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## Contents

Underground Coal Gasification Studies on Chakwal Coal, Punjab, Pakistan  
Rashid Mehmood, Muhammad Habib, Muhammad Arif Bhatti, Asia Yousuf and Shahid Tufail Shaikh  

The Production of Activated Carbon from Nigerian Mineral Coal via Steam Activation  
Friday Onyekwere Nwosu, Bamidele Iromidayo Olu-Owolabi and Kayode Oyebode Adebowale  

Biosorptive Removal of Cadmium from Aqueous Solutions by *Pleurotus ferulae*: Equilibrium, Kinetic and Thermodynamic Studies  
Albert Ojo Adebayo, Afamefuna Elvis Okoronkwo and Helen Olayinka Ogunsuyi  

Fatty Acids, Phospholipids and Sterols Levels of the Skin and Muscle of Tongue Sole Fish  
Emmanuel Ilesanmi Adeyeye, Sei Owokoniran, Funmilola Esther Popoola and Richard Odunayo Akinyeye  

## Short Communications

Elemental Composition of Date Palm (*Phoenix dactylifera* L.) Using Energy Dispersive X-Rays Spectrometry  
Imdad Ullah Mohammadzai, Ziarat Shah and Hamayun Khan  

Muhammad Shahid, Muhammad Saleem and Farzana Ibrahim  

## Review

Morphological, Hydrolytic and Thermal Properties of Legume Starches  
Adeleke Omodunbi Ashogbon, Isaac Ayodele Oloade, Yekini Deboh Aliu and Adebowale Sayo Abitogun  


Author Index of Volume 54 Phys. Sci.  

Subject Index of Volume 54 Phys. Sci.
Underground Coal Gasification Studies on Chakwal Coal, Punjab, Pakistan

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(received September 20, 2010; revised March 11, 2011; accepted April 11, 2011)

Abstract. Underground coal gasification (UCG) experimentation was carried out on low-rank lignite coal of Eastern Salt Range, Chakwal, Punjab Province, Pakistan. A simulation reactor was designed in laboratory environments and gas input volume, type of gas input, gasification linkage and mode of combustion were investigated. Geological characteristics of the coal were also studied. The composition of emitted gases was evaluated and the syngas having calorific value of 2.42 MJ/m³ was produced.

Keywords: underground coal gasification, lignite, combustion, gas composition, Chakwal

Introduction

Coal is a valuable fuel resource and is far more abundant than oil or gas. It is burned to produce heat which is used for various purposes. The most significant uses are in electricity generation, steel production, manufacture of cement, fertilizers and paper, preparation of liquid fuels, synthetic natural gas, methane, ammonia and hydrogen gas in alumina refineries and in pharmaceutical industries (Prebstein and Hicks, 1982).

Coal gasification is a technology of converting coal into combustible gas by reacting it with controlled amount of air (oxygen) and water (steam) at high temperature. The resulting gas mixture, called synthesis gas or syngas, is itself a fuel which can be used for industrial heating. Currently a number of coal gasification technologies are being used in the world. However, underground coal gasification (UCG) has recently emerged as a technology for coal conversion and utilization (Kostur and Blistanova, 2008). It is carried out in non-mined coal seam, which is deep-underground, using injection of oxidants and bringing the product gas to surface through production wells, drilled from the surface. UCG can produce syngas at 1/2 to 1/4 of the cost compared to the surface gasifier (Khadse et al., 2010; Blinderman and Anderson, 2004).

Mining is the most common method for extraction of coal associated with constraints and disadvantages of mining. Surface mining is economical only when the coal seam is nearer to the surface. UCG offers an alternate technique to conventional methods and can be applied to deep and uneconomical resources to extract (Ghose and Paul, 2007). Compared to traditional coal mining and gasification, the UCG technology has the advantages of low plant cost, less environmental impact and absence of coal transport (Shuqin and Junhua, 2002). However, the presence of seam at a depth of 30 to 800 m having thickness of more than 5 m with minimal discontinuities are the basic requirements for UCG (Turner and Liu, 2004).

Siemens (1868) first suggested the underground gasification of waste coal left in the mine. Later on, many significant researchers took part in the development of this technology. In 1989, European Working Group recommended that a series of trials should be undertaken to evaluate the commercial feasibility of UCG. The trials were undertaken by the UK and Belgium, and were supported by the European Commission. The largest ongoing programme is being conducted by China, which includes 16 UCG trials. The successful demonstration of UCG during 1999-2003 at Chinchilla town in Australia resulted in gasification of around 35,000 tonnes of coal (Blinderman and Anderson, 2004).

Pakistan has large estimated deposits of over 185 billion tonnes of low quality lignite to sub-bituminous coal of tertiary age. Only the Punjab Province has 235 million tonnes of coal reserves located in the Eastern and the Central Salt Range and in Makerwal area of Surghar Range. Coal seams of economic value are present locally in Dandot area in the Eastern Salt Range and belong to the Patala Formation of late Paleocene (Shah, 1977).
The Production of Activated Carbon from Nigerian Mineral Coal via Steam Activation

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Abstract. Activated carbon was produced from Okpara sub-bituminous coal and Ogwashi brown lignite coal of Nigeria through steam activation at 900 °C and 960 °C each for 30 min and 60 min. Okpara and Ogwashi precursor coals had carbon content of 67.41 and 64.47%, respectively, whereas the bulk density and the ash content were 0.59-0.68 g/mL and 2.56-9.91%, respectively. The former exhibited up to 901.0 mg/g iodine number and Brunauer Emmett Teller (BET) surface area of 604 m²/g while the latter, iodine number of 998.0 mg/g and 669 m²/g BET surface area. Both showed adequate porosity indicative of their potential for utilization for commercial production of active carbons.

Keywords: Nigerian coal, activated carbon, steam activation, adsorption capacity

Introduction

The advent of oil exploration in Nigeria as well as import and operation of heavy trunks and trains with diesel engines led to total neglect of large deposits of mineral coals found in the most parts of Nigeria. This state of affairs gave impetus to investigate the possible conversion of two Nigerian coals, namely Okpara sub-bituminous coal and Ogwashi lignite coal to useful products like activated carbon.

Total recoverable coal reserves around the world have been estimated to be 930 billion tonnes, about 76% of which are located in USA (28%), Russia (19%), China (14%), Australia (9%), India (7%), while the remaining 23% is distributed among other 65 countries (EIA, 2008; USDA, 2008; IEA, 2007). The only African country is South Africa that produces 5.75 quadrillion Btu and consumes 3.81 quadrillion Btu, (Coal Association, 2007; EIA, 2005).

Some of these imported coals are utilized by Japan and China in production of activated carbon. The global consumption of activated carbon has been put as over 350,000 tonnes per annum and due to its high market demand and applications related to the environmental policies worldwide, a projected (7%) annual increase has been forecasted. Thus, by the year 2020, a total of 600,000 metric tonnes of activated carbon might be needed globally (EMS Energy Institute, 2001). Activated carbons are used in industry, medicine, agriculture, and in almost all areas of human activities. No single active carbon has universal application. Thus, commercial active carbons could be classified into four groups on the basis of their physico-chemical properties, pore structure and applications (Choudhury et al., 1985; Hassler, 1963). (i) Decolourizing carbon grade which are soft, finely powdered with high porosity and large surface area; (ii) gas/vapour adsorbent grade which are granular with high density, porosity and strength, used for industrial gas/vapour adsorption; (iii) metal adsorbent grade used as catalyst and catalyst support and (iv) medicinal grade adsorbent.

Active carbon is versatile and indispensable adsorbent especially in removal of colour, taste and odour from municipal water, industrial waste water and from food products. It is also used for recovery of gold in mineral industries and recovery of toxic organic solvents in chemical industries. Their use in pharmaceutical industries and medicine cannot be over emphasized such as its use in kidney dialysis machine (Lozano-Castello et al., 2001; Zanzi et al., 2001; Teker et al., 1999). In gas applications, active carbon acts as gas filters, in general air conditioning and in storage of natural gases.

Coal and lignocellulosic materials are two main sources utilized for commercial production of active carbons. Low ash content is desirable in commercial active carbon and is prepared either by acid leaching or by a suitable selection of precursors (Bansal et al., 1998).
Biosorptive Removal of Cadmium from Aqueous Solutions by
Pleurotus ferulae: Equilibrium, Kinetic and Thermodynamic Studies

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(received September 6, 2010; revised January 19, 2011; accepted April 12, 2011)

Abstract. Equilibrium, kinetics and thermodynamic parameters were evaluated to establish the potential usefulness of the Pleurotus ferulae biomass for biosorption of cadmium from aqueous solutions. Maximum biosorption was observed at initial pH of 4.5, temperature of 30 °C and at the initial cadmium concentration of 100 mg/L. Pseudo-second order rate expression well fitted the experimental data for cadmium when compared to pseudo-first order kinetic model. Equilibrium analysis using Langmuir and Freundlich models showed that the biosorption process is Langmuir model. The process was exothermic and ΔGo was negative showing spontaneity of the process within the studied temperature range. The possible functional groups on the dried Pleurotus ferulae biomass, responsible for the sorption of Cd (II), are: – OH, – NH, – COO– and – C– O.

Keywords: biomass, biosorption, cadmium, Pleurotus ferulae

Introduction

Heavy metal pollution in wastewaters is an extremely important environmental problem. Discharge of heavy metals from various industrial operations such as mining, ore processing, smelting and metal plating can easily cause metal pollution and hazardous effects on humans, animals as well as environmental imbalance. Due to metal accumulation through food chain and persistence, it is necessary to remove such chemical agents from wastewater before discharging it to the environment. Cadmium is usually associated with some principal metal ores widely used in daily life such as zinc, copper, mercury, iron, lead etc. Cadmium is also a dangerous pollutant originating from metal plating, metallurgical alloying, mining, ceramics and other industrial operations. Chronic exposure to elevated levels of cadmium is known to cause renal dysfunction (Fanconi syndrome), bone degeneration (‘Itai–itai’ syndrome), liver damage and blood damage (ATSDR, 1993). The US Department of Health and Human Services has determined that cadmium and cadmium compounds may be carcinogens. Cadmium has been found in at least 388 of 1300 items of national priority list identified by the Environmental Protection Agency (ATSDR, 1993).

Though much efforts have been significantly put into curtail the amount of cadmium in the environment, these have not really yielded the results desired by the most world related health and environmental standard regulatory bodies possibly due to inefficient and uneconomical removal technology used in the past two to three decades (Roskill Information Services, 1995). Therefore, the release of Cd into the environment, and resultant risk of exposure at various trophic levels still remain substantial. Some of the bases of conventional technologies for removing metallic ions from wastewater are solvent extraction, ion exchange, chemical precipitation, adsorption and reverse osmosis techniques (Kapoor and Viraraghavan, 1995). Chemical precipitation, especially as metal hydroxide or sulphide, is widely practiced, being simple employing inexpensive chemicals. However, it is not effective to reduce toxic metal concentrations to the level of water quality standards; also the generation of voluminous toxic waste sludge is a major problem encountered. Therefore, during the last few decades, research yielded adsorption to be one of the attractive techniques for removing noxious substances and for water purification; it is fast becoming an alternative to conventional precipitation and other techniques, especially for wastewaters that contain low concentrations of metals (Sahu et al., 2010; Jytikusum et al., 2009; Wahid, 2009; Sing et al., 2008; Sheng et al., 2004).

Activated carbon is the most widely used adsorbent in the wastewater treatment. Owing to high cost and
Fatty Acids, Phospholipids and Sterols Levels of the Skin and Muscle of Tongue Sole Fish

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(received March 1, 2010; revised May 6, 2011; accepted June 21, 2011)

Abstract. The levels of fatty acids, phospholipids and sterols were determined in the skin and muscle of Tongue sole fish on dry weight basis. Results showed crude fat varied from 0.027-0.360 g/100 g; SFA varied from 35.0-36.9% of total fatty acids, total unsaturated fatty acids varied from 42.6-47.3%, PUFA ranged from 0.068-0.149. In the phospholipids, phosphatidylcholine was highest in both skin and muscle, with respective values of 12.7 and 16.1 mg/100 g. The sterols level in the skin varied between 6.86-6.94 (6.90±0.04) mg/100 g and muscle was n.d.-0.961 mg/100 g. Samples had low levels of n-6 fatty acids [4.20% (skin) and 0.140% (muscle)] and n-3 fatty acids [1.20% (skin) and 2.36% (muscle)].

Keywords: lipid profiles, skin, muscle, tongue sole fish

Introduction

Fish and meat from wild animals are the chief source of animal protein in the diets of the rural communities, especially in the southern states of Nigeria (Petrides, 1962). The FAO calculation for apparent annual per capita consumption of fish and shellfish for human food, by region and country (2001-2008) put the expected estimate for 2008 as 26.6 kg or 58.8 pounds in Nigeria (Adeyeye, 2009). Hence work on the determination of the chemical composition of fish should be an important part of aquaculture research.

Fish are widely recognized as a nutrition source, due to their high content of proteins, phospholipids and polyunsaturated fatty acids, as well as essential minerals (Simopoulos, 2002). In particular, fish are an important source of essential polyunsaturated fatty acids, which contribute to the reduction of cardiovascular disease (Kris- Etherton et al., 2003), inflammatory diseases (Tapiero et al., 2002), colon cancer (Roynette et al., 2004), and disorders of the immune system (Belluzzi, 2001).

Sole is the common name for various species of flatfish. Generally speaking, they are the members of the family Soleidae, but outside Europe, the name ‘sole’ is also applied to various other similar flatfish. The main aim of this paper was to investigate the lipid composition (fatty acids, phospholipids and sterols) of Tongue sole fish (Cynoglossidae), commonly found in the fish markets of Nigeria. These fish are sold after drying and with their skin peeled off for storage, hence the skin and the muscle of the fish in this study were separately evaluated, to determine the potential loss of nutrition from the consumption of fish without their skin.

Materials and Methods

Sample collection and treatment. Five Tongue sole fish were purchased from the local fish market and brought to the laboratory; all bones and viscera were carefully removed and oven-dried at 55 °C for 5 h. The cooled dried samples were further separated into the skin and muscle, ground using mortar and pestle into a fine powder. The ground portions were kept in plastic rubbers in the freezer (-4 °C) pending analysis.

Determination of ether extract. An aliquot (0.25 g) of each part was weighed in an extraction thimble and 200 mL of petroleum ether (40-60 °C boiling range) was added. The covered porous thimble containing the sample was extracted for 5 h using a Soxhlet extractor. The extraction flask was removed from the heating mantle when it was almost free of petroleum ether, oven dried at 105 °C for 1 h, cooled in a desiccator and the weight of dried oil was determined.

Preparation of fatty acid methyl esters and analysis. A 50 mg aliquot of the dried oil was saponified for 5 min at 95 °C with 3.4 mL of 0.5 M KOH in dry methanol. The mixture was neutralized by 0.7 M HCl and 3 mL of 14% boron trifluoride in methanol was

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**Short Communication**

**Elemental Composition of Date Palm (Phoenix dactylifera L.) Using Energy Dispersive X-Rays Spectrometry**

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**Abstract.** In the present study, date palm (Phoenix dactylifera L.) including fruit and pit (Mashkeel variety) was collected from a local market in Peshawar, Pakistan and analyzed using EDX spectrometry. The results showed the presence of various important elements such as O, C, K, Cl, Ca, S, Mg, Fe, Co and Si in date palm fruit and pit. Sufficient amount of oxygen (>54 wt.%) and carbon (>42 wt.%) were determined in the date palm, which is the evidence of the presence of nutritionally enriched constituents. Similarly, the mineral elements including Na, Ca, Mg, K, Ni, Si, Co, Fe and Mo were present in sufficient quantities.

**Keywords:** date palm, EDX spectrometry, elemental composition, essential nutrients, Pakistan

The date palm (Phoenix dactylifera L.) is usually grown in hot, arid and desert regions of the world. At present, more than 2000 different cultivars of date palm are known to exist all over the world, but only a few important ones have been evaluated for their agronomic performance and fruit quality. The fruit of date palm is composed of fleshy pericarp and seed and is well known as staple food. The fruit undergoes several changes during various stages of growth and development. Different varieties of dates growing in various countries have been studied for chemical composition and nutritional quality (Mohammadzai et al., 2010a & b; Williams et al., 2005; Al-Hooti et al., 1997; Al-Showimain, 1990; Sawaya et al., 1983).

The date is considered an important cash crop and a good source of foreign exchange earnings. Pakistan is the fourth largest dates producing country in the world which grows different varieties of dates. Total cultivated area of all types of dates in the country exceeds 78.1 thousand hectares, which produce over 630 thousand tones dates annually (Mohammadzai et al., 2010a & b; Ihsanullah et al., 2005). The effect of gamma irradiation, and colourless and coloured polyethylene packing on the quality and shelf life of Pakistani dates were studied by Mohammadzai et al. (2010a) and Ihsanullah et al. (2005). They found that irradiation caused minor losses in the tested parameters (moisture, proteins, fibres and fats) of controlled and irradiated packed samples. Similarly, Baloch and co-workers improved the quality of Dhamki dates of Pakistan during its various growing stages using the different physio-chemical processes (Saleem et al., 2005; Baloch et al., 2003). Recently, mineral composition of Pakistani dates was also reported using atomic absorption spectrophotometry (Mohammadzai et al., 2010b). The Mashkeel variety of dates grown in Pakistan have not been subjected to elemental analysis using EDX spectrometry so far. The current study, therefore, was aimed at assessing the level of various elements present in the date palm fruit and pit.

Among various analytical techniques, EDX spectrometry is highly proficient for the elemental analyses of samples of diverse nature. The method is non-destructive and is more advantageous in multi-elementary analysis as compared to other existing methods, in the ease of sample preparation and analysis as it requires no chemical treatment or separation of the sample constituents. Although, this technique has been extensively used for elemental analyses of samples of biological and environmental importance (Khan et al., 2009; Khan et al., 2006), however, in the present study, this modern and rosted analytical technique has been applied probably for the first time, to determine the elemental composition of date palm fruit and pit.

Date palm (Mashkeel variety) was collected from a local market of Peshawar, Pakistan, in the same form as marketed. For each sample, ten date palm fruits and pits were collected in properly cleaned polyethylene
Short Communication


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Abstract. Activated carbon was produced from shisham wood and coconut shell through chemical activation, using phosphoric acid and low temperature carbonization. Proximate analysis and characterization of the product were carried out and Brunauer Emmett Teller (BET) surface area, total ash content, moisture content, pH value and iodine number were determined. The product characteristics were well comparable with those of the commercially available activated carbon.

Keywords: waste material, activated carbon, chemical activation, carbonization

Activated carbon can be produced from different raw carbon sources such as lignite, peat, coal, wood, sawdust, bagasse, and coconut shells. Earlier researchers utilized eucalyptus bark (Patnauo and Pavanast, 2008), flax shive (Marshall et al., 2007), date stone (Haimour and Emesh, 2006), hardwood (Lima et al., 2004), almond shell, pecan shell (Bansode et al., 2003) and coal (Jagtoyen et al., 1992) as precursor for production of activated carbon. Despite many related studies, there is little information available on the preparation of activated carbon using shisham wood as the precursor.

In principle, the methods for preparing activated carbon can be divided into two categories: physical activation and chemical activation (Narbaitz and Karimi-Jashni, 2009). In the physical activation, the raw material is first carbonized and then activated by steam or carbon dioxide, air or their mixture. The carbonization temperature ranges between 400 and 850 °C, and the upper limit being sometimes 1000 °C, whereas the activation temperature ranges between 600 and 900 °C. In the chemical activation method, the raw material is impregnated with an activating agent and then heat-treated under inert atmosphere. The carbonization step and activation step are carried out simultaneously in the chemical activation process, with the precursor being mixed with chemical activating agents as dehydrating agents and oxidants (Moreno-Piraján et al., 2010). Investigations have been extensively conducted to elucidate the mechanism of phosphoric acid activation (Al-Qaessi and Abu-Farah, 2010; Lim et al., 2010). In the present study, activated carbon was produced from locally available waste materials i.e., coconut shell and shisham wood through chemical activation method. The product was characterized and characteristics were compared with the activated carbon commercially available in the market.

Initially, raw samples were washed with the hot water (50-60 °C), dried in oven and then soaked in 30% phosphoric acid (H3PO4) overnight (Saleem et al., 2010; Masood-ur-Rehman, 2008). Later the samples were again dried in oven, poured in steel cylinders and placed in furnace for 45 min. The resulting material was cooled, washed with hot water to neutralize, dried in oven and stored in air-tight bottles for further characterization.

Characterization was carried out on the basis of volatile matter, fixed carbon, total ash content (ASTM D2866-94), moisture content (ASTM D4933-99), pH value (ASTM D3838-05) and iodine number (ASTM D4607-94). Surface area of the activated carbon was characterized by a physical technique involving nitrogen adsorption at 195.6 °C, Brunauer Emmett Teller (BET) surface area.

Results of the proximate analysis of both the types of activated carbon are presented in Table 1, which show that properties of both are comparable with those supplied commercially at international level (Zakwan, 2010). Especially, low values of moisture content and volatile matter endorse the good quality of the produced activated carbon. The results of the product relating to BET surface area, Iodine number, moisture content, ash content and pH value and typical values of powdered activated carbon (PAC) and granular activated carbon (GAC) are also shown in Table 1 and are compared with the characteristics of activated carbon reported in...
Review

Morphological, Hydrolytic and Thermal Properties of Legume Starches

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Abstract. Legumes are an excellent source of carbohydrate and provide an inexpensive source of protein. With the exception of beach pea (12.3%), the percentage yields of extracted legume starches fall within the range of 18.0-45.0% on a whole seed basis. The total lipid contents of legume starches range from 0.01-0.87%. Legume starches have variable granule diameters, generally between 4 and 80 µm. Granule shape may be oval, spherical, elliptical or irregular, depending on the source. Legume starches exhibit a two-stage solubilization pattern; the rates of hydrolysis for the first and second stages are identical in some legume starches but differ in others. Most legume starches exhibit C-type X-ray diffraction patterns. The degrees of crystallinity of most legume starches are similar to, or slightly lower than, those of cereal starches. Most legume starches exhibit nearly identical gelatinization transition temperatures and enthalpies. However, their gelatinization temperature ranges (Tc – To) differ. Legume starches easily retrograde due to their relatively high amylose contents, although long term retrogradation is attributed to short chains of amyllopectin.

Keywords: legume, starch, granule morphology, hydrolysis, gelatinization, retrogradation, thermal properties, granule crystallinity

Introduction

The legume fruit is formed from a single carpel, which splits along the dorsal and the ventral sutures, and usually contains a row of seeds borne on the inner side of the ventral suture. Grain legumes are dicotyledonous seeds of plants that belong to the family Leguminosae having 16,000-19,000 species in approximately 750 genera (Allen and Allen, 1981). They rank fifth in terms of annual world grain production (171 million metric tons) after wheat, rice, corn and barley (FAO, 2003; Deshpande and Damodaran, 1990). Approximately 12 species of the Leguminosae, which is the third largest family of flowering plants, are widely used as food (Chavan et al., 1999). Examples include lima bean, garbanzo bean, lentil bean, mung bean, pinto bean, adzuki bean, red kidney bean, smooth pea, wrinkled pea, and the two oilseed legumes, soybean and groundnut. The food legumes are rich in starch, protein, dietary fibre, minerals and water-soluble vitamins. Legumes constitute an important source of carbohydrates for a large part of human population, mainly in the developing world. India is the largest producer and consumer of legumes in the world (Singh et al., 2008). The total carbohydrate contents of food legumes vary from 24% (winged bean) to 68% (cowpea) (Ratnayake et al., 2001). Starch is the most abundant carbohydrate in the seed (22-45%; Hoover and Sosulski, 1991). Legumes are used as food and feed (Leon et al., 1991) as the seed is a good source of both starch and protein, 36.7-50% (Leon et al., 1989; Duke, 1981) and 29.7% (Clemente et al., 2000; Menkov, 2000; Kessler, 1985), respectively. But lentil seeds contain more protein than other legume seeds, the protein content ranges from 24.3% to 30.2% for different cultivars (Wang and Daun, 2006). Variations in the values for the starch and protein contents of legumes reported in the literature may be attributed, in part, to differences in the methods of analyses.

A major factor which has an adverse effect on the widespread utilization of legume starches in the food industry is their relatively high amylose contents (Hoover and Sosulski, 1985). The association between amylose molecules and the outer branches of amyllopectin in
Pakistan Journal of Scientific and Industrial Research
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Volume 54
Contents

Series A: Physical Sciences
Vol. 54, No.1, January - February, 2011

Deposition and Characterization of ZnS Thin Films Using Chemical Bath Deposition Method in the Presence of Sodium Tartrate as Complexing Agent
Anuar Kassim, Tan Wee Tee, Ho Soon Min and Saravanan Nagalingam 1

Rapeseed Lipase Catalyzed Synthesis of Butyl Butyrate for Flavour and Nutraceutical Applications in Organic Media
Muhammad Liaquat 6

Effects of Storage and Packaging Materials on Some Physicochemical Properties and Microbiological Parameters of Pineapple Juice (Ananas comosus)
Itunnu Oluwabunmi Shakpo and Jacob Olalekan Arawand 14

Osmotic Dehydration of Pomegranate (Punica granatum L.) Using Response Surface Methodology
Muhammad Abdul Haq and Abid Hasnain 19

Effect of Roasting Temperature on the Fatty Acid Composition and Physicochemical Characteristics of Extracted Oil Carthamus tinctorius Thori-78 of Pakistani Origin Seeds
Razia Sultana, Rubina Saleem and Ambrat 26

Effect of Moisture Content and Heat Treatment on Peroxide Value and Oxidative Stability of Crude Palm Kernel Oil
Akinoso Rahman, Aremu Ademola Kabir and Raji Abdulganiy Olayinka 33

Effect of Citric Acid and Storage Containers on the Keeping Quality of Refined Soybean Oil
Jacob Olalekan Arawande, Eniayo Ayodeji Komolafe and Itunnu Oluwabunmi Shakpo 40

Soil Micronutrient Status in Hazro Area of District Attock, Pakistan
Sarosh Alvi, Rizwan Khalid, Muhammad Rashid, Abdul Waheed and Abdul Sattar Javed 45

Contribution of Different Global Varieties of Cotton towards Water Hardness in Textile Wet Processing
Mumtaz Hasan Malik, Tanveer Hussain and Aroosa Shaukat 48

Study of Tannery Wastewater Treatability by Precipitation Process
Naeem Abbas, Farah Deba, Khalid Iqbal, Tahira Shafique and Hafiz Sameer Ahmed 52
Facile Synthesis and Characterization of Substituted Pyrimidin-2(1H)-ones and their Chalcone Precursors
Olayinka Oyewale Ajani, Ruth Itoroabasi Ituen and Ayorinde Falomo 59

Vol. 54, No.2, May - June, 2011

Comparative Study of the Characteristics of Seed Oil and Seed Nutrient Content of three Varieties of Cucumis sativus L

Removal of Copper from Aqueous Solutions Using Sawdust, Zeolite and Activated Carbon: Equilibrium Time Convergence
Zaman Shamohammadi Heidari, Esmat Jamalia, Milad Ghallehban Tekmedash and Mostafa Khajeh 75

Investigation of Carbon Monoxide at Heavy Traffic Intersections of Karachi (Pakistan) using GIS to Evaluate Potential Risk Areas for Respiratory and Heart Diseases
Akhtar Shareef, Durdana Rais Hashmi, Muhammad Azam and Imran Ahmad Khan 84

Petroleum Hydrocarbon Pollution after the Tasman Spirit Oil Spill of Coastal/Deep Sea Sediment along the Clifton Beach Karachi, Pakistan
Alia Bano Munshi, Fayyaz Ahmed Ansari, Hina Asgar Siddiqi and Mohammad Zeeshan 90

Lead Concentration in Road Side Dust and Selected Vegetables of Lahore City, Pakistan
Naz Imtiaz, Tahir Butt, Muhammad Irfan, Tahira Shafiq and Arshad Chaudhry 98

HPLC Determination of Betamethasone and Prednisolone in Urine Samples Using Monolithic Column
Kamran Abro, Najma Memon, Muhammad Iqbal Bhanger, Shahnaz Perveen and Rehana Jafri 103

Technology for Treatment and Recycling of Wastewater of Automobile Service Stations
Abdur Rahman Khan, Mumtaz Khan, Tehseen Aslam, Naveed Jan, Jehangir Shah and Inayat-ur-Rehman 108

Short Communication

Influence of Expeller Design Parameters on Free Fatty Acid Content and Colour of Palm Kernel (Elaeis guineensis) Oil
Rahman Akinoso, Abdulganiy Olayinka Rajib and Joseph Chuluwoziem Igbeka 114

Vol. 54, No.3, September - October, 2011

Underground Coal Gasification Studies on Chakwal Coal, Punjab, Pakistan
Rashid Mehmood, Muhammad Habib, Muhammad Arif Bhatti, Asia Yousuf and Shahid Tufail Shaikh 117

The Production of Activated Carbon from Nigerian Mineral Coal via Steam Activation
Friday Onyekwere Nwosu, Bamidele Iromidayo Olu-Owlabi and Kayode Oyebode Adebowale 123
Biosorptive Removal of Cadmium from Aqueous Solutions by *Pleurotus ferulae*:
Equilibrium, Kinetic and Thermodynamic Studies
A. O. Adebayo, A.E. Okoronkwo and H.O. ogunsuyi

Fatty Acids, Phospholipids and Sterols Levels of the Skin and Muscle of Tongue Sole Fish
Emmanuel Ilesanmi Adegbe, Seyi Owokoniran, Funmilola Esther Popoola and
Richard Odunayo Akinyeye

**Short Communications**

Elemental Composition of Date Palm (*Phoenix dactylifera* L.) Using Energy
Dispersive X-Rays Spectrometry
Imdad Ullah Mohammadzai, Ziarat Shah and Hamayun Khan

Muhammad Shahid, Muhammad Saleem and Farzana Ibrahim

**Review**

Morphological, Hydrolytic and Thermal Properties of Legume Starches
Adeleke Omodunbi Ashogbon, Isaac Ayodele Oloade, Yekini Deboh Aliu and Adebowale Sayo Abitogun


Author Index of Volume 54 Phys. Sci.

Subject Index of Volume 54 Phys. Sci.
Pakistan Journal of Scientific and Industrial Research
Series A: Physical Sciences
Volume 54
Author Index

Abdul Sattar Javed, 54A(1)45
Abdul Waheed, 54A(1)45
Abdulganiy Olayinka Rajib, 54A(2)114
Abdur Rahman Khan, 54A(2)108
Abid Hasnain, 54A(1)19
Addal Mir Khan, 54A(1)57
Adebowale Sayo Abitogun, 54A(3)155
Adeleke Omodunbi Ashogbon, 54A(3)155
Afamefuna Elvis Okoronkwo, 54A(3)132
Akhtar Shareef, 54A(2)84
Akinoso Rahaman, 54A(1)33
Albert Ojo Adebayo, 54A(3)132
Alia Bano Munshi, 54A(2)90
Ambrat, 54A(1)26
Anuar Kassim, 54A(1)1
Aremu Ademola Kabir, 54A(1)33
Aroosa Shaukat, 54A(1)48
Arshad Chaudhry, 54A(2)98
Asia Yousef, 54A(3)117
Astaq Mohal Khan, 54A(2)68
Ayorinde Falomo, 54A(2)59
Bamidele Iromidayo Olu-Owolabi, 54A(3)123
Durdana Rais Hashmi, 54A(2)84
Emmanuel Ilesanmi Adeyeye, 54A(3)140
Eniayo Ayodeji Komolafe, 54A(1)40
Esmat Jamalia, 54A(2)75
Fadzilah Adibah Abdul Majid, 54A(2)68
Farah Deba, 54A(1)52
Farzana Ibrahim, 54A(3)152
Fayyaz Ahmed Ansari, 54A(2)90
Friday Onyekwere Nwosu, 54A(3)123
Funmilola Esther Popoola, 54A(3)140
Hafiz Sameer Ahmed, 54A(1)52
Hamayun Khan, 54A(3)149
Helen Olayinka Ogunsuyi, 54A(3)132
Hina Asgar Siddiqi, 54A(2)90
Ho Soon Min, 54A(1)1
Imdad Ullah Mohammadzai, 54A(3)149
Imran Ahmad Khan, 54A(2)84
Inayat-ul-Rehman, 54A(2)108
Isaac Ayodele Ololade, 54A(3)155
Ittenu Oluwabummi Shakpo, 54A(1)14, 54A(1)40
Jacob Olalekan Arawand, 54A(1)14, 54A(1)40
Jehangir Shah, 54A(2)108
Joseph Chulwugoziem Igbeka, 54A(2)114
Kamran Abro, 54A(2)103
Kayode Oyebode Adebowale, 54A(3)123
Khalid Iqbal, 54A(1)52
Md. Abbas Ali, 54A(2)68
Md. Abu Sayeed, 54A(2)68
Milad Ghallehban Tekmedash, 54A(2)75
Mohammad Zeeshan, 54A(2)90
Mostafa Khajeh, 54A(2)75
Muhammad Abdul Haq, 54A(1)19
Muhammad Arif Bhatti, 54A(3)117
Muhammad Arshadullah, 54A(1)57
Muhammad Ayaz Khan Malghani, 54A(1)57
Muhammad Azam, 54A(2)84
Muhammad Habib, 54A(3)117
Muhammad Iqbal Bhanger, 54A(2)103
Muhammad Irfan, 54A(2)98
Muhammad Liaquat, 54A(1)6
Muhammad Maqsood Ahmed, 54A(1)57
Muhammad Rashid, 54A(1)45
Muhammad Saleem, 54A(3)152
Muhammad Shahid, 54A(3)152
Mumtaz Hasan Malik, 54A(1)48
Mumtaz Khan, 54A(2)108
Naeem Abbas, 54A(1)52
Najma Memon, 54A(2)103
Naveed Jan, 54A(2)108
Naz Imtiaz, 54A(2)98
Olayinka Oyewale Ajani, 54A(2)59
Rahman Akinoso, 54A(2)114
Raji Abdulganiy Olayinka, 54A(1)33
Rashid Mehmood, 54A(3)117
Razia Sultana, 54A(1)26
Rehana Jafri, 54A(2)103
Richard Odunayo Akinyeye, 54A(3)140
Rizwan Khalid, 54A(1)45
Rubina Saleem, 54A(1)26
Ruth Itoroabasi Ituen, 54A(2)59
Sandip Kumar Ghosh, 54A(2)68
Saravanan Nagalingam, 54A(1)1
Sarmina Yeasmin, 54A(1)68
Sarosh Alvi, 54A(1)45
Seyi Owokoniran, 54A(3)140
Shahid Tufail Shaikh, 54A(3)117
Shahnaz Perveen, 54A(2)103
Syed Ishtiaq Hyder, 54A(1)57
Tahir Butt, 54A(2)98
Tahira Shafiq, 54A(2)98
Tahira Shafique, 54A(1)52
Tan Wee Tee, 54A(1)1
Tanveer Hussain, 54A(1)48
Tehseen Aslam, 54A(2)108
Yekini Deboh Aliu, 54A(3)155
Zaman Shamohammadi Heidari, 54A(2)75
Ziarat Shah, 54A(3)149
Pakistan Journal of Scientific and Industrial Research
Series A: Physical Sciences
Volume 54
Subject Index

Activated carbon from Nigerian mineral coal ................................................................. 54A(3)123
Activated carbon: equilibrium time convergence, removal of copper .......................... 54A(2)75
Aqueous solutions, removal of copper from ................................................................. 54A(2)75
Attok, Pakistan, soil micronutrient status ................................................................. 54A(1)45
Automobile service stations, technology for treatment and .......................................... 54A(2)108
Betamethasone and prednisolone in urine samples, HPLC determination .................. 54A(2)103
Biosorptive removal of cadmium from aqueous solutions by Pleurotus ferulae .............. 54A(3)132
Butyl butyrate synthesis for flavour and nutraceutical applications ............................... 54A(1)16
Cadmium removal from aqueous solutions by Pleurotus ferulae .................................. 54A(3)132
Carbon monoxide investigation at heavy traffic intersections of Karachi ..................... 54A(2)84
Carthamus tinctorius Thori-78 of Pakistani origin seeds oil, effect of ......................... 54A(1)26
Chakwal coal, Punjab, Pakistan, underground coal gasification studies ....................... 54A(3)117
Characterization of activated carbon, production and .................................................... 54A(3)152
Characterization of substituted pyrimidin-2(1H)-ones, facile synthesis ......................... 54A(2)59
Characterization of ZnS thin films using chemical bath, deposition and ......................... 54A(1)11
Chemical bath deposition method for ZnS thin films ................................................... 54A(1)11
Citric acid and storage containers effect on refined soybean oil quality ....................... 54A(1)40
Coastal/deep sea sediment pollution along the Clifton beach Karachi, Pakistan .......... 54A(2)90
Copper removal from aqueous solutions activated carbon .......................................... 54A(2)75
Cotton varieties towards water hardness in textile wet processing ............................... 54A(1)48
Cucumis sativus L. varieties, seed oil and seed nutrient characteristics ......................... 54A(2)68
Date palm (Phoenix dactylifera L.), elemental composition of ..................................... 54A(3)149
Dust and selected vegetables, lead concentration in ..................................................... 54A(2)98
Elemental composition of date palm (Phoenix dactylifera L.) ...................................... 54A(3)149
Equilibrium, kinetic and thermodynamic studies, biosorptive removal of ....................... 54A(3)132
Expeller design parameters influence on palm kernel (Elaeis guineensis) oil ............... 54A(2)114
Fatty acid composition of extracted oil Carthamus tinctorius Thori-78 seeds ............... 54A(1)26
Fatty acid content and colour of palm kernel (Elaeis guineensis) oil ............................ 54A(2)114
Fatty acids, phospholipids and sterols levels of tongue sole fish .................................... 54A(3)140
Fish, fatty acids, phospholipids and sterols levels ...................................................... 54A(3)140
Heavy metals in soils of Quetta irrigated by sewage water ........................................ 54A(1)57
HPLC determination of betamethasone and prednisolone in urine samples ................ 54A(2)103
Hydrolytic, morphological and thermal properties of legume starches ......................... 54A(3)155
Lead concentration in road side dust and selected vegetables .................................... 54A(2)98
Legume starches, morphological, hydrolytic and thermal properties of ......................... 54A(3)155
Microbiological parameters of pineapple juice (Ananas comosus), effects of ............... 54A(1)14
Morphological, hydrolytic and thermal properties of legume starches ......................... 54A(3)155
Nigerian mineral coal, the production of activated carbon from ................................... 54A(3)123
Nutrient content of three varieties of Cucumis sativus L., comparative study .................. 54A(2)68
Osmotic dehydration of pomegranate (Punica granatum L.) ....................................... 54A(1)119
Oxidative stability of crude palm kernel oil, effect of moisture..................................................54A(1)33
Pakistan, soil micronutrient status .................................................................................................54A(1)45
Pakistan, underground coal gasification studies .......................................................................54A(3)117
Palm kernel \textit{(Elaeis guineensis)} oil, influence of expeller design .....................................................54A(2)114
Palm kernel oil, effect of moisture content and.............................................................................54A(1)33
Peroxide value and oxidative stability of crude palm kernel oil ..................................................54A(1)33
Petroleum hydrocarbon pollution after the Tasman Spirit oil spill .............................................54A(2)90
Phospholipids, fatty acids and sterols levels of fish Skin .............................................................54A(3)140
Physicochemical characteristics of extracted oil \textit{Carthamus tinctorius} Thori-78 seeds ..................54A(1)26
Physicochemical properties pineapple juice \textit{(Ananas comosus)} .....................................................54A(1)14
Pineapple juice \textit{(Ananas comosus)}, effects of storage and .........................................................54A(1)14
\textit{Pleurotus ferulae} for biosorptive removal of cadmium ..........................................................54A(3)132
Pomegranate \textit{(Punica granatum} L.), osmotic dehydration ............................................................54A(1)19
Precipitation process for tannery wastewater treatability ..........................................................54A(1)52
Prednisolone and betamethasone in urine samples using monolithic column ..............................54A(2)103
Production and characterization of activated carbon .................................................................54A(3)152
Pyrimidin-2(1H)-ones and their chalcone precursors, facile synthesis .......................................54A(2)59
Rapeseed lipase catalyzed synthesis of butyl butyrate ...............................................................54A(1)6
Recycling of wastewater of automobile service stations, technology for ..................................54A(2)108
Respiratory and heart diseases, investigation of carbon monoxide .............................................54A(2)84
Response surface methodology of pomegranate \textit{(Punica granatum} L.), osmotic dehydration ........54A(1)19
Roasting temperature effect on the fatty acid composition and ..................................................54A(1)26
Sawdust, Zeolite and activated carbon used for coper removal .................................................54A(2)75
Seed oil and seed nutrient content of three varieties of \textit{Cucumis sativus} L. .................................54A(2)68
Sewage water soils, quantitative status of heavy metals .............................................................54A(1)57
Sodium tartrate as complexing agent for ZnS thin films ............................................................54A(1)1
Soil micronutrient status in Hazro area of district Attok, Pakistan ...........................................54A(1)45
Soils of Quetta irrigated by sewage water, quantitative status ..................................................54A(1)57
Soybean oil .................................................................................................................................54A(1)40
Steam activation, the production of activated carbon .................................................................54A(3)123
Sterols, fatty acids and phospholipids levels of tongue sole fish skin ........................................54A(3)140
Storage and packaging materials effects on pineapple juice \textit{(Ananas comosus)} .........................54A(1)14
Storage containers and citric acid effect on refined soybean oil .................................................54A(1)40
Synthesis and characterization of substituted pyrimidin-2(1H)-ones .........................................54A(2)59
Synthesis of butyl butyrate for flavour and nutraceutical applications .....................................54A(1)6
Tannery wastewater treatability by precipitation process ..........................................................54A(1)52
Tasman Spirit oil spill of coastal/deep sea, petroleum hydrocarbon pollution ..............................54A(2)90
Textile wet processing and water hardness of cotton .................................................................54A(1)48
Thermal, morphological and hydrolytic properties of legume starches ......................................54A(3)155
Traffic intersections of Karachi (Pakistan), investigation of carbon monoxide ...........................54A(2)84
Treatment and recycling of wastewater of automobile service stations ....................................54A(2)108
Underground coal gasification studies on Chakwal coal ............................................................54A(3)117
Vegetables of Lahore city, Pakistan, lead concentration in ..........................................................54A(2)98
Waste materials for production and characterization of activated carbon ..................................................54A(3)152
Wastewater treatability of tannery by precipitation process........................................................................54A(1)52
Wastewater treatment of automobile service stations ..................................................................................54A(2)108
Water hardness in textile wet processing, contribution of...........................................................................54A(1)48
X-rays spectrometry, elemental composition of date palm ...........................................................................54A(3)149
ZnS thin films deposition and characterization ............................................................................................54A(1)1