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Proximate analysis of fruits and vegetables wastes from Nairobi County, Kenya

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ABSTRACT: Proximate analysis of twenty fruits and vegetable waste from Nairobi County was evaluated. They were obtained from Kangemi and Wakulima markets. Standard procedures were used for the analysis of crude fat, protein, fiber, carbohydrates, moisture, ash, nitrogen-free extract and energy. The results obtained revealed that moisture content was in the range of 82.8 to 95.86% apart from sweet potato and banana which was 62.05 and 74.30% respectively. Protein range was between 0.57 to 3.49% with high-fat content being recorded in avocado at 9.03%. The ash content was highest in comfrey at 3.46% and lowest in mango at 0.44%. The carbohydrate level obtained by the difference method was lowest in courgette at 1.99% with crude fiber ranging from 0.69 to 2.73%. The total calculated energy ranged from 1.94 to 39.98 Kcal/100g. The macro-nutrient concentrations were 3.59 and 1.53% for potassium and calcium respectively. Lead, iron and zinc were detected at 15.1±3.6, 3742±235 and 176±11 ppm respectively. There is the presence of proximate properties in the edible portion of wasted fruits and vegetable and therefore, this study recommends proper fruits and vegetable handling during harvest, transportation, storage and marketing. Besides, the unavoidable waste should be used as biomass in energy production to deal with landfilling issues in the market places.

Keywords: Analysis, fruits, proximate, vegetables, wastes.

INTRODUCTION

Food wastage and its accumulation are becoming a critical problem around the globe due to the continuous increase in the world population (Paritosh et al., 2017; Gustavsson et al., 2011; Anonymous, 2008). The exponential growth in food waste is imposing serious threats to our society like environmental pollution, health risk, and scarcity of dumping land (Beede and Bloom, 1995). Food loss refers to as the reduction of safe to eat food mass throughout the part of the supply chain that specifically leads to scarcity of edible food (Gustavsson et al., 2011; Anonymous, 2008). On the other hand, food waste refers to the removal of foodstuff from the supply chain resulting from spoilage or expiry caused by poor economic behavior (Beede and Bloom, 1995; Oliver, 2007). Fruit and vegetable wastes are created during harvesting, transportation, storage, marketing and processing. According to FAO, almost 1.3 billion tonnes of food comprising of vegetables, fruits, meat, bakery, and dairy products are wasted (FAO, 2012). The amount of food waste (FW) is expected to rise in the next 25 years due to economic and population growth. For instance, in Asian countries, the annual quantity of city FW might rise from 278 to 416 million tonnes from 2005 to 2025 (Melikoglu et al., 2013). Approximately 1.4 billion hectares of fertile land (28% of the world's agricultural area) are used yearly to produce food that is wasted. Apart from food and land resource wastage, the carbon footprint of food waste contributes to the greenhouse fuel (GHG) emissions via accumulating about 3.3 billion tonnes of CO_2 into the atmosphere per year. Conventionally, this food waste, which is a component of municipal strong waste, is incinerated (Agarwal et al., 2005; Kumar and Goel, 2009; Kumar et al., 2009; Pattnaik & Reddy, 2010; Talyan et al., 2008) or dumped in an open place which may additionally purpose extreme health and environmental issues.

Figure 1. A picture of fruits and vegetable wastes at Kangemi market.

Incineration of food waste consisting of excessive moisture content results in the release of dioxins (Katami et al., 2004) which might also, in addition, lead to environmental problems. Also, incineration reduces the economic fee of the substrate as it hinders the recovery of nutrients and precious chemical compounds from the incinerated substrate. Therefore, splendid methods are required for the administration of food waste (Ma et al., 2009). Anaerobic digestion can be an attractive alternative to give a boost to the world's energy security by employing food waste to generate biogas while addressing waste administration and nutrient recycling. Due to high biodegradability nature and high moisture content (75–90%), wet fresh fruit and vegetable wastes seemed to be a good substrate for bio-energy recovery through anaerobic digestion process (Forster-Carneiro et al., 2008).

In this research study, the proximate composition of fruits and vegetables in market wastes from Wakulima and Kangemi market, Nairobi County in Kenya was investigated due to high levels of edible market products wastage as shown in Figure 1.

MATERIALS AND METHODS

The fruits and vegetables selected for this study are among the most common wastes in the markets in addition to making part of the daily diet for most Kenyans. Most of these wastes are seasonal with bumper production during short rain seasons in addition to being perishable. The samples were collected in sampling bags and transported to the lab where they were washed under running water. The whole portion of the selected locally consumed vegetable and fruit samples composing of cabbage (*Brassica oleracea Capittta*), coriander (*Coriandrum sativum L*.), spinach (*Spinacia oleracea*), banana (*Musa spp*), sweet potato (*Ipomoea batatas*), kales (*Brassica oleracea Acephala*), cucumber (*Cucumis sativus*), watermelon (*Citrullus lanatus*),pumpkin leaves (*Cucurbita maxima*), tomato (*Lycopersicon lycopersicum*), potato (*Solanum tuberosum*), avocado (*Persea americana*), carrot (*Daucas carota*), mango (*Mangifera indica*), papaya (*Carica papaya*), kahurura (*Cucumis ficifolia*), pig weed (*Amaranthus spp*.), African nightshade (*Solanum nigrum*), togotia (*Erucastrum arabicum*), comfrey(*Symphytum spp*.) and courgette (*Cucurbita pepo*) were obtained from Kangemi and Wakulima markets in Nairobi County and analyzed for crude protein, carbohydrates, fat, moisture, ash, nitrogen-free extract and energy.

Physico-chemical analysis

Ash and moisture levels were determined using weight difference method while fiber content was determined using AOAC (1990) method. Fat were extracted from the samples using Soxhlet extraction method while the crude nitrogen contents were determined using Kjedhal methods described in Pearson (1976) involving digestions, distillation and finally titration of the sample. The nitrogen value was converted to protein by multiplying by a factor of 6.25. Energy content was carried out using the AOAC method described in Onwuka (2005) while total and

Table 1. The % Moisture, total solids and ash contents in different fruits and vegetable wastes.

Sample	% Moisture	% Total solids	% Ash content
Kale	89.85±3.63	10.15±0.99	1.94±0.05
Cabbage	94.87±2.56	5.13±0.98	0.49±0.02
Pumkin leaves	90.78±1.55	9.22±1.00	2.06±0.12
Cucumis Ficifolia	86.62±2.98	13.38±2.11	2.34±0.05
Pigweed	88.64±2.00	11.36±2.36	2.86±0.01
Erucastrum Arabicum	89.37±2.11	10.63±2.60	1.99±0.07
Coriander	92.12±4.47	7.88±1.56	1.91±0.05
African nightshade	88.15±1.99	11.85±2.44	1.97±0.03
Spinach	93.27±2.33	6.73±1.89	1.73±0.03
Comfrey	85.04±3.56	14.96±2.60	3.46±0.14
Tomato	95.16±4.00	4.84±0.78	0.46±0.01
Potato	83.78±4.23	16.22±2.65	0.81±0.02
Sweet Potato	62.05±2.99	37.95±2.98	1.06±0.05
Pawpaw	89.22±2.12	10.78±1.58	0.5±0.04
Banana	74.3±2.10	25.7±1.99	1.67±0.05
Avocado	82.83±3.00	17.17±2.33	0.84±0.02
Courgette	95.34±2.00	4.66±0.87	0.72±0.03
Cucumber	95.86±2.04	4.14±0.99	0.46±0.04
Mango	86.82±3.89	13.18±1.54	0.44±0.02
Water Melon	92.85±4.55	7.15±1.56	0.74±0.04

volatile solids were determined using Renewable Technologies (2005) method (Onwuka 2005). The total carbohydrate was determined by difference method (Otitoju, 2009). All the proximate values are reported in percentage (Anon, 1990; Hussain et al., 2009).

Macro, micronutrient and heavy metals analysis

500 g of each vegetable and fruit samples were blended separately using a kitchen blender after chopping into small pieces. The samples were thoroughly mixed in a bigger container to make a homogenous waste mixer. The mixture was dried in the sun before being ground into a fine powder and made into a pallet. Analysis in triplicates was done using an x-ray fluorescence spectrophotometer at the Institute of Nuclear Science, University of Nairobi, Kenya. The macro and micronutrients concentration of Cu, Ni, Zn, Pb, Co, Cd, Fe, Cr, Ca and Na of the twenty selected wastes was evaluated.

Statistical analysis

Analyses were performed in triplicate and variation in the samples was routinely less than 10%. Mean values and standard deviations were calculated for each waste and the results tabulated as mean ± standard deviation.

RESULTS AND DISCUSSIONS

The edible vegetables and fruits are essential component of human diet comprising essential biochemical important for human metabolism (Aliyu, 2006). The result of proximate analysis showed variation in proportions of biochemical (carbohydrate, fats and protein) and other contents (ash, fiber, moisture). Table 1 shows percentage moisture content in fruits and vegetable waste on as received basis. Total solids were obtained by subtracting moisture content from 100. The moisture content on fresh tomato wastes was 95.16%. Previous studies by Mohammed et al. (2017) showed moisture content of 90.75% in tomato fruits. Moisture content reported in this study is slightly higher but in range with previous studies by Oko-Ibom et al. (2007), Adubofuor et al. (2010) and Hossain et al. (2010) who reported moisture content in the range of 88.19 to 90.67%. Ash content represents the minerals remaining when moisture and organic matter are driven off from a sample. The ash content in leafy vegetables was higher compared to fruit wastes samples. For instance, the obtained ash content was between 2.06 to 2.46% for pig weed, pumpkin leaves, *Cucumis ficifolia* and highest in comfrey at 3.46%. Lower ash content was reported in wastes e.g. 0.46% in tomatoes and cucumber wastes. Avocado, mango, watermelon and pawpaw ash content were 0.84, 0.44, 0.74 and 0.50% respectively.

Nitrogen free extract (NFE) in proximate analysis represents sugars and starch and is obtained by difference rather than by measurement. NFE represents soluble carbohydrates while crude fiber gives the insoluble carbohydrates (Dhont and Berghe, 2003). From Figure 2, the highest NFE was reported in sweet potato, avocado and banana wastes respectively with the lowest being

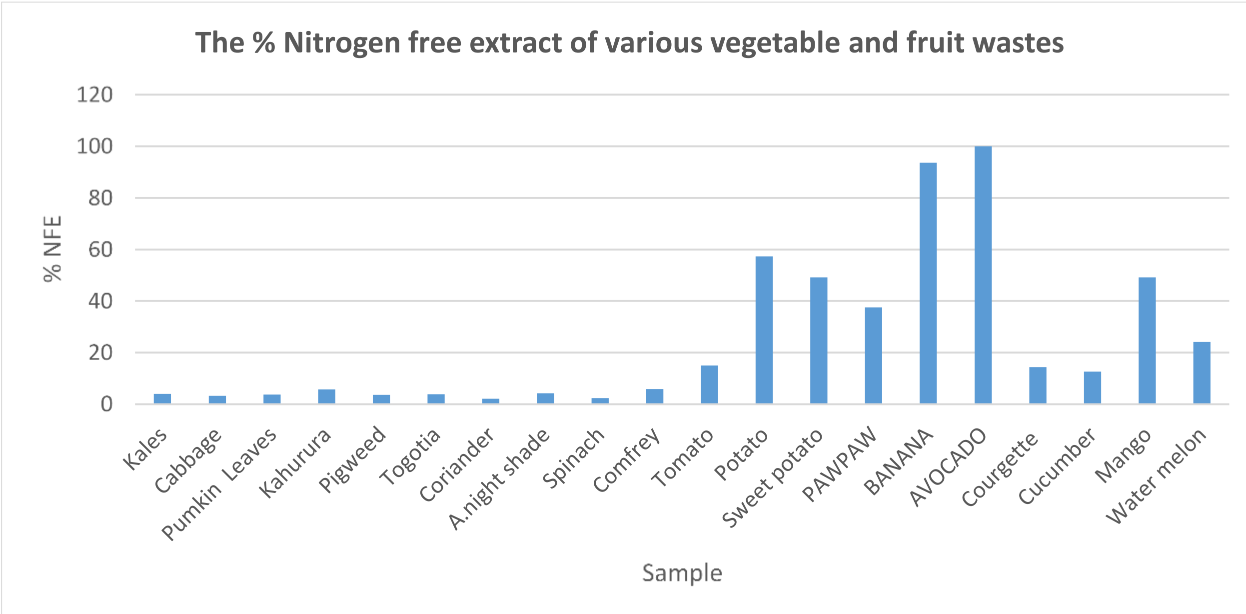

Figure 2. Bar graph of % nitrogen free extract.

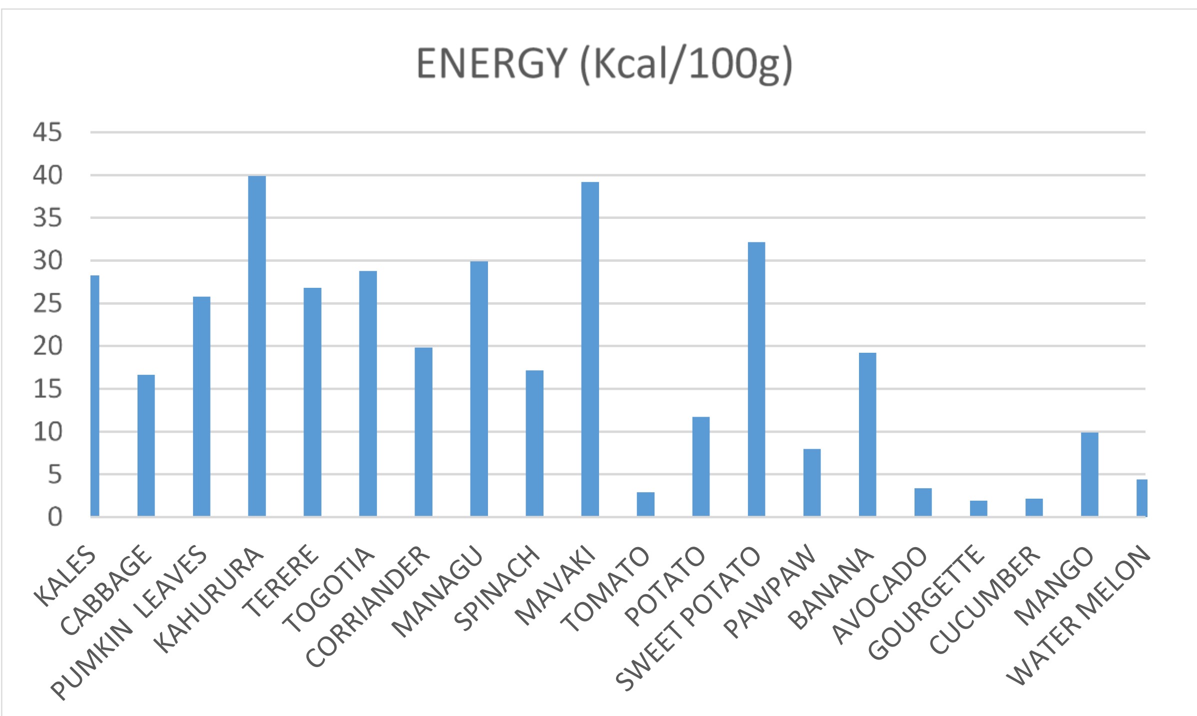

Figure 3. Bar graph of energy on fresh weight basis.

recorded in leafy vegetables like kales, spinach and coriander.

Figure 3 represents the energy obtained from different market wastes on as received basis. It was lowest in tomato, courgette and cucumber fruits wastes. The energy levels in the wastes was calculated from the data on protein, carbohydrates and fats using factors of 4, 4 and 9 kcal/100g, respectively (Pereira et al., 2008). The energy per 100 g of the sample was between 3.06 to 40.00 kcal/100g and 189.95 to 513.94 kcal/100g on wet and dry

Table 2. Table of the % crude protein, fat, fiber and carbohydrates in fruits and vegetable wastes

Sample	% Protein	% Fat	% Fibre	% Carbohydrate
Kales	2.27±0.12	0.34±0.17	1.57±0.12	4.03±1.00
Cabbage	0.83±0.07	0.05±0.01	0.54±0.06	3.22±0.92
Pumkin leaves	2.27±0.36	0.18±0.08	0.94±013	3.77±0.87
Cucumis Ficifolia	3.49±0.72	0.33±0.11	1.48±0.52	5.74±1.02
Pigweed	2.61±0.55	0.21±0.7	2.06±0.78	3.62±0.85
Erucastrum arabicum	2.82±0.89	0.19±0.02	1.68±0.23	3.95±0.47
Coriander	2.6±0.23	0.09±0.03	1.12±0.09	2.16±0.36
African nightshade	2.68±0.36	0.26±0.10	2.73±0.11	4.12±0.56
Spinach	1.53±0.09	0.17±0.10	0.92±0.12	2.38±0.54
Comfrey	3.24±0.78	0.29±0.12	2.07±0.23	5.9±1.11
Tomato	0.57±0.01	0.12±0.01	0.76±0.01	2.93±0.09
Potato	1.41±0.87	0.54±0.21	1.74±0.14	11.72±1.00
Sweet Potato	1.67±0.09	1.54±0.14	1.51±0.23	32.17±2.31
Pawpaw	0.68±0.03	0.34±0.07	1.31±0.45	7.95±0.98
Banana	3.05±0.12	0.5±0.07	1.24±0.14	19.24±1.00
Avocado	1.32±0.14	9.03±1.36	2.61±0.98	3.37±0.55
Courgette	1.06±0.54	0.25±0.08	0.69±0.10	1.99±0.12
Cucumber	0.52±0.08	0.21±0.03	0.78±0.11	2.17±0.34
Mango	0.87±0.07	0.68±0.08	1.28±0.21	9.91±1.00
Water Melon	0.90±0.09	0.33±0.04	0.76±0.09	4.42±0.88

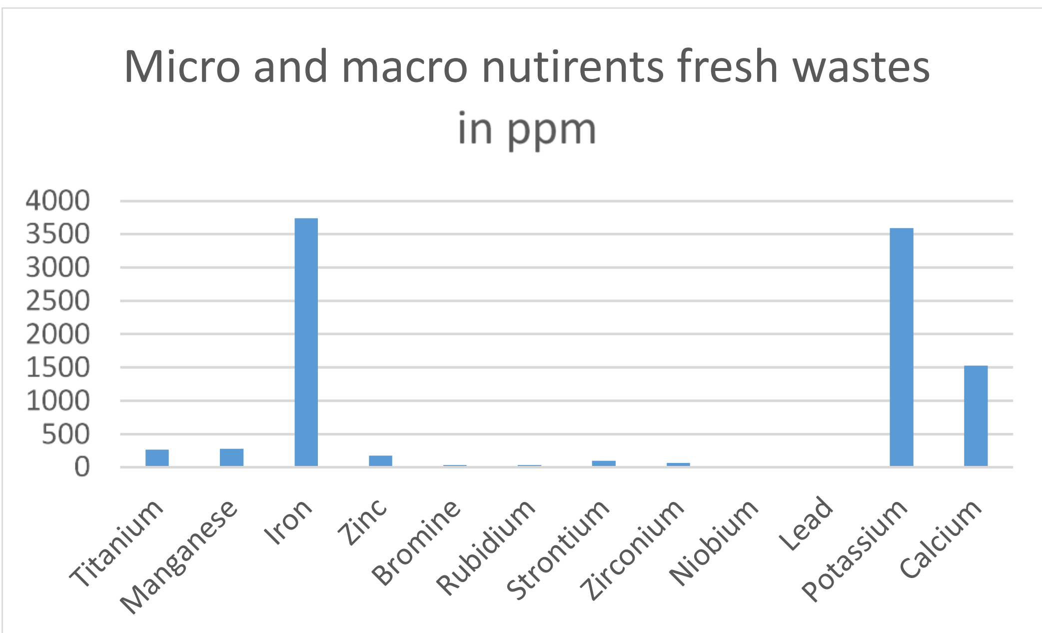

Figure 4. Bar graphs of macro and micro nutrient compositions of fresh wastes.

basis respectively. Previous studies on the energy levels of *Cucurbita moschata* and *Luffa acutangula* were estimated to be high compared to 248.8 to 307.1 kcal/100g reported in some Nigerian leafy vegetables (Isong et al., 1999). Asibey-Berko and Tayie (1999) also reported high energy content in some Ghanaian green leafy vegetables such as *corchorus tridens* (283.1 kcal/100g) and sweet potato leaves (288.3 kcal/100g).

The obtained results for crude fat, proteins, fiber and carbohydrates are shown in Table 2. High crude fat content was recorded in avocado at 9.03% while protein was lowest in tomato at 0.57%. Low crude protein content in fruits had earlier been observed by Pugalenthi et al. (2004). Roger et al. (2005) reported that protein level of green leafy vegetables ranges from 20.48 to 41.66% while in the current study the range is 1.53 to 3.49%. The difference can be explained by the fact that Roger et al. (2005) worked on fresh samples while in this study discarded samples were used. The crude fiber in this study were in the range of 0.54 to 2.61%. The fiber levels in pumpkin leaves is similar to the one obtained by Javid et al. (2010) at 0.94%.

The observed macronutrients were potassium and calcium at 3.59% and 1.53% respectively. Heavy metals in the samples like lead and zinc at 15.1 and 176 ppm respectively as shown in Figure 4. Other nutrients in the fruit-vegetable wastes samples are as shown in the bar graph in Figure 4. It has been reported that for many plant species Cr proved to be toxic at 5 mg/l. In this regard, all the studied produces have very lesser concentration of Cr as compared to the recommended level for toxicity in plants (Adriano, 1986; Khanzada et al., 2008; Hussain et al., 2009).

Conclusion

The moisture content in the wastes was in the range of 62.36 to 95.86% while ash content was 2.06 to 2.46%. High crude fat composition was recorded in avocado at 9.03% while protein was lowest in tomato at 0.57%. Therefore, this study recommends that food wastage should be avoided as the wastes contain high levels of nutritious properties which are required for healthy lives. For further studies, it is recommended to determine the total carbohydrates of selected fruits by experimental method for more accurate results. In addition, the wastes should be used as biomass in energy production to deal with landfilling based on high moisture content reported in this study.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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