosity. Absorbance of caramel increased with colour concentration. Increase in absorbance results in increase in colour intensity. Increase in absorbance also result in increase in colour intensity. At neutral pH colour intensity was low and higher in basic and acidic solution. Colour intensity was highest in basic solution. Storage of caramel at different temperatures has a significant change to the colour absorbance. As temperature increased absorbance decreased.

DESIGN EQUIPMENT FOR MOBOLA SEED KERNEL CRUSHER

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Parinari curaterifolia has been propagated as a potential source for edible oil production in the rural areas. Before the oil extraction from the seeds, its shelling process is essential. This study presents the design and evaluation of a small scale mobola seeds shelling machine for purpose of aiding to oil extraction, snack and peanut butter production in rural areas. In order to design the machine, the project started by observing the overall physical properties for mobola seeds such as average

geometric mean diameter, linear velocity and force required to deform a seed kernel, seed moisture content ,thickness and volume of seeds where studied. These parameters were then used to derive the necessary calculations to design of the machine. The machine consisted of hopper, frame, and drive motor. Results of the shelling machine showed mean values of shelling capacity, shelling percentage 97.05%, 141.78 kg h 1, 46.33% and 48.76%, respectively.

DESIGN OF A HYPOBARIC DRIER FOR DRYING APPLES

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The aim of the project was to design a hypobaric drier for drying apples. It focused on reducing the drying time and temperature in order to retain colour and heat labile nutrients. A vacuum pump was connected to the deigned drier in order to reduce the pressure. Golden delicious were peeled, sliced and soaked in ascorbic acid then dried using the drier to evaluate it. Another sample of apples was prepared the same way and dried using a forced draft oven and the drying time and quality of the apples was compared. The lowest drying time achieved was 4.5 hours at 65oC.

STABILITY OF FREEZE DRIED AND VACUUM DRIED AVOCADO SEED COLORANT

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The objectives of this study were to extract the orange pigment from avocado seeds and obtain both a slurry and powdered form using vacuum evaporation and freeze drying methods respectively and then establish the contribution of different physiochemical parameters which included temperature, light and air, on the stability of the colorants.

An orange colour was formed when avocado seeds were crashed, blended in water and incubated at 28°C for 45 minutes in the presence of air followed by extraction with methanol. The extract was centrifuged at 3000 rpm for 10 minutes and the supernatant was decanted into amber bottles. Part of the sample was freeze dried to obtain a powder and the other part was stored at 4°C. Physico – chemical tests were performed which included temperature, air and light conditions for both the vacuum dried and freeze dried colorants for a period of 120 hours. All the four trials were performed

at four different temperatures (0, 4, 25 and 30°C) for both freeze dried and vacuum dried samples. In the first trial air and light were excluded in the samples while in the second trial both air and light were included. For the third trial only air was included while in the fourth trial only light was included. Generally, the freeze dried colorant had a high initial absorbance at 480nm as compared to the vacuum dried colorant. The rate of decrease in absorbance was high for vacuum dried colorant exposed to air and light followed by those exposed to air and lastly those exposed to light at 25°C and 30°C and low at 0°C and 4°C. A low rate of decrease in absorbance was obtained for the freeze dried colorant at all temperatures.

Physico – chemical conditions such as temperature, oxygen and light have a profound bearing on the colour intensity and integrity as a significant decrease in absorbance at 480 nm was observed in the vacuum dried colorant. Colour intensity degradation is directly influenced by the presence of water. In order to gather enough data on the stability of the freeze dried over the vacuum dried colorants pH stability tests should also be performed since pH affects stability of most foods. The stability tests were only done for a period of 120 hours (5 days), which is not enough to safely conclude on the shelf – life of the two colorants, therefore there is need of a time frame of at least 30 days. Significant changes in rates of reaction are noticeable at temperature difference of 10°C, thus temperatures used should have at least that difference.

COMPARISON OF SOLVENT EXTRACTION AND ENZYME MEDIATED EXTRACTION OF BETA-CAROTENE FROM ORANGE PEELS

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This project aimed at comparing solvent extraction and enzyme mediated extraction of beta-carotene from orange peels. Extraction of beta-carotene was by simple solvent liquid-liquid extraction while in enzyme mediated extraction, cellulose enzyme was used to disintergrate cells prior to solvent extraction. Ultraviolet-Visible absorbance was measured at 450 nm. The UV spectrophotometric method illustrated excellent linearity (r2 = 0.9931). The beta-carotene contents of the orange peels varied in each sample and the values obtained were similar to the values previously reported in the literature. Solvent extraction had generally higher yields of beta-carotene compared to enzyme mediated extraction. The yields of the samples in solvent extraction ranged from 46.30 to 55.02ug/ml while those in solvent extraction ranged from 41.61 to 51.13ug/ml. Solvent consumption was generally higher in solvent extraction method while enzyme mediated extraction took more time for extraction. Solvent extraction has much more potential for use compared to enzyme mediated extraction due to the above mentioned results. The systematic extraction of beta-carotene may replace the use of synthetic colourings in food processing and also use their functional potential.

DESIGN OF A MACHINE TO RETARD LOCAL TOMATO CULTIVAR PRE-RIPENING SHELF LIFE BY HEAT STRESSING

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The project mainly focused on the designing of a machine to retard local tomato cultivar pre-ripening shelf life by heat stressing the fruits in a water medium. The local cultivars considered in the machine development were Roded and Moneymaker. The increase in pre-ripening shelf life is beneficial to farmers and tomato sellers. This is through a reduction of tomato losses due to over ripening and going bad before being sold, heat stressing will increase the time they can be kept while being sold or even in storage. Tomatoes were selected for the heat application in terms of maturity. Only mature tomatoes were used in the trail. Titratable acidity was used to determine maturity. For the Roded cultivar percentage acid should be 0.47% (±0.10%) and for Moneymaker it should fall within the range of 0.58% (±0.10%) for the sample to be deemed mature. The tests for ripeness of the tomatoes were the tomato colour and the total sugars (oBrix) Tests were conducted at a heat application of 45oC for the Roded and Moneymaker cultivars and the time was varied from 10,30,50,70 minutes and a control was untreated with heat. It was seen that the application of heat for times longer than 30 minutes results in the tomatoes rotting after a relatively quick ripening time for both cultivars. For the Moneymaker cultivar the control ripened after 8 days from the heat treatment. The longest ripening time for this cultivar noted with the heat treatment for a time of 30 minutes, with a total time of 12 days to ripen for the Moneymaker cultivar. The heat treatment times of 10, 50 and 70 minutes yielded times of 10, 8 and 9 days respectively. As for Roded cultivars the control took 7 days to ripen after heat treatment. The longest ripening time was noted from the samples heated for 30 minutes. The time recorded was 13 days after heat treatment for the tomatoes to ripen. The heat treatment times of 10, 50 and 70 minutes yielded times of ripening of 9, 10 and 8 days respectively. The results of colour displayed that for both cultivars 30 minutes of the 45oC heat treatment gave the highest time before ripening. This showed the slowest change from the green colour of raw tomatoes as it developed to the red colour of the ripe tomato. This result of 30 degrees confers with the total sugars test that heat treatment of 45oC for 30 minutes for both cultivars is the most optimum to maximise pre-ripening shelf life. The final detailed design of the heat stressor uses water as a medium to heat stress the tomatoes. The design consists of two trays that are removable and used to hold the tomatoes in the water and not allow them to stack over each other and thus squashing. The design also takes into use circular coil 3000W element that is positioned at the bottom of the water tank. The positioning at the bottom is so as to allow heat to travel by.

DEVELOPMENT OF AN ANALYTICAL METHOD OF DETERMINING THE AMOUNT OF PACKAGING MATERIAL (ACETALDEHYDE) THAT MIGRATES INTO BOTTLED WATER

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The objective of this project was to develop an analytical method of quantifying the amount of acetaldehyde that will migrate into bottled still water. The principle behind the method is that aldehydes (in this case acetaldehyde) can be oxidized into a carboxylic acid by almost any oxidizing agent which can be quantified by titration. The method was set by first setting an optimum exposure time and temperature combination to accelerate the rate of migration of acetaldehyde from PET bottles. Optimum exposure conditions for the designed methodology were determined as 70°C for 120minutes. Tollen reagent was then used to oxidize the migrated acetaldehyde to acetic acid which was then quantified by back titration with 0.1M HCL using a methyl orange indicator. The amount of acetaldehyde was a maximum of 1.3mg/L a value which is below the Tolerable Daily Intake10mg/L. Tollen reagent was proven to be a better oxidizing agent (compared to chromic acid and felling's reagent) for easy determination of the endpoint. An analytical method was finally designed, and the obtained mass of the final experiment were compare with visible spectrometry results. The titration results were relatively higher than the spectrometry results which were attributed to interference of some other migrants such as ethlylene glycol.

PRODUCTION OF ETHANOL FROM POTATO PEEL WASTE

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To design a process for the production ethanol by fermenting potato peels using Saccharomyces cerevisae. Potato peels were subjected to both enzymatic and acidic hydrolysis. Fermentation of the substrates was carried out with Baker's and Brewer's yeast. Ethanol yields of the two yeast was compared. Brewer's yeast produced a higher yield of ethanol than Baker's yeast. Hydrolysis with acid also produced a higher amount of reducing sugar as compared to enzymatic hydrolysis.

EXTRACTION OF D LIMONENE FROM SWEET ORANGE PEEL CITRUS SINENSIS

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In this study extraction of D Limonene from Sweet orange peel Citrus sinensis , which is a waste in juice industry, was extracted using microwave assisted hydro distillation. Characterization of the

essential oil obtained was performed using high performance liquid chromatography (HPLC) to obtain quantity of d limonene extracted. Extraction efficiencies of extraction process was investigated by varying three factors, peel size, time of extraction and microwave power and dryness of peel . The results showed that all the concerned factors have a positive effect on the yield. Oil yield is proportional to extraction time and microwave power. Higher yield can be obtained with smaller particle size and dried sample. The essential oil of extracted from sweet orange peels is mainly comprised of d-limonene on average 89.30%. Microwave irradiation was shown to be a more efficient method when compared to conventional heating due to its high selectivity for D-limonene, significantly shortened extraction durations and D-limonene yields twice that of conventional heating.

OPTIMISATION OF A CHICKEN PLUCKING (PPC) MACHINE

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The pedal powered chicken plucking (PPCP) machine was optimized from using an electric motor to being driven by a bicycle and its performance was evaluated. The machine consists of metal drum, plucker fingers, feather outlet plate, bicycle system, shaft, pulley, v-belt and metallic frame. A bicycle of an average adult size provides drives to the feather plate through v-belt and pulley via 45mm diameter shaft. The rubber fingers that were fixed on the feather plate rotate against the stationary cylinder drum that was studded with rubber plucker. The machine performed the plucking as the plate rotates with the fingers against the stationary rubber plucker on the casing. The machine was evaluated basing on five trials of chicken plucking at three different speeds ranges of 200-300rpm, 300-400rpm and 400-500rpm. The results obtained showed that the machine performed highest at an average efficiency of 96.12% at the speed between 200 and 300rpm on average time of 22.8 seconds. The analysis of variance (ANOVA) of the results obtained showed that speed and number trials significantly affect the efficiency of the machine.

EXTRACTION AND QUANTIFICATION OF ASCORBIC ACID FROM JUJUBE FRUITS (ZIZIPHUS JUJUBA)

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The objectives of the project were to design a method for the extraction of vitamin C from jujubes (Ziziphusjujuba), to extract Vitamin C from jujubes and to quantify Vitamin c that can be extracted from jujubes. Vitamin C is an essential nutrient for humans and certain other animal species. Vitamin C is a cofactor in at least eight enzymatic reactions, including several collagen synthesis reactions that when dysfunctional cause the most severe cases of scurvy. Vitamin C occurs in different forms

which are tablets, capsules, chewables, powdered crystalline and liquid forms. Vitamin C was extracted by precipitation with lead acetate and Ammonia to produce a salt. A yellow Vitamin C containing compound was obtained and the concentration of Vitamin C in the compound was determined by titration of the obtained Vitamin C containing compound against iodine solution with starch solution as the indicator solution. The best method of extracting vitamin C was a precipitation method in which 100g jujube sample blended with water with 10mls of 1% Butylatedhydroxytolune (BHT) dissolved in it and had 5 grams lead acetate, 6mls ammonia solution, 4 ml butanol, 4ml dilute hydrochloric acid 8 ml acetone, 8mls petroleum ether and 4 ml ethyl acetate were used to extract Vitamin C. the amount of vitamin C obtained from this procedure was 249.832mg/100g jujube and the percentage yield was 75.12%. vitamin C in jujube fruits was successfully isolated and quantified.

EXTRACTION AND STABILISATION OF ANTHOCYANIN PIGMENT FROM MULBERRIES

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This project was carried out to extract and stabilise anthocyanin pigment from mulberries. The mulberries were dried and mashed and anthocyanins were eluted by leaving the dried mulberries in a known volume of extraction solvent for a certain period of time. The solution was centrifuged and the anthocyanin solution was collected. Washing of the anthocyanin solution was done using ethyl acetate and distilled water acidified with hydrochloric acid. The washed solution was eluted with a solvent and the pigment was obtained by using a rotary evaporator to remove the solvent. The pH of the pigment was obtained. A test for anthocyanins was carried out and to determine the concentration of the anthocyanins, the solution was put into a visible spectrophotometer. Different samples of the pigment were subjected to different conditions such as temperature, light and pH and the changes in the anthocyanin content were observed by noting the change in anthocyanin concentration. The stability of the pigment was obtained. The results showed that anthocyanins were present in the extracted pigment and they constituted the highest percentage of the pigment solution. The absorbance of the solutions decreased with increasing temperature and long exposure to light. The pigment solution proved stable at low pH low temperature and dark storage.

DESIGN AND FABRICATION OF A MECHANICAL FISH DESCALER

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The project was mainly focused on the design and fabrication of a mechanical fish descaling machine. For large food processors, supermarkets and restaurants of all sizes, the question of how fast fish can be cleaned is a crucial one. With the aid of a fish descaling machine, the work load is decreased effectively.

EXTRACTION OF FISH OIL AND OMEGA -3 FATTY ACIDS FROM FISH EGGS

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The fish processing industry faces problems due to the negative environmental impact of its wastes. Fish wastes can be used to produce oil ,protein ,calcium, bio-diesel and numerous bioactive compounds.in particular ,fish oil is rich in omega -3 fatty acids which can aid prevention and treatment of various diseases .in this study ,extraction of fish oil and omega -3 fatty acids from fish eggs was studied. experimental work was performed on three steps that is (a)extraction of fish oil from fish (b) removal of fatty acids from oil and (c) recovery of omega -3 fatty acids from free fatty acids composition .Fish egg samples were prepared ,oil was then saponified and acidified to remain with fatty acids .Different samples of fatty acids were then urea complexed at different conditions and essential omega -3 fatty acids were then concentrated .A sample of 100g of fish eggs contained an average of oil yield of 6.7g and an average omega -3 content 532mg (238mg and 292mg EPA and DHA respectively).

COMPARISON AND COMBINING DIFFERENT METHODS OF EXTRACTING A NATURAL COLORANT "PHYCOCYANIN" FROM THE SPIRULINA ALGAE

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The objective of this experiment was to design a process of optimising extraction of Phycocyanin a blue pigment protein produced by a cyanobacteria spirulina and comparison of the different methods of extraction to obtain maximum yield. The product Phycocyanin, produced by spirulina, is used in the food and beverage industry as the natural colouring agent 'Lina Blue' and is found in sweets, candies, confectionery, ice cream and dairy products, jellies. Dried biomass of Spirulina plantesis algae were used for Phycocyanin extraction. A wide range of Phycocyanin extraction methods were studied for the processing of Spirulina biomass. Among the various extraction methods used were organic acid, inorganic acid and freeze thaw extraction methods. Organic and Inorganic acid extraction methods spirulina wet and dry biomass samples were treated with 5ml of

volume of solvent and were incubated at 2hrs, 24hrs and 48hrs to analyse any increase in the yield of Phycocyanin. Freeze thaw method, spirulina wet and dry biomass were treated with 5ml of solvent which was then frozen at -18°C for 12 hrs and thawed at 4°C for 48hrs to analyse any change yield in the concentration of Phycocyanin. The samples were then analysed using a visible spectrophotometer to quantify the colorant obtained and identify the pigment at wavelength of 630nm. Inorganic acid treatment yielded higher amount of Phycocyanin 58mg/5g, and organic acid treatment yielded about 38 mg/5g. Freezing and thawing yielded 6mg/5g. Combination of freeze thaw and sonicaton yielded the highest amount of Phycocyanin of 33.08mg/g. The best method for the optimizing extraction of Phycocyanin is freezing dry biomass in an 0.1M HCL at -21°C and thawing at 4°C for 48hrs followed by sonication at 50khz for 30minutes. Hydrochloric acid alone showed the greatest increase in yield of Phycocyanin 30.76mg/g and extraction using acetic acid resulted in poor yields of 3.08mg/g. We can conclude that yield of Phycocyanin is dependent on the type of extraction method used, the extraction time and concentration of acid used.

PROCESS DESIGN FOR EXTRACTION OF STARCH FROM POTATO PEELS.

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The purpose of the present study was to design a process for the extraction of starch from potato peels, a cheap raw waste material that is being underutilized in Zimbabwe. The resulting starch was to be purified and tested for its chemical and physical properties. A process was designed and different methods of purification were used using that method with slight modifications of purifying steps that included addition of sodium chloride, filtration, sieving and centrifugation. Results showed that the blending speed, time and sedimentation times affected the yield of starch extracted. It was shown however that purification methods resulted in increase in starch extraction as well as the starch content in the extracted starch rendering them effective. They did not alter the physical and chemical properties of the starches although things like molecular structure and granular size did affect water absorption (WAC), the swelling and solubility of starches. Overally the starches obtained using different purification methods were of high purity with method one (M1) yielding the lowest purity of 95.26%, followed by method 2(M2) having 96.73% and method 3(M3) having 98.9 % purity. Starch extracted using all the methods ranged from 17.45g to 29.54g out of 500g sample of potato peels. It was concluded that the process designed was effective in terms of starch extracted although purification effect was to a lesser extent since potato peels contain little impurities making it possible to purify only by washing and filtering the resulting starch.

PROCESS DESIGN FOR THE pH STABILISATION OF SOTHERBY'S STILL BOTTLED WATER PRODUCED BY INSTI FOODS, A DIVISION OF INSTI HOLDINGS

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The objective of the project was to innovate the processing of Sotherby's still bottled water that is produced by Insti Foods, a division of Insti Holdings so as to stabilise the pH of processed water. The main aims were to find the pH of the still water, prepare treatment solutions and treat the still water for pH stabilisation. Samples of reverse osmosis and UV light treated still water ready for packaging were taken in distilled water containers to reduce chances of contamination and pH measurements were done using a standardized electronic pH meter. Standardisation was done using a pH 4 and pH 10 buffer. A number of samples were done and the pH values obtained were quite deviant from the expected pH range and had an average value of 6.3. Different solutions of treatment chemicals, Ca $(OH)_2$, NaOH, $CaCO_3$ and $NaNO_3$ were prepared and used to treat the purified water. Chemical preparations were done taking into consideration the required amount of each of the compounds and ions in water. Water was added to the prepared solutions, thus addition of an acid to water. The first samples harvested quite basic water samples until perfection made it possible to harvest water samples that had pH values comfortably accommodated in the (WHO) pH range. The average pH value obtained was 7.00 and it was obtained by the addition of Ca $(OH)_2$ to the water However, despite the achievement of the pH stabilisation by compound addition, a recommendation for toxicological tests is conspicuously essential. Additively, the determination of the ion concentration which affects water TDS is important since it is an essential water quality parameter.

DEVELOPMENT OF A PROCESS FOR PRODUCTION OF VITAMIN B_{12}- CYANOCOBALAMIN FROM MOLASSES

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The study was carried out based on the aim to design a process for the use of locally produced molasses to optimise the production of vitamin B12. Molasses is a by-product of the manufacture or refining of sucrose from sugar cane. The fermentation was done as a microbiological process which made use of the bacteria Propionibacterium shermani, sugarcane molasses, soya milk and rice steep water as the nitrogen source, glucose, sodium hydroxide and a phosphate buffer as the pH regulating agents. During the fermentation process several samples were carried out while varying properties such as the concentration of molasses, the incubation period, and the substance used as the nitrogen source and the pH regulating agent used in controlling the pH of the process. The fermentation process was then followed by the cultivation of vitamin B12 from the cells of Propionibacterium shermani. In the cultivation process there was the use of activated carbon, potassium cyanide, methanol, sodium nitrite, zinc chloride and sodium sulphite which was used

during the acidification in order to stabilize the vitamin. The method which involved the use of crude molasses, soya milk as the nitrogen source for the bacteria, a phosphate buffer as the pH regulator and incubation time of four days produced the highest yield of vitamin B12 which also had the highest absorbance of light during quantitative analysis of vitamin B12 in the visible spectrometer.

Pharmaceutical Technology Department

ANTIBACTERIAL AND ANTIFUNGAL ACTIVITIES OF HOLARRHENA PUBESCENS ROOT, BARK AND LEAF EXTRACTS

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Infectious diseases are the leading cause of premature deaths. In recent years, drug resistance to human pathogenic bacteria has been commonly reported from all over the world .The situation is alarming in developing countries in Africa as well as developed countries in Europe and Asia due to indiscriminate use of antibiotics. Drug-resistant bacteria and fungal pathogens have further complicated the treatment of infectious diseases in immunocompromised, AIDS and cancer patients. In the present scenario of emergence of multiple drug resistance to human pathogenic organisms, this has necessitated a search for new antimicrobial substances from other sources including plants. In recent years, antimicrobial properties of medicinal plants are being increasingly reported from different parts of the world. It is expected that plant extracts showing target sites other than those used by antibiotics will be active against drug-resistant microbial pathogens. However, very little information is available on such activity of medicinal plants. Holarhhena pubescens root, bark leaves extracts were extracted and used to conduct MIC tests and zones of inhibition against selected strains.

All the plant extracts showed activity against a specific strain of the used microorganisms because of the presence of saponins, alkaloids, coumarins, anthraquinones and flavonoids in combination. In general leaf extract showed high antibacterial activities as compared to other plants extracts and its effectiveness is almost similar to that of ciprofloxacin and generally bark extract showed high antifungal activities as compared to other plant extracts and its effectiveness is almost similar to that of ketoconazole. Increasing the concentrations of extracts increases their activity against the bacteria and fungi. Since the plant extracts showed significant ability to inhibit antibacterial and antifungal activity against different strains used which is similar to the standards used which have broad spectrum of activity.

Key words: antimicrobial resistance, herbal medicines, Holarrhenna pubescens, leaf, bark, root plant extracts, Minimum Inhibition Concentration, Zone of Inhibition

SUBACUTE TOXICITY EVALUATION OF STRYCHNOS SOINOSA LEAF EXTRACT

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Strychnos spinosa plant belongs to the species which contains strychnine, one of the most potent toxins. The plant has been used systematically in traditional medical practices in Zimbabwe and neighboring countries for the management of various ailments. The aim of the present work was to evaluate systemic and target organ subacute toxic effects of hydroethanolic leaf extract of strychnos spinosa in rats. Initially , a sighting acute toxicity test was carried out to determine the starting dose for the main study, The plant extract was administered for 14 days after which the toxic effects were evaluated using cage side observation, food consumption, weight changes, relative organ weight, liver function tests and kidney function test.

After the extraction, it was found out that administration of 13mg, 26mg and 65mg of the extract to different groups of rats corresponded to the administration of 1000mg/kg, 2000mg/kg and 5000mg/kg of powdered dry leaves. The administrations of these doses were found to have no toxic effects to the rats in both sighting and main study.

Key words: *Strychnine, potent toxins, hydroethanolic, systematically, rats*

ANTHELMINTIC ACTIVITY OF PILIOSTIGMA THONINGII ROOTS, BARKS AND LEAVES AGAINST EARTHWORM

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Piliostigma thonningii is a potential non-cultivated medicinal plant that is commonly found in the southern east regions of Zimbabwe. The alcoholic extracts were obtained by soxhlet extraction and the extracts obtained were evaluated for their anthelmintic activity against earthworm Pheretima Posthuma. Three concentrations (10, 30 and 60 mg/ 50 ml) were prepared for each extract and were used for study over the earthworms. A solution of Albendazole was prepared in same concentrations as that of the extracts and was used as the standard. Distilled water was used as the control .The study involved the determination of time of paralysis and time of death of the tested earthworms. The results obtained from the study indicated that P. Thoningii significantly demonstrated paralysis and also caused death as compared to Albendazole. It is then concluded that P. Thonningii barks

showed greatest anthelmintic activity with at 60mg/50 ml. The average time of paralysis of barks at this concentration was 36 minutes for methanol extract and 37 minutes for chloroform extract. While the average time of death was 45 and 55 minutes for methanol and chloroform bark extract respectively. This was due to the presence of tannins, phenols and saponins in plant.

KEY WORDS: *Anthelmintic, phytochemical, Pheretima posthuma, Piliostigma thonningii*

INVESTIGATION OF POUZOLZIA MIXTA AND DICHROSTACHYS CINERIA SEPARATELY AS CONTRACEPTIVE OPTIONS FOR NON-LACTATING WOMEN AND THEIR EFFECT ON BLOOD LIPID VALUES USING SPRAGUE DAWLEY FEMALE RATS AS TEST MODELS

Herbal medicines have been used traditionally for a large number of health concerns and maintenance. Herbal medicines have been used in preventing pregnancy and to induce abortions when taken as decoctions or concoctions. Dichrostachys cineria and Pouzolzia mixta which are documented to be traditional contraceptives had their contraceptive activity investigated in Sprague Dawley female rats as potential contraceptive options for non-lactating women. The drive for the investigation is the absence of natural options for contraception. Also, the effect of these agents on lipids was investigated as the current agents on the market cause serum lipid levels to increase. Prior to the investigations, tinctures of the extracts were prepared, separated from the 40% ethanol solvent using a rotary evaporator and underwent phytochemical screening. The plant extracts were administered intraperitoneally for 17 consecutive days and the female rats were mixed with male rats for breeding and were separated after 10 days. D.cineria was found to have a contraceptive activity of 60%, P.mixta having 80% contraceptive activity and the combined extract having no contraceptive activity at all. To the rats to which nothing was administered the average lipid values were as follows, LDL 0.41mmol/l, HDL 0.92mmol/l, total cholesterol 1.26mmol/l and triglycerides at 0.61mmol/l. Following administration of P.mixta the lipid values were LDL 0.43mmol/l, HDL 0.95mmol/l, total cholesterol 1.22mmol/l and triglycerides at 0.59mmol/l and after administration of D.cineria the values were LDL 0.31mmol/l, HDL 0.88mmol/l, total cholesterol 0.90mmol/l and triglycerides at 0.38mmol/l. P.mixta did not cause an increase in lipid values whilst D.cineria had a significantly lower LDL, Triglyceride and Total Cholesterol

Key words: *contraception, phytochemicals, serum lipids*

INVESTIGATION OF LIPPIA JAVANICA, SOLANUM INCANUM AND PSIDIUM GUAJAVA FOR ANTIMICROBIAL AND ANTI-INFLAMMATORY ACTIVITIES FOR POTENTIAL USE IN FORMULATING DENTAL CONES FOR PERIODONTITIS.

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Periodontitis is the inflammation of the tissue around the teeth, often causing shrinkage of the gums and loosening of the teeth. Solanum incanum, Lippia javanica and Psidium guajava were used in traditional medicine for treatment of various infections. The antibacterial activity detected was against Actinomycetemutant and F. nucleater. Four possible combination were formed to test for synergism that is L. javanica and S. incanum; L. javanica and P. guajava; S. incanum and P. guajava; and L. javanica, S. incanum, P. guajava. The highest antibacterial activity was observed in L. javanica, S. incanum, P. guajava which showed a Zone of inhibition of 17mm and 16 mm on Actinomycetemutant and F. nucleater respectively. This showed that the plant extracts when used together have better antibacterial activities. The zone of inhibition of metronidazole and amoxicillin was lower than the combination of L. javanica, S. incanum and P. guajava that is 15mm and 13mm for metronidazole on F. nucleater and Actinomycetemutant respectively; and 12mm and 14mm for amoxicillin on F. nucleater and Actinomycetemutant respectively. The minimum inhibition concentration of L. javanica and S. incanum; L. javanica and P. guajava; S. incanum and P. guajava; and L. javanica, S. incanum , P. guajava on P. intermedia on F. nucleatum are 10-9, 10-10, 10-10 and less than 10-10 respectively. On Actinomycetemutant the minimum inhibition concentration of L. javanica and S. incanum; L. javanica and P. guajava; S. incanum and P. guajava; and L. javanica, S. incanum, P. guajava on P. intermedia are 10-9, 10-9, 10-10 and less than 10-10 respectively. Phytochemical testing showed the presence of tannins, flavonoids, saponins, glycosides and alkaloids in L. javanica, S. incanum. P.guajava had an addition of phenols. An acetic writhing test for analgesia was carried out to test for anti-inflammatory properties. The percentage inhibition of writhing was dose dependently increased from zero in the negative control group (normal saline) to 88.3% in the group that received 100% of the extract. There was no significant difference between the group that were given 50% and those treated with the reference drug ASA but the extract at the dose of 100% had a better analgesic activities than the reference drug.

Key words: *lippia javanica, solanum incanum, Psidium guajava, antimicrobial, anti-inflammatory, dental cones, periodontitis.*

PRELIMINARY ANTIBACTERIAL, ANTIFUNGAL AND PHYTOCHEMICAL SCREENING ON ELEPHANT DUNG

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Medicines have become the most exemplary representation of therapeutic enterprise to many. People are resorting to herbal medicines which make a huge part of traditional medicines the other part being zoo-therapy. Though they have a long history of use from time immemorial, they lacked adequate documentation especially in light of modern scientific knowledge. The practice is widespread in Africa, common in both rural and urban markets in many African towns and cities. For over a century elephant dung has been used as one of the traditional medicine by different populations which include the Africans, Indians and Chinese. However its phytoconstituents and antimicrobial activity has never been documented. Thus the need to investigate elephant dung. The phytochemical constituents tested for were tannins, saponins, glycosides, flavonoids, terpenoids,steroids, anthraquinones and alkaloids. For antimicrobial activity E.coli, S.aureus and C.albican strains were used.

The elephant dung was acquired from Imire Game Park in Marondera. The digested material was washed off the undigested material. The remaining material will be divided into two major portions. The first portion (A) was sterilised using an Autoclave at 15kpa and 120oC for 20 minutes. The second portion (B) remained unsterilized. Both potions were sun dried for 7 days followed by oven drying for 24 hours at 50 ºC to facilitate proper grinding. For the extraction of polar phytoconstituents, part of A (A1) and part of B (B1) were weighed. Then about 130 g of powdered A1 and B1 were soaked in ethanol (99.8%) for 5 days. For the extraction of non-polar phytoconstituents part of A (A2) and part of B (B2) were weighed. Then about 130 g of powdered A2 and B2 were soaked in chloroform for 5 days, then proceeded by filtering (Whatman filter paper no 1, 125 mm) all the extracts. The extract obtained were concentrated with a rotary evaporator at reduced temperature and pressure. The recovered contents were stored in a dark bottle at 4oc until use. Diameter of Zones of Inhibition (mm) of Bacterial Isolates [MIC] by different concentration of the extracts were carried out using Kirky-Bauer Disk Diffusion Susceptibility Test on E.coli, S.aureus and C.albican strains.

The phytochemical test results were as following. In the ethanol extract tannins ,flavonoids, saponins, glycoside and alkaloids were present. And in the chloroform extract flavonoids, saponins and alkaloids were present. The inhibition zone diameters (IZD) ranged from 13 mm to 5mm for the sterile ethanol extract and from 10mm to 2mm for the sterile chloroform extract, the activity decreasing with decreased concentration for S.aureus strains. The inhibition zone diameters (IZD) ranged from 13 mm to 5mm for the sterile ethanol extract and from 10mm to 2mm for the sterile chloroform extract, the activity decreasing with decreased concentration for E.coli strains. And both extracts zero activity for the non-sterile extracts and against C.albican strain.

Key words: antibacterial, antifungal, phytochemical screening, elephant dung

In-vivo testing for hypoglycaemic activity of mangifera indica, sclerocarya birrea and ziziphus mucronata bark extracts

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The antidiabetic activity of Sclerocarya bierrea, Ziziphus mucronata and Mangifera indica were investigated in Alloxan induced diabetic albino rats. A comparison was made amongst the three plant extracts and a known antidiabetic drug Glibenclamide (5 mg/kg body weight). The dried barks of Sclerocarya bierrea, Ziziphus mucronata and Mangifera indica were subjected to extraction by using methanol as solvent and were subjected to standardization by phytochemical screening. Dose selection was made on the basis of acute oral toxicity study (200 mg/kg body weight) as per OECD and CPCSEA guidelines. Oral administration of extracts of Sclerocarya bierrea, Ziziphus mucronata and Mangifera indica for 14 days resulted in a significant reduction in blood glucose levels. Alloxan induced diabetic rat model was used for the evaluation of antidiabetic activity. Activity is more for Sclerocarya bierrea followed by Ziziphus mucronata and lastly Mangifera indica. These showed significant ($p<0.001$) antidiabetic activity. The synergistic activity of the bark extracts was investigated by administering the bark extracts in combination. All of bark extract combinations showed synergy with the combination of Sclerocarya bierrea and Ziziphus mucronata having the greatest hypoglycaemic activity. On day 14 percentage decrease in blood glucose was 60.20% for Sclerocarrya Bierrea and Ziziphus Mucronata combination and 58.89% for glibenclamide. These plants extracts and their combinations have the potential to be used as antidiabetic drugs. However there is need to further investigate the mechanism of action and side effect profiles of these medicinal plants.

Keywords: *Sclerocarya bierrea, Ziziphus mucronata, Mangifera indica, Antidiabetic, Synergistic, blood glucose*

FORMULATION OF AN ANTIFUNGAL ORAL GEL TO ALLEVIATE SYMPTOMS OF ORAL CANDIDIASIS INCORPORATING MENTHA PIPERITA OIL, BIDENS PILOSA AND CLEOME GYNANDRA EXTRACTS.

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Oral candidiasis is a fairly distinctive condition, usually presenting as white patches in the mouth, tongue or gums. It is a commonly encountered infection in immunocompromised patients and is classified as a WHO stage 3 infection. Often, if untreated the lesion can spread beyond the oesophagus resulting in inflammation, pain and fever. This condition thus results in stigma and

affects the quality of life of sufferers. Oral candidiasis can be treated with topical anti-fungal drugs, such as nystatin, miconazole and amphotericin B. The available treatments have numerous shortfalls including low availability, high costs and minimal symptomatic relief. The purpose of the project was to formulate a herbal cream incorporating the crude extracts from Bidens pilosa, Cleome gynandra and peppermint oil. The extracts were obtained by liquid-liquid extraction, liquid-liquid extraction and distillation respectively. The antifungal effects of the gel were tested using the agar diffusion method in comparison with miconazole oral gel. A zone of inhibition of 15mm was observed with the formulated gel compared to that of 17mm of miconazole gel. The gel was evaluated for its stability using various methods including window ledge tests, accelerated stability tests and freeze-thaw tests. Acute toxicity tests were conducted on albino rats and no irritation, redness or erythema was observed.

Keywords: *Mentha piperita oil, Bidens pilosa, Cleome gynandra, antifungal oral gel, oral candidiasis*

UTEROTONIC ACTIVITY OF COMBRETUM MOLLE, FICUS SYCOMORUS AND CASSIA ABBREVIATA EXTRACTS.

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Medicinal plants are the primary source of medicines and the main ingredients used by traditional medicine practitioners. The practice of herbalism has become popularized throughout the world. During past decade public interest in natural therapies is increasing both in developing as well as developed countries. Approximately 25 percent of all prescription drugs are derived from trees, shrubs or herbs (). Plant-extract-based medicine is quite appreciated and well accepted by rural and even urban population. Uterotonics plants are those plants which have the ability to contract uterus and since ancient times these uterotonic plants have been used to assist labour, induce labour and for abortifacient purposes. Current available uterotonics include oxytocin, ergot derivatives and prostaglandins. Alternative to these synthetic agents, many herbal plants with uterotonic properties are known from across the regions. For this purpose contractile activities of the three plants commonly used by Zimbabwean women were tested for their uterotonic activities. Phytochemical screening was carried out using the accepted standard procedures and the extracts were prepared by maceration. Methanolic extraction was done for Cassia abbreviate roots, Ethanolic extraction done for Ficus sycomorus barks and Methanol. Chloroform extraction were done for Combretum molle barks. Purification of the crude extracts were done using a rotary evaporator. Percentage yields of 11, 21 and 28 % were obtained for cassia abbreviata, ficus sycomorus and combretum molle respectively.

Phytochemical screening revealed the presence of alkaloids, glycosides, tannins, flavonoids and saponins. In-vitro contractility tests on an isolated guinea pig ileum were done using concentrations

of 25%, 50 %, 75%, and 100% for both the plant extracts and controls. Cassia abbreviata extracts demonstrated weak contractions even at highest concentration. Percentage response of contractions upon adding cassia abbreviate ranged from 16.4 to a maximum of 22.5%. Second in better contractility response was Ficus sycomorous which gave a percentage response of 65.2% at its highest concentration and this was comparable to the response obtained from 50% dose of oxytocin. Combretum molle extracts gave percentage responses which were so close to those of oxytocin and a difference of not more than 5% was obtained in the four concentrations used. At 50% concentrations Combretum molle extract gave a percentage response of 61.2 whereas oxytocin gave a percentage response of 65.7. However, the three extracts and the two controls demonstrated that contractility levels were dose dependant and these increased with increase in concentrations. Of the three plants tested, Combretum molle showed to be the most effective, followed by Ficus sycomorus and lastly Cassia abreviata

Key words: *Uterotonic, parturition, phytochemicals, labour, prostaglandin, post-partum*

CHARACTERIZATION OF OILS FROM SELECTED UNDERUTILISED SEED BEARING PLANTS AND THEIR UTILIZATION POTENTIAL AS A SOURCE OF ANTIMICROBIAL ACTIVITY (GARCINIA BUCHANANII, SYZYGIUM CORDATUM, PILIOSTIGMA THONNINGII, UAPACA KIRKIANA AND PARINARI CURATELLIFOLIA)

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Due to the widespread popularity and blatant dominance of modern medicine in Western society, natural medicine has received much criticism for being backwards and unreliable. However more than 80% of the world's population now relies on traditional medicine for their primary health care needs and this is so particularly for the African continent. In Africa, natural products have proven to be great sources of essential oils which combine the function of health care and nutrition. However various plant seeds have received little attention in fatty acid research and this has prompted for more analysis of fatty acid in plant seeds.

The aim of the study was the characterization of oils from underutilised Zimbabwean seed bearing plants, and to assess their utilization potential as sources of antimicrobial activity. Pulverisation of plant seeds into a meal was achieved using mortar and pestle. Then oil extraction by soaking the seed meal in n-hexane for 5 days, filtering (Whatman filter paper no 1, 125 mm) and recovering the filtrate and evaporating the solvent at 50°C using a rotor evaporator. Carrying out oil analysis tests as well as antimicrobial MIC tests.The oil content for Garcinia buchananii is high, it was found to be 38.57% (Table 5) as well as that of Parinari curatellifolia (34.75%), Piliostigma thonningii (21.57%) which shows that the processing of the oil for industrial or edible would be economical. However Uaparka Kirkiana had a relatively low percentage yield of 8.27%, whilst Syzygum Cordatum unfortunately produced insignificant oil. The study showed also explicitly revealed that the seed oils

had a concentration-dependent antimicrobial activity against both bacterial and fungal organisms used in the study. However there seemed to be resistance of gram-negative bacteria as most seed oils couldn't show activity against the gram-negative.

Keywords: *Garcinia buchananii, Syzygium cordatum, Piliostigma thonningii, Uapaca kirkiana and* Parinari curatellifolia, antibacterial, underutilised plants

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TESTING FOR ANTIOXIDANTS PROPERTIES IN BULBINELLA FLORIBUNDA LEAVES, ANNONA STENOPHYLLA ROOTS AND FICUS SYCAMORE FRUIT.

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An antioxidant is defined as a substance that when present in low concentrations compared to those of oxidizable substrate significantly delays or prevents oxidation of that substance. Phenolic derivatives are among the most natural antioxidants present in the environment. These compounds have many uses which include prevention of organ damage, elimination of free radicals, used as food preservatives, prevent ultraviolet related cancers, prevent DNA mutations, reduce coronary heart disease, have anti-bacterial and ant-inflammatory properties and used in several industrial processes to manufacture chemicals such as pesticides, explosives, drugs and dyes. They also are used in the bleaching process of paper manufacturing and phenolic compounds also have substantial applications in agriculture as herbicides, insecticides and fungicides. They are found in different plants and this project aimed in the analysis of these compounds from three different plants which are Annona stenophlla roots, Bulbinella floribunda and Ficus sycamore fruits. The technique employed to extract the extracts from these plant materials was 60% ethanol which saw the percentage yield of 17.5%, 27.1% and 7.2% respectively. Phytochemical tests for different phenolic compounds were also conducted and the tests were for flavonoids, alkaloids, tannins, anthracenes, sterols and terpenes, saponins and anthracyanidins. The results showed that A. stenophylla had negative results only for the tests for saponins and anthracyanidins, while B. floribunda had all positive test results for all the phytochemical tests conducted and F. Sycamore had only flavonoids and alkaloids present in the plant extract. Spectrophotometry was used to determine the reducing power using beta carotene as standard and of these respective plants extracts and the results indicated that B. floribunda had the highest reducing power, followed by A. stenophylla and F. sycamore had no or little reducing power.

Keywords: *Antioxidants; Phenolic compounds; ethanol extraction; Phytochemical; Annona stenophylla; Bulbinella floribunda; Ficus sycamore; Spectrophotometry; Reducing power; Beta carotene.*

CHARACTERIZATION, ANTIMICROBIAL AND IN-VITRO ANTIDIARRHEAL ANALYSIS ON ETHANOLIC AND AQUEOUS EXTRACT OF CASSIA ABBREVIATA (MURUMANYAMA).

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Diarrhoea is one of the diseases of major concern here in Zimbabwe. Hence they is need to find now medicines which are potent and effective in diarrhoea. I chose Cassia abbreviata (Murumanyama) in my project because of its well-known traditional uses for treating diarrhoea (Tembo, 2004). An aqueous decoction of the Cassia bark is used for diarrhoea and other stomach ailments (Tembo, 2004). In my project I used two methods of extraction which are the ethanolic and aqueous extraction method. This was done so as to compare the effectiveness of the aqueous and the ethanolic extract on alleviating symptoms of diarrhoea. The tests that were done in this project were phytochemical tests, MICs, AAS and in-vitro antidiarrheal investigation on isolated guinea pig ilium. Phytochemical tests were done so as to find the presence of the secondary metabolites that would aid in the antidiarrheal activity of Cassia abbreviata. From the results of the phytochemical tests, the ethanolic extract showed greater number of secondary metabolites than the aqueous extract. This is due to the fact that ethanol is a better extraction solvent than water (Perry, 2008). For the sensitivity tests the ethanolic extract also showed greater activity on the three bacteria chosen which were S. Aureus, E. coli and Salmonella than the aqueous extract. The aqueous extract was only effective against E. coli and Salmonella. It was not effective against S. Aureus because S. Aureus is a gram negative bacteria and since the aqueous extract lacked anthocyanins which are active against gram negative bacteria. For the in-vitro antidiarrheal test the ethanolic extract showed greater activity than the aqueous extract. This is due to the fact that the aqueous extract did not have a lot of secondary metabolites unlike the ethanolic extract. AAS was done so as to note the amount of trace elements in Cassia abbreviata. This was done because trace elements like zinc are known to have antimicrobial properties. The results of AAS showed that Cassia has a high concentration of calcium ions. From the project I would recommend ethanolic extraction method because it showed greater antimicrobial, antidiarrheal and more phytochemicals than the aqueous extract. Cassia abbreviata ethanolic extract is effective in alleviating symptoms of diarrhoea.

Key words: *Diarrhoea, Cassia abbreviata, ethanolic extract and aqueous extracts*.

DEVELOPMENT OF A TANNIN SOLUTION FROM ADANSONIA DIGITATA FRUIT AND EUCALYPTUS GLOBULUS BARK EXTRACTS.

Extraction of the tannins from the Adansonia Digitata fruit pulp was successful using 50% ethanol and that of Eucalyptus Globulus using 70% ethanol. The obtained yield could have been more, but was as it is because the pulp was exposed to one cycle of extraction by the alcohol. Other compounds that would have increased the yield of tannins were Sephladex 50.

The tannin solution is intended to be produced as a tannin spray that is to be sprayed o a mainly non-penetrative wounds for their healing. The efficacy of tannins has already been proven on wounds. However I intend to conduct further studies on the tannin extract of adanson Digitata because of the different phytochemical composition of this particular extract and the ones studied.

But as my justification said, they are not being used and produced in the region as a general treatment agent. The solution is then again intended to be mass produced and sold as an OTC product and also be part of a 1st aid Kit. According to my economic analysis it would cost $3.60 as a 120ml spray container. This product will be the best treatment for considering the fact that they will be cheap, effective, safe and readily available to almost every patient who gets injured one way or the other. The pain-free solution does not contain harmful chemicals, preservatives or additives that can irritate a wound and contradict the tannin effects. The solution is also self-preserved, because not all the alcohol is evaporated in the rotor vapour. The mentioned quality of this formulation makes it gentle and effective. This kit stands a chance to be the best treatment for bedsores currently and in the future.

Key words: *tannin solution, Adansonia Digitata, Eucalyptus Globulus*

EVALUATION OF ANTI-BACTERIAL AND ANALGESIC PROPERTIES IN ZANHA AFRICANA AND ALBIZIA HARVEYI FOR THE INTENTION OF TREATING OTITIS MEDIA

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The inappropriate usage of antibacterial agents, has led to an increase in the cases of antibiotic strains of pathogens causing otitis media in the past decade. Amongst the strains, S. pneumonia is the one responsible of the antibiotic resistance. Medicinal plants have stood the test of time in the management of various illness. In the last decade the advocacy of the use as alternative source of drugs has increased. In Zimbabwe Z. Africana and A. Harveyi are two common plants used for the treatment of antibacterial and anti-inflammatory respectively. In order to investigate their potential, use a research was conducted. The active metabolites from Z. Africana and A. Harveyi were extracted using ethanolic solvent extraction and the disc diffusion method was used for the determination of antimicrobial activities with MacConkey agar as the nutrition broth. To test for analgesia properties of A. Harveyi leaf extract, the acetic acid induced writhing method was used. The phytochemical investigation carried out on the leaves and bark of the medicinal plants revealed the presence of saponins and flavonoids in A. Harveyi and Z. Africana plant extracts. Z. Africana contains high concentration of these metabolites. Other secondary metabolites such as alkaloids and terpenes were only present A. Harveyi leaf extracts. Only the Z. Africana bark was found to contain tannins in trace amount while glycosides were completely absent in all the three plant samples. Maximum antimicrobial activity was shown by Z. Africana bark aqueous extracts which had highest zone of inhibition diameter of 17mm as opposed to that of the leaf extract which was 16mm. The

MIC of 20% w/v was lower than of the leaf which is 40% w/v. The acetic acid-induced abdominal constriction test, showed that extract of A. Harveyi was dose- dependent and significantly reduced the abdominal writhing and was comparable to that of the acetyl salicylic. The study reviewed that these plants could be used for the formulation of antimicrobial agents for treatment of Otitis media in children

Key words: *A. Harveyi, antimicrobial activity, otitis media, minimum inhibitory concentration, zone of inhibition and Z. Africana.*

PHYTOCHEMICAL SCREENING AND TESTING OF CURCUMA LONGA, HARPAGOPHYTUM PROCUMBENS AND ALOE VERA EXTRACTS AND FORMULATION OF CAPSULE FOR THE MANAGEMENT OF GOUTY ARTHRITIS.

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The aim of the study was the phytochemical screening and testing of Curcuma longa, Harpagophytum procumbens and Aloe vera extracts and formulation of capsule for the management of gouty arthritis. Rats were divided into six groups which were further sub-divided into five groups containing three rats each. All sixty-four rats were injected with 0.2mg/Dl uric acid. Extracts of Aleo Vera, Curcuma longa and Harpagophytum procumbens were screened, characterized and injected into the rats in order to determine the effectiveness of the extracts. Extracts of herbal plants were found resolve inflammation in 80% of the rats. Curcuma longa and Harpagophytum procumbens were found to lower the concentration of serum uric acid in 85% of the rats ($p = 0.01$). A capsule was formulated consisting of A vera/C longa/H procumbens 175/140/210mg. Stability tests showed that the capsules were stable in various environmental conditions.

Key words: *Curcuma longa, Harpagophytum procumbens, Aloe vera, gout, arthritis*

EVALUATION OF ANTIMICROBIAL ACTIVITIES OF AZANZA GAKEANA FRUIT PULPS, FICUS SYCAMORUS ROOT AND MAGNIFERA INDIACA BARK.

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Antimicrobial activity of plant extracts was assessed by on selected bacterial and fungal strains by the diffusion disc method. Antibacterial activity was assessed against six pathogenic bacteria strains. Three gram negative strains – Escherichia coli, Pseudomonas auruginaso, and Shigella flexneri and three gram positive bacteria – Staphylococcus aureas, Enterococcus faecalis and Bacillus subtilis, were used in this study. The fungi that was used were: C. neoformans, A. fumigatus, A. brasillensis and C albicans. Activity was assessed by measuring the zone of inhibition. Results indicated that gram negative bacteria were more sensitive to the plant extracts compared to gram positive bacteria. The largest zone of inhibition against bacteria of 19mm was exhibited by methanol extract of F. sycamorus root (20mg/ml) against P aeruginosa. This was comparable to the 25mm zone of inhibition shown by ciprofloxacillin. The largest zone of inhibition against fungi of 21mm was exhibited by the ethanolic extract of A. Garkeana Fruit pulp (20mm/ml) against C. Neoformans. Ketoconazole has a zone of inhibition of 23mm. Extract showing activity were further tested for antimicrobial activity after undertaking serial dilutions.

Results showed that traditional medicinal plants have merit for use in traditional medicinal practice as shown by the inhibition of bacterial and fungal growth in the experiments.

Key words: *Azanza gakeana fruit pulps, Ficus sycamorus root, antimicrobial activity, Magnifera indiaca bark.*

TESTING FOR ANTIMICROBIAL AND ANALGESIC PROPERTIES OF MYROTHAMNUS FLABELLIFOLIUS, GUANZUMA ULMIFOLIA AND FISCUS COCCULIFOLIA EXTRACTS FOR POTENTIAL USE IN THE TREATMENT OF BURNS

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Burn injuries contribute significantly to high morbidity and mortality rates globally. It is estimated that approximately 26500 deaths every year are caused by burns globally. Burns care is a significant financial burden on both the patient and the hospital. In developing countries, outcomes are made worse by lack of resources which contribute to unacceptable high levels of burn-related complications such as wound infections, contractures, and death. The causes of pyogenic infections in wound burns are Staphylococcus aureas, Pseudomonas aeruginosa and Escherichia coli. This study sought to test for antimicrobial and analgesic properties of Myrothamnus flabellifolius, Guanzuma ulmifolia and Fiscus cocculifolia extracts for potential use in the treatment of burns. An in vitro experimental study was performed using F. cocculifolia, U ulmifolia and M flabellifolius which were properly identified and verified. The herbal plants were subjected to 95% ethanolic extraction of the active ingredients and then serially diluted to produce 1% to 8%. Standards strains of S. aureus, P. aeruginosa and E. coli were inoculated on agar and subjected to standardized disk susceptibility testing method. Zones of inhibition of each extract were measured for each test extract and

compared to chloramphenicol one of the currently used antibiotics. A trend of increase in antibacterial activity was noted with increase in concentration of the extracts. The ethanolic plant extracts were also evaluated for analgesic potential using the acetic acid induced writhing method on mice. The crude extracts of all the plants were found to have significant ($p<0.001$) analgesic activity at oral doses of 50 and 100mg/kg in tested models. In conclusion, data from the study show that the three plants exhibit antibacterial and analgesic activity and they can be used in the treatment of burns.

Key words: *antimicrobial, analgesic properties, myrothamnus flabellifolius, Guanzuma ulmifolia and Fiscus cocculifolia, burns*

ESTIMATION OF ACID NEUTRALIZATION CAPACITY AND FORMULATION DEVELOPMENT OF AN ANTACID INCORPORATING ZEA MAYS COB ASH FOR TREATMENT OF INDIGESTION ASSOCIATED WITH HYPERACIDITY.

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Indigestion can be pain or discomfort in your upper abdomen (dyspepsia) or burning pain behind the sternum (heartburn). Dyspepsia and heartburn may occur together or on their own. Dyspepsia covers upper abdominal pain, fullness, early satiety, bloating, and nausea. It can occur with gastric and duodenal ulceration and gastric cancer but most commonly it is of uncertain origin. Dyspepsia may be accompanied by 'alarm features' (e.g. bleeding, dysphagia, recurrent vomiting, or weight loss) and this may require immediate attention. Urgent investigation should also be considered for patients over 55 years with unexplained, recent-onset dyspepsia that has not responded to treatment. (BNF, 2011). Antacids are a type of medication can control the acid gastric acid levels. They are available over the counter from pharmacies and are often used to treat the symptoms of heartburn and indigestion. The inhibition of gastric secretion has been a therapeutic objective for decades. A variety of pharmacological and nonpharmacological approaches have been proposed throughout history. Some antacids neutralize the gastric acids while others coat the surface of the oesophagus (gullet) with a protective barrier against stomach acid, or produce a gel on the stomach's surface which helps stop acid leaking into the oesophagus and causing acid reflux (Dale, 2009). Antacids work by restoring acid-base balance, attenuating the pepsin activity and increasing bicarbonate and prostaglandin secretion. Antacid was formulated from Zea mays cob ash and was found to have high acid neutralizing capacity than the generic magnesium trisilicate. This can be explained using results found from atomic absorption spectroscopy which indicated that Z. mays has high calcium, magnesium and potassium content.

High yield of these elements can be obtained after dissolving the ash in 20%HL. A suspension formulated had high buffering capacity after the stabilization with citric acid. Using the amber

coloured bottled some of the unwanted characteristics could be masked and the suspension protected. Stability was evaluated and aesthetics established. Therefore an antacid suspension was formulated from Z. mays cob ash with high acid neutralizing capacity. It was stabilized using thickening and flocculating agents and the pH was stabilized using citric acid. This resulted in the formulation of an antacid with good resuspendabilty and odour.

Keywords: *Dyspepsia, Z. mays, antacid, suspension, AAS, acid neutralizing capacity*.

ANTIFUNGAL PROPERTIES OF FIXED OILS FROM SELECTED ZIMBABWEAN SEED BEARING PLANTS

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The objective was antifungal assessment of commonly available seed oils from Zimbabwean plants. This project came up due to the increasing antifungal resistance to current treatments as well as undesirable side effects that come with them. Fixed Oils were extracted from seeds of Mimusops decorifolia, Mangifera indica, Uapaca kirkiana and Strychnos spinosa by using solvent extraction and N-hexane was the solvent used and the disc diffusion method was used for the determination of antimicrobial activities with dextrose agar as the nutrition broth. Physicochemical parameters of the oils were reviewed by standard analytical techniques. The physicochemical properties of the plant oils reviewed were found to be at the range concentrations as follows: Acid value (AV): 0.84 -3. 366 mg KOH/g, free fatty acid (FFA): 0.42 - 1.693%. Ketoconazole exhibited ZI between 13 mm and 19mm against the test species and it was more effective in C. albicans and griseofulvin between 12mm and 15mm against the test species and is less effective in aspergillus furmigutus. On the other hand for the test oils mangifera indica and mimisops decorifolia had the highest inhibition zones against all the test species with the ZI ranges of 10 mm to 16mm and 12 to 16mm respectively. Uapaca kirkiana and Strychnos spinosa did not exhibit satisfactory results compared to the other two plant oils. The antimicrobial agents analysed in this study have demonstrated substantial antimicrobial activities against the test microorganisms, an indicative of possession of active ingredients. The study did not however reveal the toxicity of the seeds. However, further studies should be conducted to confirm the content specifications and other relevant parameters of each fixed oil.

Keywords: *fixed oils, Mimusops decorifolia, Mangifera indica, Uapaca kirkiana, Strychnos spinosa, antifungal activity, zone of inhibition and minimum inhibitory concentration.*

ANTIMICROBIAL ACTIVITIES OF TECLEA TRICHOCARPA AND ZANTEDESCHIA ALBOMAACULATA ON SELECTED DRUG RESISTANT MICROBES.

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Antimicrobial resistance is a phenomenon where microorganism fights on an antimicrobial drug that was originally effective for treatment of that particular infections caused by same microorganism. It can also be defined as failure to respond to standard treatment. This has caused a global concern. It is imperative that new drugs should be which are totally different from those in the market though giving more therapeutic results. The purpose of the project was to assess the antimicrobial activities of Teclea trichocarpa and Zantedeschia albomaculataon selected drug resistant microbes. The extracts were obtained by solid liquid extraction, liquid- liquid extraction and expression respectively. The antimicrobial activities of Teclea trichocarpa and Zantedeschia albomaculata extracts were tested using the Kirby-Bauerdisk diffusion method and confirmed by the formation of a zone of inhibition on the differential Mannitol salt agar. Phytochemical screening tests were conducted using standard methods which confirmed the presence of tannins, flavonoids, alkaloids, tannins, saponins, flavonoids, terpenoids, in all extracts the yield was calculated. A comparison was drawn from the results using the conventional dosages of ciprofloxacin. The results were analysed using ANOVA. Tecleatrichocarpa showed effective against E.coli Antimicrobial resistance is a phenomenon where microorganism fights on an antimicrobial drug that was originally effective for treatment of that particular infections caused by same microorganism. It can also be defined as failure to respond to standard treatment. This has caused a global concern. It is imperative that new drugs should be which are totally different from those in the market though giving more therapeutic results. The purpose of the project was to assess the antimicrobial activities of Tecleatrichocarpa and Zantedeschia albomaculata on selected drug resistant microbes. The extracts were obtained by solid liquid extraction, liquid- liquid extraction and expression respectively. The antimicrobial activities of Teclea trichocarpa and Zantedeschia albomaculata extracts were tested using the Kirby-Bauer disk diffusion method and confirmed by the formation of a zone of inhibition on the differential Mannitol salt agar. Phytochemical screening tests were conducted using standard methods which confirmed the presence of tannins, flavonoids, alkaloids, tannins, saponins, flavonoids, terpenoids, in all extracts the yield was calculated. A comparison was drawn from the results using the conventional dosages of ciprofloxacin. The results were analysed using ANOVA. Teclea trichocarpa showed effective against E.coli

Key words: *Teclea trichocarpa, Zantedeschia albomaaculata, drug resistant microbes*

PHYTOCHEMICAL AND ANTIMICROBIAL SCREENING FOR ACTIVITY IN SOLANUM INCANUM (NDUNDURWA), A HERBAL FRUIT USED IN THE TREATMENT OF EYE INFECTIONS IN CATTLE.

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Eye infections are one of the popular livestock disease in farm animals in Zimbabwe. They are mostly due to Moraxella bovis, a bacterium that causes keratoconjuvititis, and eye worms. The urgency in the need to evaluate alternative options that can be used in the management of eye infections in livestock cannot therefore be over emphasised. Solanum incanum fruits, of the Solanaceae family, are the major form of ethnoveterinary medicine that is being used to manage eye infections. The fruits of the plant are crushed and ground into powder before applying to the infected eye(s). The aim of the study was to run phytochemical screening of the methanol extracts of Solanum incanum, and screen for both antibacterial and antifungal activity. After testing for activity using disk diffusion method, the minimum inhibitory concentrations of the methanol extracts against these microorganisms were determined. Alkaloids, saponins, flavonoids, sterols. triterpenes and tannins were found to be present in the methanol extract of the fruits of Solanum incanum. Anthraquinones were not detected. The methanol extracts inhibited growth of the strains of microorganisms. The minimum inhibition concentrations were found to be 0.8mg/ml for Staphylococcus aureus, O.8mg/ml for Escherichia coli, and 0.4mg/ml for Candida albicans. Solanum incanum methanol extracts have antibacterial and antifungal effects, this was explained by the diameter of zone of inhibition which were 21 mm, 15mm and 14mm for Staphylococcus aureus, Escherichia coli and Candida albicans respectively. The antimicrobial activity of the plant may be explained by the presence of alkaloids, flavonoids, saponins, coumarins and tannins.

Keywords: *Solanum incenum, antimicrobial screening, Minimum Inhibitory Concentration (MIC), zone of inhibition.*

MEASURING THE IRON CONTENT OF THE LEAFY PARTS OF HIBISCUS. DIVERSIFOLIUS, CLEOME. GYNADRA AND VIGNA. UNGUICULATA AND SEEDS OF VIGNA. UNGUICULATA AND AMARANTHUS. TUMIDA FOR THE FORMULATION OF FOOD SUPPLEMENTS TO SUBSTITUTE CURRENT ORAL IRON SUPPLEMENT FORMULATIONS.

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Iron deficiency and iron deficiency anaemia are among the commonest deficiency diseases in the majority of developing countries as a result of irregular meal patterns and a hugely unbalanced meal regimen with respect nutritional values. These deficiency diseases then lead to severe morbidity and even mortality especially in infants. The treatment of the iron deficiency syndromes has been historically been done using oral iron supplement and parenteral iron administration in the more severe cases. These treatments are fraught with side effects and toxicities as they come with very high doses of iron. The drawbacks to using these treatment include GIT disturbances, fatal poisoning

and anaphylaxis among many others. The aim of the project was to look for African indigenous vegetables that have high

iron content and measure their content with the hope to use them as alternatives to the afore mentioned iron based treatments for iron deficiency syndromes. The quantification of iron was done in the leafy parts of Hibiscus. diversifolius. Cleome.gynandra and Vigna. unguiculata and seeds of Vigna. unguiculata and Amaranthus. tumida using two methods a chemical and a spectroscopic one. The iron values were then compared with recommended daily amounts in order to analyse their viability as alternatives to oral iron supplements. The analysis of the iron content yielded results narrated below. Using the iron content values obtained in the project the following observations were made, the first being that the AIVs when used alone had enough Iron to supply at least the RDA of iron for a healthy adult male. They however did not possess iron sufficient to treat those with iron deficiency. So the solution to this predicament became the use of low dose iron supplements in conjunction with the AIVs in order to reduce side effects of oral iron supplements whilst supplying enough iron to alleviate the iron deficiency anaemia.

Keywords: *Iron deficiency syndromes, iron quantification, supplements, alternative, herbal remedies.*

FORMULATION OF HERBAL SYRUP FOR PREVENTION OF ALCOHOL INTOXICATION AND THE TREATMENT OF ACUTE ALCOHOL WITHDRAWAL SYMPTOMS USING EXTRACTS OF EYTHROPHLEUM AFRICANUM, SILLYBUM MARINUM AND FOENICULUM VULGARAE

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Alcohol Use Disorder is defined as alcohol abuse and alcohol dependence. Alcohol binds to GABA-A receptors in the CNS. Alcohol affects brain function by interacting with multiple neurotransmitter systems. Alcohol can disrupt the delicate balance between gaminobutyric acid (GABA), the primary inhibitory neurotransmitter, and glutamate, the major excitatory neurotransmitter in the central nervous system. Excessive consumption of alcohol leads to loss of coordination and sedation. After withdrawal from alcohol, the downregulation of the GABAARs contributes to many of the symptoms of AWS. It is characterized by physical and mental effects with a variety of symptoms. The most common symptoms include: headache, nausea, attention problems, dry mouth, dizziness, gastrointestinal discomfort, fatigue, tremors, loss of appetite, sweating, drowsiness, anxiety, and irritability. The alcohol effects, that are related to hangover and have been recently studied, rely on the increase of cytokines, changes in sleep, hypoglycaemia, acetaldehyde accumulation. Current pharmacological treatments include Disulfiram, Naltrexone, Acamprosate, T opiramate and Ordansetron. Over-the-counter medications include Guronsan C and ALCOHOL KILLER. In this

project, a herbal syrup was formulated using extracts of Erythrophleum africanum,sillybum marinum and foeniculum vulgarae. Extraction of phytochemicals was done using the clavenger etraction with water as the extraction solvent. Testing for efficacy of the phytochemicals in the reduction of intoxication was done on mice by recording the times the mice take to lose their righting reflexes, duration of sedation and the time taken to regain their reflexes. The tests for alleviation of alcohol withdrawal symptoms was done by recording the time taken for mice to move around a maze and the time mice spend in dark corners. Formulation of syrup was done according to the British Pharmacopoeia 2012 formulation standards. Test for stability of the syrup was focussed on viscosity, pH, crystallisation and physical inspection

Key words: *alcohol intoxication, acute alcohol withdrawal symptoms, Eythrophleum Africanum, sillybum marinum , Foeniculum vulgarae*

EVALUATION OF ANTIFUNGAL ACTIVITY OF SEED OIL EXTRACTS OF XIMENIA CAFFRA, MIMUSOPS DECORIFOLIA, GARCINIA BUCHANANII AND FLACOURTIA INDICA.

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Garcinia buchananii seed oil was extracted by cold expression. Ximenia caffro and imusops decarifolia seed oils were obtained by triturating seed pastes with warm water. Flocourtioindica seeds were macerated in n-hexane to get a clear seed oil. Antifungal activities of extracted seed oils against Candida albicans and Cryptococcus neoformans were studied using disc diffusion and serial dilution techniques to determine Minimum Inhibition Concentrations of the oils. The extracted seed oils exhibited antifungal activities against both C. albicans and C. neoformans with minimum inhibitory concentrations (MICs) ranging between O.125mg/ml and O.250mg/ml. Garcinia buchananii, Flacourtia indica, Mimusops decorifolia and Ximenia caffra seed oils exhibited MIC's of 1mm at 12.5 as well as 3mm, 3mm and 2mm at 25 respectively.

Key words: *Ximenia caffra, Mimusops decorifolia, Garcinia buchananii, Flacourtia indica*.

FORMULATION DEVELOPMENT OF A HERBAL CREAM FOR THE MANAGEMENT OF THIGH CHAFING INCORPORATING ALLIUM SEPPA, STERCULIA APPENDICULATA, ZANTHOXYLUM CHALYBEUM AND PTEROCARPUS ANGOLENSIS EXTRACTS.

Zimbabwe is rich with varied flora of medicinal plants. The present project deals with the utilisation of indigents to formulate a herbal cream for the management of thigh chafing. Thigh chafing is a condition that results from the thighs constantly rubbing against each other leading to non-penetrating wounds 'which are very painful and if left untreated can lead to blisters as a result of Staphylococcus aureas infection. Usually people who are at risk are those who have bulky inner thighs and this increases the frequency of friction as the inner thighs are constantly rubbing against each other. The plants utilised were Allium seppa,

Zanthoxylum chalybeum, Pterocarpus angolensis and Sterculia appendiculata. Qualitative analysis tests are used to determine the phytoconstiuents present in given sample. The qualitative tests were carried out to determine the presence of flavanoids, tannins, saponins and terpenoids of which these active constituents were thought to contribute to the required properties of the cream. The tannins attributed to the cream being resistant to removal by abrasion therefore having longer lasting effects. All plant materials were also found to have remarkable antibacterial activity against S. aureas with zones of inhibition diameter between 15-28mm. Zanthoxylum chalybeum and Pterocarpus angolensis were found to have analgesic activity similar to Nitrofurazone cream and can thus substitute this cream. Wound healing activity was also observed with the formulation reducing the normal healing time from 26 days to 18 days. Stability tests carried out on the formulation proved that the formulation was stable. The 250ml cream is going to be sold at $3 each after all the expenses were calculated.

Keywords: *Staphylococcus aureas, Thigh chafing, Zanthoxylum chalybeum, Allium seppa, Pterocarpus angolensis, Sterculia appendiculata.*

FORMULATION OF PERFUMES AND MASSAGE OILS USING ESSENTIAL OILS FROM UNDER-UTILIZED INDIGENOUS PLANTS.

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The basis of this research was on the formulation of a perfumes and massage oil from under-utilised indigenous plants found in Zimbabwe. Citrullus lanatus, Artemesia afra, Clausena anisata, Zanthoxylum chalybeum, Tagetes minutaare underutilised plant species in Zimbabwe with a great potential to serve the communities and country economically. The leaves of the different plants were first of all washed and cleaned. A steam hydrodistiller was used for extraction of the oils. The oil was collected and used to formulate the massage oils and perfumes. The different percentage yield of the plants were C.lanatus 24.42%, Tagetes minuta 0.71%, Clausenaanisata 1.35%, Artemesia afra 26% and Zanthoxylum chalybeum 30%. The perfume was formulated by trying to harmonise the different fragrance oils i.e. top note, base note and middle note. The oils were classified as base oils, top notes and middle notes based on the time taken for the fragrance oil to disappear from the cotton swab. The following results were recorded Artermisia afra 6minutes Top note, Tagetes

minuta 144 minutes Base note, Clausena anisata Middlenote and Zanthoxylum chalybeum 17 minutes Middle note.

The different amounts of the fragrant oils were according to IFRA (International Fragrance Association and therefore for the top notes of the parfum were 18.33, middle notes 30 and 51.67% base notes. For the ead du parfum16.67% of the top notes was used followed by 33.33% of the middle notes and 50% for the base notes. The two perfumes were classified as parfum and eau de parfum because the parfum contained 19.73% and the ead du parfum contained 7.59%. 77mls and 80 mls were used for the perfume and ead du perfume respectively. A carrier oil in this case watermelon seed oil was used with 5 drops for the ead de parfum and 40 drops from the parfum. The bridging oils included sandalwood, lavender, vanilla, geranium oil and lemon oil. For the massage oils 24 drops of the total essential oils was diluted with 36m Is of Citrullus lanatus.

Key words: *perfumes, massage oils, essential oils, under-utilized indigenous plants*