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THE CHEMICO-ECONOMIC ANALYSIS OF WATER MELON *(Citrullus lanatus)* PRODUCTION IN NIGERIA TOWARDS THE ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT GOALS (SDGS).

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Abstract

This paper explores the chemico-economic analysis of water melon (Citrillus lanatus) production in Northern Nigeria, with a special focus on its potential to contribute to sustainable development goal and food security initiatives. This study presents considerations regarding the accumulation of chemicals water melon and the assessment of the impact of contamination produced by their consumption on human health. The variation in the level of the elements in the water melon could be attributed mostly to atmospheric deposition. The study concluded that, the water melon from sample sites are safe for consumption and not above maximum permissible limits. Also the study utilized data from multiple sources to illustrate the current state of water melon production in the region, including information on inputs, labor, and outputs. Additionally, the study examined the potential environmental and social impacts associated with water melon production in the region. Based on the findings of the study, it was concluded that water melon production in Northern Nigeria offers an opportunity for sustainable development goal and food security initiatives. The study also highlights the need for improved data collection and monitoring in the region to ensure the long-term success of these initiatives.

Keywords: Water melon, Citrillus lanatus, Nigeria, Sustainable Development Goals, Chemico-economic Analysis

1. Introduction

Water melon is a crop of economic importance. The fruit can be round, long or spherical in shape and has distinctive thick green rinds that are often spotted or stripped. The fruit is made up of fruit coat, mesocarp and seed. The mesocarp can be white, green, yellow, orange, pink or red. Water melon seeds are excellent sources of protein, oil, dietary fibre, micro and macro-nutrients such as copper, manganese, iron, phosphorus, zinc, vitamins.

Consumption of fruits and food offers the most rapid and lowest cost means of providing adequate supplies of vitamins, minerals and fiber to the body. Some fruits and have been noted to contain quite reasonable levels of proteins, carbohydrates and fats, which are often needed nutrients for a healthy balanced diet. That is why it is important to grow or purchase fresh fruits for consumption along with our daily meals (Moran1996).

Adequate production of most Nigeria staple crops such as cereals, yam, cassava, cash crops and some vegetables like melon which is consumed in many parts of the country, will contribute positively to the agricultural sector.

The entrance of heavy metal in the food chain is the major route of heavy metal exposure to human (Zhuang *et al.,* 2009). Fruits are an important part of human diets and the prime source of minerals, fibers, and vitamins. Plants, fruits absorb these heavy metals from contaminated soil. Besides, heavy metals are also deposited on the different parts of fruits from the air (Calderon *et al.,* 2003). According to Wang *et al.* (2005), heavy metals are the major contaminants of the food supply that affect the nutritive values of fruits eventually pose deleterious effects to human health. Intake of contaminated fruits supply the heavy metals in the human body that cause a detrimental effect on the human body like damage of DNA, change the genetic code and reduce the energy level of the human body. Exposure to certain metals like mercury and lead may also cause autoimmune disorders such as rheumatoid arthritis, kidney diseases, etc. Besides, they inhibit the common functions of liver, kidneys, lungs, and heart, etc. (Bouchard *et al.,* 2011). Heavy metals are extremely persistent in the environment. They are non-biodegradable and non-thermo degradable and therefore readily accumulate to toxic levels (Bahiru *et al*., 2019). It is notable that plants that grow and develop between intensive anthropogenic and severe activities are contaminated by heavy metals such as Pb,As, Mo, Co, Ni, Mn and C. (Machate, *et al*., 2021). Heavy metals generally combine with the thiol, amino and imino group of protein and form a metal complex. As a result, the proteins lose their biological activities and cause the breakdown of the cell (Kumar and Seema, 2016). In addition, heavy metals also affect the philological functions of plants and retard the nitrogen fixation, chlorosis, metabolism and the growth of plants (Kumar and Seema, 2016).

Afterwards, the consumption of contaminated water melon constitutes an important route of heavy metal exposure to animals and humans (Sajjad *et al.,* 2009; Tsafe *et al.,* 2012). Abandoned waste dumpsites have been used extensively as fertile grounds for cultivating water melon, though research has indicated that the fruits are capable of accumulating high levels of heavy metals from contaminated and polluted soils (Cobb *et al.,* 2000; Benson and Ebong, 2005).

Agronomic practices such as fertilizer and water managements as well as crop rotation system can affect bioavailability and accumulation of heavy metals in water melon, thus influencing the thresholds for assessing dietary toxicity of heavy metals in the food chain (Mubofu, 2012). Generally, most heavy metals are not biodegradable, have long biological half-lives and have the potential for accumulation in the different body organs leading to unwanted side effects (Jarup, 2003; Sathawara *et al*., 2004). There is a strong link between micronutrient nutrition of plants, animals and humans and the uptake and impact of contaminants in these organisms (De Leonardis *et al*., 2000; Yuzbasi *et al*., 2003; Baslar *et al*., 2005; Yaman *et al*., 2005). The content of essential elements in water melon is conditional, the content being affected by the characteristics of the soil and the ability of plants to selectively accumulate some metals (Divrikli *et al*., 2006).

Water irrigation is among the major sources of soil contamination with heavy metals and increased metal uptake by water melon grown on such contaminated soils is often observed (Ferré-Huguet *et al*., 2008). Water melon are consumed enormously in many countries and thus constitute one of the important food sources. It is therefore imperative to analyzes chemical properties water melon.

Water melon (Citrillus lanatus), also called honeydew melon, among other vegetables crops plays an important dietary role in any parts of Africa. It belongs to Cucurbitaceae family. It is grown virtually everywhere in tropical, subtropical and temperature region where rain and irrigation is adequate (Namdari, M. (2011)). Melon is an important component of most Nigerian diets. A valuable vegetable oil is extracted from the seeds, while the ground seed is used to prepare various delicacies including cake and soup. Unlike the red juicy flesh of the watermelon variety, the white flesh of melon fruits has a bitter taste and therefore it is not eaten fresh or uncooked (Rhodes, and X. Zhang 1999). Melon may be inter-cropped with Cassavva, yam and maize or grown sole (Baameur. 2009).

1.1 Background of the Study

Water melon (*Citrillus lanatus*) is a warm, long season crop that is adopted to all climatic zones. Annual world production of water melon has increased from 9 million in 2009 to 22 million in 2016 (FAO 2017). Major water melon producing countries in the world are china with 400,000ha the America (United State, Mexico central and south American countries) producing 165,000 northern African (Egypt, morocco, Tunusia) producing 110,000, southern Asia (Indian, Pakistan, bangle dash) producing 100,000, European union (Spain, Italy, France, Greece, Portugal) producing 95,000, Romania producing 50,000, Japan producing 13,00 and Korean republic producing 11,000, (FAO, 2017)

1.1.1 Economic Importance or Uses of Water Melon

The mature fruits of water melon are usually consume fresh for the water and juicy pulp. The is also mixed with water and sugar or sometime with milk and served as a refreshing drink or made introduce cream. Immature fruits of non water types, including snake melon are used as a a fresh, cooked or pickled vegetable. They can also be stuffed with meat, rice and spice and fruits in oil.

Water melon is often composed with cucumber (the edible fruits of this plant having a green rind and crisp white flash) and often used as such, the seeds are eaten after roasting, they, contain edible oil. The house people in Nigeria grind the Kernels (A single seed or grain) to a paste and make it into formatted cakes, the young leaves are occasionally consumed and also the fruits provide good forge, for all livestock's. in Mauritius the seeds and roots are used as a diuretic (A drug that increases the rate of urine) and vermifuge (A drug that acts cause the expulsion or death, of intestinal, worms such as tapeworms Dung, et al. (2010).

1.1.2 Factors Affecting Water Melon Production

Several literatures have reported on the factors affecting fruit production such as (Okike, 2006), (Awoyemi, 2000) cited by (Oladimeji, *et. al* 2016a) have shown the importance of labour in farming particularly in developing countries where mechanization is only common in large commercial farmers. He also reported that in the study area, farming is still at the subsistence level generally. This involves the use of traditional farming implement such as hoe and machete. Human power plays cervical role in virtually all farming activities. This situation has variously been attributed to small and scattered land holding, poverty of the farmers and lack of affordable equipment (Oladimeji, *et. al* 2016a).

It appears that labour will continue to play important role in urban agricultural, affecting its efficiency, until those factors constraining mechanization are addressed.

Another finding on the fertilization as the factor affecting the fruit production by (Oladimeji, *et. al* 2016a), which reported that the production elasticity of fertilizer is 0.4183, by increasing the quantity of fertilizer by 10% output level will improve by margin of 4.183%.

Similarly, Dung, et al. (2010) also had similar findings. The production elasticity value of output with respect to quantity of fertilizer applied was 0.5584. the co-efficient was statistically significant at 5% probability level of the means that if the quantity of fertilizer was increased by 10% output will be improved by a margin of 5.584%.

1.1.3 Human Exposure and Health Hazards Associated with Heavy Metals

Humans are· always ·exposed to the natural levels of trace elements. Under normal circumstances the body is able to control some of these amounts. However, continuous exposure to elevated levels of metals could cause serious illness or death (Okonkwo, 2005). Increased exposure may occur through inhalation of airborne particles or through ingestion of contaminated soil by children or by absorption through the skin (WHO, 1981).

1.2 Copper (Cu)

Copper is a commonly encountered substance in the environment. When in soil, Cu strongly attaches itself to organic matter and soil minerals and is picked up by plants. Through food, organisms are able to ingest Cu which initiates many biological activities (Addae, 2015). In humans, the essentiality of copper arises from its incorporation into a large number of proteins. Copper has the ability to cycle between stable oxidised Cu^{2+} and unstable reduced Cu^{+} (EBRC, 2007). Cu is carried by the protein ceruloplasmin and acts as a reductant in the enzymes superoxide dismutase, cytochrome oxidase, lysil oxidase, dopamine hydroxylase, and several other oxidases that reduce molecular oxygen in the organism (Fraga *et al.,* 2005). Cu forms an essential structural component of many macromolecules, ensuring normal activity for a large number of enzymes and other proteins. Cu essentiality is known in its physiological effects where it is critical to foetal/infant development and growth, immune function, brain development and function, bone and collagen strength, haematopoiesis, iron metabolism, cholesterol and glucose metabolism, myocardial contractility, maintenance of hair and skin, and pigment formation. Cu also participates in both iron and energy metabolism (Addae, 2015). Adverse health effects due to copper excess are focused on the liver which is the target organ for copper-related toxicity. With a damaged liver (cirrhosis); a high amount of zinc may produce adverse nutrient interactions with Cu and reduces immune function and the levels of high density lipoproteins (FDA, 2001). Again, emphasizes is made that true absorption rates are intake dependent, decreasing with increasing daily intakes. From the intake mechanisms, systemic absorption of 63-65% occurred at an intake of 1mg/day, whereas at an intake of 8 mg/day, the systemic absorption dropped to 29-32% (EBRC, 2007).

1.3 Zinc (Zn)

Zinc is an essential trace element found in fruit such as water melon. Its deficiency as well as excess is harmful. Recent research has shown that zinc is extremely important especially in fetal development and the nutrition of infants. The adult human body contains about 2.3g of zinc which occurs mostly in over 100 enzymes (Sarmah, 2010). The normal daily requirement for zinc is 15 mg for adult and 5 mg for children. Zinc plays a role in carbohydrate, lipid and protein metabolism and in the synthesis and breakdown of DNA. Because of these functions, zinc deficiency in the fetus will result in retarded growth; malformation of body, and chromosomal abnormalities. A zinc deficiency after birth may result in dwarfism, poor appetite, mental lethargy, etc. (Sarmah, 2010). Excess amount of zinc on the other hand can cause stomach cramps, nausea, vomiting, central nervous system disorder. Nriagu, (1980) stated that zinc is· toxic also for aquatic biota.

1.4. Iron (Fe)

Iron occurs as a natural constituent of water melon. In water melon it occurs as iron oxides, inorganic and organic salts or organic complexes such as haem iron. Processing may affect the chemical form of iron. Levels of iron range from low for water melon, vegetables and fats, to medium for red meats, chicken, eggs, whole wheat flower, too high for organ tissues, fish, green vegetables and tomatoes. Iron fortification of food, and also contamination of food during its preparation could increase the intake of iron. The rate of absorption of iron is affected by the chemical form of the dietary iron, the source of iron (plant or animal), its interaction with other food components and the body's need for iron (mucosal regulation) (Codex, 2011).The effects of toxic doses of iron are characterized by initial depression, coma, convulsion, respiratory failure and cardiac arrest. Post-mortem examination reveals adverse effects on the gastrointestinal tract. Some iron-forms were found positive in mutagenicity tests. Noteratogenic effects were observed (Codex, 2011). However, subjects with impaired ability to regulate iron absorption (that is suffering from idiopathic haem ochromatosis), will be at risk from excessive exposure to iron. Excess iron intake may result in siderosis (deposition of iron in tissue) in liver, pancreas, adrenals, thyroid, pituitary and heart depending on the chemical form (Codex, 2011).

1.5. Manganese (Mn)

Manganese is an essential plant mineral nutrient, playing a key role in several physiological processes, particularly photosynthesis. Manganese deficiency is a widespread problem, most often occurring in sandy soils, organic soils with a pH above 6 and heavily weathered, tropical soils. Mn is readily transported from root to shoot through the transpiration stream, but not readily remobilized through phloem to other organs after reaching the leaves (Loneragan, 1988).

Necrotic brown spotting on leaves, petioles and stems is a common symptom of Mn toxicity (Wu, 1988). This spotting starts on the lower leaves and progresses with time toward the upper leaves (Horiguchi, 1988). With time, the speckles can increase in both number and size resulting in necrotic lesions, leaf browning and death. Another common symptom is known as „„„crinkle leaf"", and it occurs in the youngest leaf, stem and petiole tissue. It is also associated with chlorosis and browning of these tissues (Loneragan, 1988). Manganese toxicity in some species starts with chlorosis of older leaves moving toward the younger leaves with time. This symptom starts at the leaf margins progressing to the interveinal areas and if the toxicity is acute, the symptom progresses to marginal and interveinal necrosis of leaves (Bachman and Miller, 1995).

1.6 Statement of the Problem

Water melon being a major source of vast array of vitamins are consumed by majority of people in the world. Accumulation of chemicals by the fruit usually occurs when grown within contaminated aquatic environment or when the fruits are exposed to heavy metal contaminated dust during handling. Due to the health hazards associated with the consumption of chemicals polluted water melon, it has therefore become imperative to ascertain the levels of these chemicals (heavy metals) in all consumable items especially fruits for public awareness.

1.7 Objective of the Study

The broad objective of this study is:

i. Determine some physicochemical analysis of toxic metals that support the growth of the water melon.
ii. Determine the levels of some toxic metals water melon.
iii. Determine the profitability of water melon production.

1.8 Research Question

i. What are the physicochemical analysis of toxic metals which support the growth of the water melon.
ii. What are the levels of toxic metals water melon.
iii. What are the profitability of water melon production.

1.9 Significance of the Study

The consumption of water melon is increasing to boost the production and to meet it high demand, therefore, the study become relevant in updating data on the level of contamination of the various fruits. The study will also benefit other researchers who are interested on the level of heavy metals in fruits in gathering data and will also benefit the farmers as it will recommend the best out/input combination for optimum yield.

2. Methodology

2.1 Sample collection

Water melon samples was collected randomly from three different sampling sites (S_1, S_2 and S_3) by plucking and cutting with stainless knife. At each sampling site, four samples were collected at an interval of at least 1-2 meters apart. This was sliced into pieces, dried in an oven at 105ºC to a constant weight, ground, sieved, homogenized and pulled together to represent a composite sample. This was placed in a polyethylene bags separately and labeled with a unique identification number for subsequent analysis.

3. Result and Discussion

3. 1 Level of Concentration of Chemicals (Heavy Metals)

This section presents level of concentration of heavy metals; Cupper (Cu), Zinc (Zn), Iron (Fe), and Manganese (Mn) in water melon in irrigation site (S_1, S_2 and S_3)

3.2. Copper

Copper is an essential micronutrient which functions as a biocatalysts, required for body pigmentation in addition to iron, maintain a healthy central nervous system, prevents anemia and interrelated with the function of Zn and Fe in the body (Akinyele and Osibanjo, 1982). However, most plants contain the amount of copper which is inadequate for normal growth which is usually ensured through artificial or organic fertilizers (Itanna, 2002). In this study, the concentrations of Cu in water melon samples varied between 0.6115µg/g to 0.0026µg/g.

3.3. Zinc

Zinc is the least toxic among all the heavy metals and an essential element in human diet as it is required for the proper maintenance of the body functions. For example, the immune system, proper brain functioning and is vital for the development of fetal growth. Deficiency of Zn in the diet may be more dangerous to living organism including human than its high concentration in the diet. The recommended dietary allowance for Zinc is 15mg/day for men and 12mg/day for Women (Ogunlesi *et al.,* 2010). It is therefore an essential element for plants and animals; however, a small increase in the required level may cause interference with physiological processes. In this study, the high concentration of zinc was observed in water (0.0056 µg/g),

3.4. Manganese

Manganese is a very essential trace heavy metal for plants and animals growth. Its deficiency produces severe skeletal and reproductive abnormalities in mammals. High concentration of manganese (Mn) causes hazardous effects on lungs and brains of humans (Jarup, 2003). The range of Manganese (Mn) concentrations in the water melon samples is between 480.17 and 2776.64 mg/kg.

Higher proportions of Mn in water melon samples are another confirmation of high absorption of Mn by the tissues from the soils on which they grow and other non-anthropogenic sources. The high absorption rate of Mn by the tissue is coupled with low re-mobility of Mn through phloem to other organs after reaching the plant. Excess Mn has been reported to inhibit synthesis of chlorophyll by blocking iron (Fe) process (Clarimont *et al*., 1986). Manganese toxicity is a relatively common problem compared to other micronutrient toxicity. Nevertheless, Mn was found in this study with concentration ranged between 9.9423µg/g to 0.1094µg/g in all samples.

3.5. Iron

It is the most abundant and essential constituent for all plants and animals. On the other hand, at high concentration, it causes tissues damage and some other diseases in humans. It is also responsible for anemia and neurodegenerative conditions in human being (Fuortes and Schenck, 2000). This study revealed that iron has (0.3413µg/g, 0.2668µg/g, 0.3553µg/g, 0.2050µg/g, 0.0786µg/g, 0.0553µg/g, 0.0036µg/g and 0.0001µg/g) in the samples. The variation in the absorption of Fe from the soil by the plant's tissues are evident in the low Fe contents in water melon samples. The low concentrations of Fe in the water melon samples relative its abundant availability in the soils, and can be attributed to: (i) low absorption of Fe by the tissues of the fruits samples, (ii) possible leaching of Fe from the soil surface and runoff during rainfall.

However, Fe is essential for the synthesis of chlorophyll and activates a number of respiratory enzymes in plants. The deficiency of Fe results in severe chlorosis of leaves in plants. High levels of exposure to iron dust may cause respiratory diseases such as chronic bronchitis and ventilation difficulties.

Water melon output was 131.74% which implies high inconsistency in output level among water melon farmers in the study area. However, if efficiency and productivity status of water melon output is adequately checked, will lead the country to attaining food security and poverty reduction, the instability in output of water melon could be attributed to inconsistency and inadequacy of variable inputs among farmers in the study area.

3.6 Productivity and Efficiency in Water Melon Production

Input and output levels in water melon production in the study area

DEA models can be either output or input oriented. The input-oriented model measures the quantities of inputs that can be reduced without any reduction in the output quantity produced. On the other hand, output oriented model measures the degree to which output quantity can be increased without any change in the quantities of inputs used. However, the relative range of the efficiency scores remains the same whether input or output-oriented methods are employed. We therefore need to compute the level of inputs used and outputs realized for better understanding.

The summary statistics of level of inputs used and outputs realized in water melon production in the study area are reported in Table 4.8. The inputs that were used in water melon production include; seed, fertilizer, labour, herbicide and farm size. Table 7 revealed that the average quantity of seed used by water melon farmers was 24.15kg/ha. The minimum and maximum quantities of seed used were 5.00kg/ha and 500kg/ha, respectively. Average fertilizer used by water melon farmers was 452.70kg/ha, while the minimum and maximum were found to be 75.00kg/ha and 3000kg/ha respectively. The mean labour recorded was 74.03mandays/ha while the minimum and maximum were observed to be 4.00mandays/ha and 1250mandays/ha respectively. Mean herbicide recorded for water melon farmers was 3.35liters/ha while the minimum and maximum used were 2.00liters/ha and 240liters/ha respectively. The mean farm size was 4.06ha. The minimum and maximum farm sizes were 0.25ha and 100ha, respectively. The output of water melon varies from one farmer to another depending on the input utilization and the management practices. The average output of water melon in the study area was 3788kg/ha (3.8ton/ha) while the minimum and maximum output produced by water melon farmers were 1000kg/ha (1.0ton/ha) and 6700kg/ha (6.7ton/ha) respectively.

The coefficient of variation of each variable inputs used and output realized are presented in Table 4.8. The higher the coefficient of variation, the greater the dispersion of the variable are while the lower the ratio of standard deviation to mean return, the better your risk-return trade-off. The coefficient of variation for a model aims to describe the model fit in terms of the relative sizes of the squared residuals and outcome values, whereas the lower the coefficient of variation, the smaller the residuals relative to the predicted value. The low coefficient of variation is a reflection of reliability (precision) of the result (Johnson and Welch, 1939) they reported that for a normal distribution, the ratio of mean to standard deviation should be of order of three or more and 33% is often stated as the permissible upper fiducially limit of coefficient of variation.

The finding shows that the coefficient of variation of all the variable inputs used; seed, fertilizer, labour and herbicide were 102.32%, 54.13%, 54.20% and 60.28% respectively. The high coefficient of variation of variable inputs implies high level of variation in the use of variable input among water melon farmers in the study area. However, the coefficient of variation for fertilizer and labour were lower compared to other variable inputs used for water melon production.

4. Summary, Conclusion and Recommendations

4.1 Summary

This study examined the concentration of chemicals (heavy metals) in water melon. The study assessed the impact of contamination produced by the consumption of these metals on human health. The studied metals are, Cupper (Cu), Zinc (Zn), Lead (Pb), Iron (Fe), and Manganese (Mn) grown in the study area. Water melon samples were collected from three different sites (S_1, S_2 and S_3). Prepared samples were digested using freshly prepared aquaregia ($HNO3+HCl$) in the ratio 1:3. The analysis of the samples was done using Atomic Absorption Spectroscopy (AAS). The result from the study showed that the concentration of lead was found to be below detection level. Zinc (Zn) was also observed only in (0.0009µg/g). Manganese (Mn) was also found in all the samples. The level of concentration of (Mn) ranged from (9.9423µg/g) to (0.1094µg/g). Iron (Fe) was found in the samples (51.834µg/g) to (0.0001µg/g). Copper (Cu) was also present in the samples from (0.5727µg/g) to (0.0026 µg/g). The variation in the level of the elements in the ssmple could be attributed mostly to atmospheric deposition. Most samples with hard pericarp had less level of the metals, the source of which therefore could be the soil or water.

4.2 Conclusions

From this study, it can be concluded that, the water melon from the three sites is safe for consumption. Generally, the variation in the levels of the metals could be attributed mostly to atmospheric deposition.

Water melon requires well planting spacing for optimum growth and fruits yield development, and the results from the study indicates that the best planting spacing for water melon is 50cm x 50cm which is found to be adequate for the production of the crop in the study area.

5.3 Recommendations

The study recommends that washing technique can be used as a tool to assess the heavy metals load in fruits through atmospheric depositions. This study further recommends that to reduce the health risk, fruits should be washed properly before consumption as washing can remove a significant amount of aerial contamination from the fruits surface.

Extension agent should be mobilized in the area to enhance the level of agronomic pctices of melon farmers. Access to extension agents enhances the chances of having access to better crop production techniques, improved inputs as well as other production incentives and in turn leads to increase in output.

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