UNTAPPED WEALTH POTENTIAL IN FRUIT WASTES FOR UGANDA COMMUNITY

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ABSTRACT

Uganda is a country rich in abundant arable lands that enhance growth of several agricultural products. About 70% of the country's land mass is currently being cultivated with fruits and vegetables being the most predominantly. With high level of farming in the entire country, there is undoubtedly high level of waste generation from such produce. Proper disposal of the fruit wastes has subsequently been a perennial problem in Uganda due to high costs involved in contracting the effluent collectors as well as limited availability of landfills. They are often disposed unscrupulously as they carry no useful value in the minds of average local citizen. Thus, if the situation is not properly managed, fruit wastes can produce odor, soil pollution, harborage for harmful insects as well as several environmental issues asides resulting in greenhouse gas emission during decomposition; hence, huge amount of valuable untapped commodities that can result in wealth creation will be lost and subsequently causing serious ecological damages. Hence this study investigates and reviews the major composition of some fruit wastes, specifically banana, mango and pineapple, as well as the drivable biotechnological and industrial applications that could be exploited from proper waste recovery system in Uganda.

The study concluded that banana, mango and pineapple wastes contain much reusable potentials to drive the idea of new and emerging technologies, such as green technology for biogas or bioethanol production to fruition in industrial, economic, social and ecological facet by providing raw materials for manufacturing, process and pharmaceutical industries; while also promoting the adoption of efficient farming system to improve overall profitability and competiveness.

Keywords: Biotechnological application; fruit wastes; waste recovery; green technology.

1.0. INTRODUCTION

Uganda, a country located in the Eastern part of Africa is blessed with abundant arable lands that support the growth of many agricultural products, with diverse species of fruits and vegetables being predominant. Studies have shown that the Global fruit production is experiencing a significant increase; with output annual growth rate of about 3 percent over the last decade (Romelle *et al*, 2016). Uganda is one of the largest producers of fruits in East Africa, with a total land area of 19,981 hectare and up to 70% (13,962 hectare) of these land mass are cultivated (FAOSTAT, 2013). This statistics shows that Uganda is purely an agricultural state. A large variety of fruits are grown in Uganda, among which banana with 9.5 million Metric Tons cultivated annually by more than 75% of Ugandan farmers (Faostat, 2013). Others include mango, Pineapple, pawpaw and water melon.

Contemporary agriculture generally categorizes these fruits into fruit crop or cash crop commodities alongside several others such as oil palm, sugarcane and rice. Similarly, some of these commodities inherently produce huge amount of cellulostic waste known as biomass. Innovation in proper managing of such vast amount of waste or biomass is a continuous challenge and recent trends favor the utilization of such biomass for value added purposes to fulfill the need in areas like renewable energy, fiber composites and textiles, food alternatives organic manure and livestock feed (Rosentrater *et al.* 2009; Padam *et al.* 2012).

Fruits wastes consist majorly of peels, core, seeds, residual pulp, pomace and as well as large volume of water which often makes them wet and easily fermentable. Proper disposal of such fruit wastes has been a perennial problem in Uganda due to high costs involved in contracting the effluent collectors as well as limited availability of landfills. They are often disposed unscrupulously as they carry no useful value in the minds of average local citizen. Thus, if the situation is not properly managed, fruit wastes can produce odor, soil pollution, harborage for harmful insects as well as several environmental issues asides resulting in greenhouse gas emission during decomposition (Shalini and Gupta, 2010). Also, if not properly managed, huge amount of valuable untapped commodities that can result in wealth creation will be lost and subsequently causing serious ecological damages (Essien *et al.* 2005; Shah *et al*. 2005; Yabaya and Ado 2008; Padam *et al.* 2012).

Previously, attempts were made to utilise the fruit wastes essentially for compost as organic manures and livestock feeds. However, efforts are now being made to develop high value biotechnological products from these wastes such as cosmetics, medicines and fuel purpose, hence, the recovery seems to be economically attractive (Ashoush and Gadallah, 2011; Romelle *et al*, 2016). The idea of utilizing fruit wastes especially the peels which in some fruits makes up 30% or more of the total weight, is gradually gaining popularity especially when researchers found that peels possessed better biological activities than other parts of the fruit (Moon and Shibamoto, 2009; Romelle *et al*, 2016).

Hence this study investigates and reviews the major composition of some selected fruit wastes as well as the drivable biotechnological and industrial applications that could be exploited from proper waste recovery system in Uganda. This no doubt will inspire future research and discovery in such useful areas within the country. The work specifically focuses on wastes from banana, mango and pineapple.

2.0. PROPERTIES / CHEMICAL COMPOSITION OF SELECTED FRUIT WASTES

The ever increasing idea of utilizing fruit wastes in creation of wealth via conversion into usable materials and biotechnological products strongly depends on the properties and chemical composition of such wastes. Thus, the various properties that make such wastes usable for economic purposes are described.

Several authors have worked on the properties / chemical composition of the fruit wastes, either singly or in dual combination. We shall review the properties as related to the selected fruits as follows:

2.1. Mineral Composition

Minerals play a vital role in various physiological and chemical functions of the body, especially in the building and regulation processes. According to Ismail *et al.,* 2011, fruits are considered as a good source of dietary minerals.

The fruit wastes, especially the peels have abundant Calcium, Zinc, Iron and Manganese in varying degrees. Pineapple has the least calcium content with value 8.30±0.54 mg/100g dry peel among the selected fruits followed by banana (19.86 ± 0.24 mg/100g dry peel) with mango (60.63± 4.58 mg/100g dry peel) having the highest composition according to Romelle *et al.,* 2016. However, pineapple has the highest composition of Zinc and Iron among the three fruits followed by Banana with Mango having the least. The corresponding ranks for Manganese show that Banana has the highest composition followed by Pineapple and Mango.

2.2. Proximate Composition

Asides the mineral composition of the fruit peels, researchers have shown that the peels contain some amount of basic nutrients such as Crude protein, Lipid, Crude Fibre, Ash as well as Carbohydrate. Banana has the highest composition of Crude Protein, Lipid and Ash followed by Pineapple and Mango. However, Crude Fibre and Carbohydrate are more abundant in Mango than Pineapple and Banana respectively (Romelle *et al.,* 2016; Omutubga *et al.,* 2012).

3.0. WASTE UTILIZATION

As described earlier, Uganda, being a predominant Agric nation has a vast economic potential inherent in the large tons of fruit waste generated annually if being exploited. We thus present the various ways by which the wastes could be utilized in the East African country.

3.1. Waste to Bioenergy

Over the years, bioenergy has become a promising, inexhaustible, sustainable source to combat the rising environmental, economic, and technological issues related to depleting fossil fuels. The vital aspect for sustainable production and supply of bioenergy is the feedstock availability. Among various usable substrates, production from wastes has received a special acceptance for maintaining environmental integrity. Hence, utilization of such fruit wastes generated would be economically beneficial. The Specific gaseous and liquid biofuels derivable from the wastes are discussed as follows.

3.1.1. Production of Bioethanol

Economic conversion of renewable sources into ethanol using cheap substrates such as pineapple, banana and mango peel wastes has gained interest in some developed counties for some years (Upadhyay *et al.,* 2010). Natural bio-ethanol is generally produced from a fermentation process using either yeast or bacteria in which sugar derived from cellulosic sources is metabolized and converted into ethanol (Raposo *et al.* 2009; Padam *et al.,* 2012). Mango peel bioethanol is economically and environmentally viable and can be a good substitute of petrol (Puligundla *et al.,* 2014). Upadhyay *et al.,* 2010 reported several good yields of ethanol with pineapple waste under the action of different organisms for the fermentation process. Also, banana peels have been reported to be a good substrate in producing ethanol and the contributing factors such as substrate concentration, fermentation parameters, and the type of fermenting organism do affect significantly the overall yield of ethanol (Manikandan et al. 2008; Padam *et al.,* 2012).

The utilization of agricultural wastes such as the Banana, Mango and Pineapple wastes as raw materials for ethanol production will potentially reduce the cost of using staple food crops like corn and wheat in conventional natural ethanol production. This is why a country having such abundant wastes from these fruits should as a matter of fact set up mercenaries in place for the conversion of such waste into wealth.

3.1.2. Production of Biomethane

Biomethane is a cheap form of renewable energy that is environmentally friendly and usually obtained during anaerobic digestion of the wastes by the microbial community. Anaerobic treatment of fruit and vegetable waste, rich in organic content, is advantageous as it not only results in the high yield of methane with varying organic loading, but also provides the digested slurry that can be used as soil conditioner/biomanure. Methane is an important fuel for industrial usage and as well powers household kitchens. It exists as gas and it is highly combustible compared to ethanol. Thus, harnessing the potential of fruit wastes in form of methane will not only boost the industrial sector of Uganda, but also provide a cheap source of cooking fuel for household kitchens. The methodology of setting up the reactor / digester for such methane extraction from fruit wastes is not as complex as that from natural gas.

Other useful bioenergy products derivable from fruit wastes include biodiesel and biobutanol which have become promising alternatives to petroleum-based transportation fuels in recent years.

3.2. Waste to Organic Acid

In search of low cost substrate, production of organic acid from fruit wastes has been a research of interest in recent times (Upadhyay *et al.*, 2010). In line with this, pineapple wastes have been reported to be utilized for the production of various organic acids particularly citric, lactic and ferulic acid using fermentation technology (Upadhyay *et al.*, 2010). Also, Jawad et al. 2013 investigated the use of mango peel as a low cost substrate for the production of lactic acid through direct fermentation using bacteria having both amylolytic and lactic acid producing capabilities.

Production of such commercially valuable products from wastes that carry no useful value in the minds of average locals is a potential that need be explored in Uganda. Bearing in mind that the organic acids are widely used in food, pharmaceutical and beverage industries as substrate to acidify and enhance flavour.

3.3. Waste as Anti-dyeing Agent

Dyes used in clothing and textile industries are becoming a threat to environmental problem as a number of commercially used synthetic dyes have been reported contributing to health problems, which justified the need for removal of such dyes from wastewaters.

Some works on utilizing pineapple waste to remove the dyes have been explored. Pineapple stem is used as low-cost adsorbent to remove basic dye (methylene blue) from aqueous solution by adsorption (Hameed *et al*., 2009; Upadhyay *et al.*, 2010). In another work, pineapple leaf powder has been applied as an unconventional bio-adsorbent of methylene blue from aqueous solution (Weng *et al*., 2009; Upadhyay *et al.*, 2010). Not only pineapple wastes could be utilized in removing dyes, Mas Harris and Sathasivam (2009) demonstrated the capacity of banana pseudostem as a potential absorber of methyl red in aqueous solutions (Padam et al., 2012).

3.4. Waste as Natural Fibers

Fiber industries are exploring alternative sustainable material that would eventually replace the usage of wood and pulp from the trees to make timbers, boards, textiles, and papers. Agricultural by-products from various sources are potentials because of their availability and mass production all year round (Reddy and Yang 2005; Padam et al., 2012).

Fibers can be obtained from numerous sources of agricultural commodity as well as their wastes and by-products such as jute, cotton, palm oil, banana, pineapple and sugarcane. A few studies have been conducted on the potential of banana fibers as the raw materials in making composite boards (Chattopadhyay et al. 2010; Ibrahim et al. 2010; Padam et al., 2012). Banana fibers have been used for years as raw materials for textiles in the production of traditional handicrafts and clothes by several groups of people in the world (Kennedy 2009). Currently, the global textile and clothing industry is undergoing significant increase in demand; hence, a great demand in fiber materials for textile purposes is a potential to be tapped into by a country that is one of the largest producers of banana in the world.

Also, paper production is one of the commercial applications of banana wastes as reported by Padam et al., (2012). The creativity in utilizing available non-woody agricultural wastes as raw materials for paper production offers a great potential in reducing the dependence on natural timbers, which is fast becoming more expensive due to depletion in supply (Bastianello et al. 2009).

3.5. Wastes as Organic Fertilizers and Animal Feeds

The use of organic fertilizers have gained impetus as a substitute to chemically synthesized fertilizers due to its reported effectiveness, the increasing cost of some chemical fertilizers as well as consciousness towards the hazardous effects of chemical fertilizers to human and the environment at large. Subsequently, the use of fruit wastes as organic fertilizer is the only area that is being explored by the locals of Uganda. However, there is still much to the use of such wastes as organic fertilizers through proper composting methods to allow for even distribution of nutrients to the applied area.

Also, the various nutrient contents such as protein, carbohydrate and fibre inherent in the fruit peels make them rich feed source for ruminant animals.

3.6. Wastes as Source of Metal Removal

Heavy metals are threat to the environment and the availability of these hazardous metals such lead, chromium, cadmium, mercury and zinc in wastewater pose a great threat to human as it might contaminate the drinking water system. Heavy metals are hardly biodegradable and can easily accumulate in living tissues making it concentrated as it goes up the food chain (Metcheva et al. 2010). Numerous agricultural have been explored and most are found to have the potential as low-cost heavy metal absorbers. Cleaning the environment from the contamination of heavy metals is very costly; hence, cheaper alternative absorbers from agricultural wastes such as banana, pineapple and mango are highly considered. For instance, Noeline *et al.* (2005) showed that formaldehyde polymerized banana pseudostem is an effective absorbent in cleaning lead (II) in batch reactors (Padam et al., 2012). Also, Banana fruit stalk was also discovered to be potential cobalt (II) and cadmium (II) remover (Anirudhan and Shibi 2007; Padam et al., 2012).

Iqbal et al. (2009) utilized Mango peel biosorbent for the removal of Cd(II) and Pb(II) heavy metals from aqueous solution. Similarly, Pineapple fruit residues have been used as an effective biosorbent to remove toxic metals like mercury, lead, cadmium, copper, zinc and nickel (Senthilkumaar *et al*., 2000; Upadhyay *et al*., 2010).

4.0. Challenges and Prospects

With recent trend in utilizing low cost renewable agricultural wastes as a raw material in making value added products to curb land degradation, increasing agricultural productivity, and reducing waste; natural biomasses such as the banana, mango and pineapple byproducts are potential substitutes for our depleting nonrenewable resources like hydrocarbon fuel and will continue to find futuristic benefits in both manufacturing, processing and pharmaceutical industries at large (Mohammadi 2006).

4.1. BANANA

Banana by-products and peels are abundantly available around the world and mostly here in Uganda for renewable and sustainable exploration as long as the global banana industry maintains its momentum. Shifting towards the utilization of agricultural wastes such as the banana by-products is also seen as an environmental friendly approach to reduce environmental problems occurring from the predominance poor waste management concept. Its versatility and usefulness as raw materials in many food and non-food industries provides good and solid prospects as the potential income generating commodity of the future. As a commodity, not only will it benefit both banana farmers and the industry but also provide alternatives in terms of generated products to consumers (Birdie et al. 2014).

4.2. MANGO

Fresh mango peel contains significant amount of moisture. Mango peel is rich in pectin, cellulose, hemicelluloses, lipids, proteins, polyphenols and carotenoids (Ajila et al. 2013). In general, the level of reducing sugars, nonproducing sugars, protein and cellulose varies depending on two key factors: cultivar, and moisture state. Dried mango peel contains higher amounts of reducing sugars and could be used as substrate for fermentative production of ethanol, organic acids and other industrial bio products. The fruit is a potential source of bio-energy and other value-added products, successfully achieved through biotechnological route.

4.3. PINEAPPLE

Pineapple peel has found variety of usage right from our fore fathers. Nonetheless, recent scientific research has found it to be rich in cellulose, hemicellulose and other carbohydrates. Ensilaging of pineapple peels produces methane which can be used as a biogas. Anaerobic digestion takes place and the digested slurry may find further application as animal, poultry and fish feeds (Rani and Nand, 2004).

Correia *et al.* (2004) investigated the ability of *Rhizopus oligosporous* to produce enhanced levels of free phenolics from pineapple residue in combination with soy flour as potential nitrogen source. Bromelain, which is probably the most valuable and the most studied component from the pineapple waste, has been investigated since 1894. Bromelain is present in pineapple wastes. Hebber et al (2008) carried out a study where they use Reverse micellar extraction (RME) technique to extract and purify bromelain from pineapple wastes.

5.0. CONCLUSION

Banana, Mango and Pineapple wastes contain much reusable potential to drive the idea of new and emerging technologies, such as green technology for biogas or bioethanol production to fruition in industrial, economic, social and ecological facet by providing raw materials for manufacturing, process and pharmaceutical companies; promoting the adoption of efficient farming system to improve overall profitability and competiveness. It also supports sufficient production for subsistence and income earning for small scale farmers who may indulge in waste collection and finally, preventing unwanted pollution of soil, water and air. Thus, environmentally polluting by-products could be converted into products with a higher economic value than the main product.

6.0. REFERENCES

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