

# Analysis of Physical and Chemical Composition of Sweet Orange (*Citrus sinensis*) Peels

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**Abstract**— Sweet orange is one of the most common fruits in the World. The waste generated from the fruits needs to be put into a beneficial use. In this study some physical and chemical properties of the primary waste of sweet orange was investigated. The result showed sweet orange rinds (peels) as the major waste and contains 45-50% of the total mass of sweet orange fruits. The chemical analysis showed sweet orange rinds to be rich in protein of 7.15% and crude fibre of 12.79% which can be used as ingredients in processed food. These uses will promote sustainable disposal of orange rinds.

**Keywords**— Orange rinds, proximate analysis, protein, crude fibre.

## I. INTRODUCTION

Citrus (*Citrus spp*) is one of the most abundant fruit crops with World production estimated at 115 million tons per year. Citrus is a large family whose dominant members include sweet oranges (*Citrus sinensis*), tangerines/mandarin (*Citrus reticulata*), lemon (*Citrus limon*), limes (several species) and grape fruits (*Citrus paradisi*). Citrus fruits are notable for their fragrance, partly due to flavonoids and limonoids contained in the rinds (Manthey, 2004). Also, citrus fruits and juices are important sources of bioactive materials including antioxidants such as ascorbic acid, flavonoids and phenolic compounds that are important to human nutrition (Kamran *et al.*, 2009). Citrus fruits are good source of folic acid, vitamin B (thiamine), potassium, phosphorus, calcium, iron, magnesium, sodium and sulphur (Nagy *et al.*, 2007).

The endocarp is rich in soluble sugar and contains significant amounts of vitamin C, pectin, fibres, different organic acids and potassium salt which give the fruits its characteristic “citrus flavour” (Ezejiofore *et al.*, 2011).

Africa produces 3,741,000 tonnes of varieties of citrus fruits of which Nigeria contributes 3,240,000 tonnes (FAO, 2004). Nigeria produces 3% of fresh citrus in the World (FAO, 2004). The rinds (peels) obtained from the pericarp of these fresh fruits are available in large quantities during the citrus season thereby constituting environmental problems since it is not being put into any productive use. The production of citrus fruits in Nigeria

is significant, with heavy direct consumption due to few and small capacity processing industries to convert the fruit to juice, concentrate and canned fruit.

The inability of the few and small capacity processing industries to convert the fruit juice and concentrate has led to the generation of wastes. Waste is anything in a ruined or devastated condition (merriamwebster). It can also be defined as any unavoidable material resulting from an activity, which has no immediate economic demand and which must be disposed of (NISP, 2003). Physical properties are important in many problems associated with the design of machines and the analysis of the behaviour of the product during agricultural processing such as extraction of phytochemicals. Physical characteristics of agricultural products are the most important parameters for determination of proper standards to design of grading, conveying, processing, and packaging systems (Tabatabaefar, and Rajabipour, 2005, Karimiet *al.*, 2009). The food industry has shown a special interest in finding uses for citrus industry by-products. Hence the need to know the physical and nutrient component of the peels.

## II. MATERIALS AND METHODS

### 2.1 Raw material characterization

Harvested sweet orange was obtained from a fruit and vegetable market centre from a local market in Akure, Ondo State, Nigeria. The samples were selected manually from unripe and overripe fruits, thus providing a uniform samples or fruits of the relatively same ripeness stage. The ripe fruits were processed at the Crop Processing Laboratory of Agricultural and Environmental Engineering, Federal University of Technology Akure. These fruits were washed to remove dirt's and foreign materials from the epicarp. The fruits were peeled with knife to remove epicarp or rind or flavedo or shell.

#### 2.1.1 Physical Properties of Citrus species

##### a. Weight determination

The weights of the selected agricultural materials were determined using a method described by Varnamkhistiet *al.* (2007). The materials were randomly selected from each sample into flat plates which were carefully weighed using an electronic balance to an accuracy of 0.01g. The

procedure is replicated three times for each sample, and average value was taken and recorded.

b. Volume determination

The volume of the fruits and peels were determined by filling a 250 ml measuring cylinder with 150 ml of water. The whole fruits and peels of each variety (separately) were immersed in the water. The amount of displacement in water was recorded. The procedure is replicated three times and volume was calculated as:

$$\text{Final volume} - \text{Initial volume} =$$

$$\text{Volume of water displaced(1)}$$

$$\text{Average volume} = \frac{\text{Volume of water displaced}}{\text{Total number of fruits/peels}}$$

(2)

c. Oven dried

The peeled epicarp were dried in an oven with forced air circulation (Marconi MA03515, Piracicaba, BR) at 50°C for 54h. The dried peeled were then crushed in knife mill type (Marconi M340 Piracicaba, BR) and kept in sealed plastic bags in a frost free freezer (BVR 28 GBBNA BRASTEMP, Joinville, BR) at -22°C until its use.

d. Moisture content determination

Thermal drying method was used in the determination of moisture content of the samples. 100g of sample were placed in oven at 105± 3°C and allowed to dry to a constant weight for 24 hours (Lagha-Benamrouche, S. and Madani, K., 2013). The moisture content (MC) was calculated by expressing the weight loss upon drying a fraction of the initial weight of sample used. The moisture content of the seeds was determined by gravimetric method which determines the mass loss from the sample by drying to constant weight (ASABE STANDARDS, 1993 and AOAC, 2000).

$$DM(\%) = \frac{W_3 - W_0}{W_1 - W_0} * 100(3)$$

$$\%MC_{db} = 100 - DM\%(4)$$

Where  $W_0$  is weight of empty crucible

$W_1$  is weight of crucible plus sample before drying

$W_3$  is weight of crucible plus sample after drying

DM is dry matter and

MC is the moisture content

e. Bulk density

The bulk density was determined using the mass to volume ratio. The volume was determined by water displacement method as described by Archimedes law of floatation. True or real density is the mass of the sample divided by volume and can be calculated using the equation (5):

$$P_r = \left(\frac{M}{V}\right) (kg/m^3)(5)$$

Where,

$P_r(kg/m^3)$  = True density

M (kg) =dry specimen mass Of 300g

$V(m^3)$  =Volume of sample = Volume of water displaced by 300g when immersed in water (Archimedes Principle of Floatation.)

f. Relative density

The relative density was determined for the dried sample of sweet orange. A fixed bed of 300 cm<sup>3</sup>(extractant) was used as standard volume of the container and the mass was measured in a previously weighed beaker. No separate manual compaction of sample was done. The bulk density was then calculated from the mass of the sweet orange peels and the volume of the container (Sakiliket al., 2003).

g. Particle Size analysis of the milled Sweet orange peels

Particle size analysis was carried out on the milled peels product from the knife edge mill after comminution. 200g sample was put into a stack employing a seven-frills set of the standard tyler series of size 10-65 mesh and un shaker screens magnetic type (Bertel, Caieiras, Brazil) which help to promote sufficient granulometric distribution of particles. Mass retained (MR) on each sieve sequel to shaking were retrieved. MR (g) is % of material retained

$$MR(D)(\%) = \frac{mmr}{ms} * 100(6)$$

Where MR (D) is mass of material retained in percent

$mmr$  is mass of material retained

The milled peels size (200 g) was determined in a vertical vibrator sieve shaker Tyler series system (Model 1868 Bertel, Caieiras, BR) with sequential openings of 10, 14, 20, 28, 35, 48, and 65 mesh. The mean particle diameter was determined using the method of ASAE S319.4 (ASAE, 2008) for granulometry.

The diameter measurement of the particles of Orange peels was determined in terms of geometric mean diameter (or median size), geometric standard deviation of log-normal distribution by mass in ten- based logarithm, and geometric standard deviation by mass (ASABE STANDARDS, 2008), A mass retained in cadapeneira was weighed in semi-analytical balance (the 5500 Mars, Sao Paulo, Brazil) and the average diameter of the particles was calculated by the equation

$$d_{gw} = \log^{-1} \left[ \frac{\sum_{i=1}^n (W_i \log d_i)}{\sum_{i=1}^n W_i} \right]$$

(7)

$$S_{log} = \left[ \frac{\sum_{i=1}^n W_i (\log d_i - \log d_{gw})^2}{\sum_{i=1}^n W_i} \right]^{1/2} = \frac{S_{in}}{2.3}$$

(8)

$$S_{gw} \approx \frac{1}{2} d_{gw} [\log^{-1} S_{log} - (\log^{-1} S_{log})^{-1}]$$

(9)

Where  $d_i$  is nominal sieve aperture size of the  $i^{\text{th}}$  sieve, (mm)

$d_{i+1}$  is nominal sieve aperture size in next larger than  $i^{\text{th}}$  sieve (just above the set ), (mm)

$d_{gw}$  is geometric mean diameter or median size of particles by mass, (mm) , or is geometric mean diameter or median size of particles on sieve, (mm) or is  $((d_i \times d_{i+1})^{1/2})$ , which is  $d_i$

$S_{log}$  is geometric standard deviation of log-normal distribution by mass in ten-based logarithm, (dimensionless)

$S_{in}$  is geometric standard deviation of log-normal distribution by mass in natural logarithm, (dimensionless)

$S_{gw}$  is geometric standard deviation of particle by mass ,(mm)

$w_i$  mass of material retained on the i-th sieve (g)

N is number of sieves +1 (pan

h. Proximate analysis

The proximate compositions of the dried sample were determined using standard methods to know the nutritive properties. All measurements were done in duplicates and values were presented in percentage.

i. Ash content determination

$$\% \text{ ash content} = \frac{\text{weight of ash}}{\text{weight of sample}} \times 100 \quad (10)$$

ii. Fat content determination

$$\% \text{ fat content} = \frac{\text{weight of ether soluble material}}{\text{weight of sample}} \times 100$$

(11)

iii. Fibre content determination

$$\% \text{ Crude fiber} = \frac{\text{loss of weight}}{\text{weight of sample}} \times 100$$

(12)

iv. Protein determination

Protein content of the sample was determined using the Kjeldahl method

v. Carbohydrate determination

$$\% \text{ CHO} = 100 - (\% \text{ fat} + \% \text{ ash} + \% \text{ fiber} + \% \text{ protein}) \quad (13)$$

### III. RESULTS AND DISCUSSIONS

#### 3.1 Physical Properties of the Citrus Species

Physical properties are important in many problems associated with the design of machines and the analysis of the behaviour of the product during agricultural processing operations such as extraction of phytochemicals. The summary of the result for all the physical parameters measured were, collated, analysed and presented (Table 1).

Table.1: Descriptive statistics of sweet orange from Nigeria.

Citrus species	Sweet orange Nig.		
Property	Max	Min	mean ± St.dev
Total mass (g)	313	202.72	250.05±27.10
Mass of fruit (g)	280.18	177.26	213.10±22.26
Mass of peel(g)	55.23	73.96	32.69±7.90
Total volume (cm <sup>3</sup> )	240	85	149.43±39.30
volume of fruit (cm <sup>3</sup> )	190	64	112.25±31.56
Volume of peels (cm <sup>3</sup> )	65	12	37.18±13.88
Bulk density of peel (gcm <sup>-3</sup> )	2.24	0.085	0.99±0.38
Relative density of dried peels (gcm <sup>-3</sup> )			0.4007±0.0023

The mass of orange ranges from 202.72 - 3132 g with average mass of 250.05 g Mass of orange peels ranges from 73.96 - 55.23 g with average mass of 32.69 g for Nigeria orange. Citrus fruits contains pulp, peels, internal tissues and seeds. Citrus pulp is the solid residue that remains after fresh fruits are squeezed for their juice. It amounts to 50 – 70% of the fresh weight of original fruit, contains peels 30 – 45%, internal tissues of 20 – 35% and seeds 0 – 10%. The result obtained from the peels were lower than the result reported by Sharma *et al*, (2017) of 50% of citrus peels.

The bulk density was determined using the mass to volume. Natural bulk density of sweet orange was 0.99 gcm<sup>-3</sup> and mean relative density obtained was 0.4007 ± 0.0023 gcm<sup>-3</sup> for the dried milled sweet orange peels.

The rinds (peels) obtained from the pericarp of citrus is the primary waste and is available in large quantities during the citrus season thereby constituting environmental hazard and pollution to the environment. There is therefore an urgent need to put it into productive use. Figure 1 shows the result of dried orange milled peels from sweet orange.

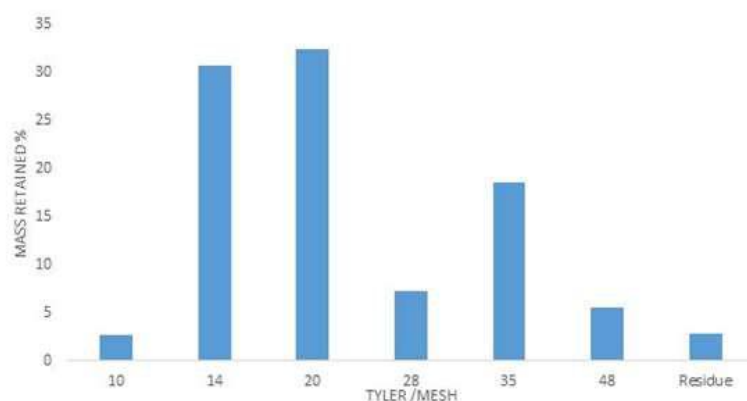


Fig.1: Mass Ground sweet orange peels retained in the sieves

### 3.2 Granulometry.

The milled peels size were determined in a vertical vibrator with six series tyler sieve shaker Tyler series system (Model 1868 Bertel, Caieiras, BR) with sequential openings of 10, 14, 20, 28, 35, 48, and 65 mesh with retained percentage mass of 2.62, 30.73, 32.53, 7.21, 18.59, 5.50 and 2.82 % respectively. The calculated average particle diameter is 0.84 mm using equation (7).

### 3.3 Nutrient composition of sweet orange (*Citrus Sinensis*) rinds

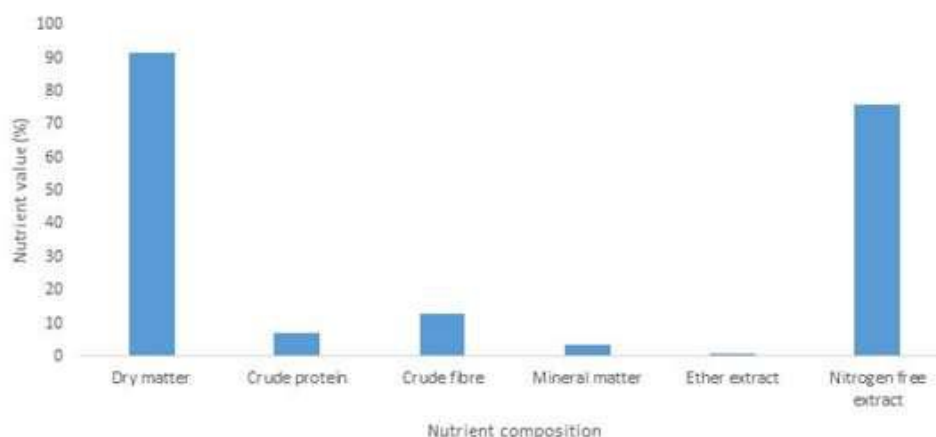


Fig.2: Nutrient composition of sweet orange (*Citrus Sinensis*) rind (dry matter basis)

The crude fibre was 12.79 % which also have high value of dietary fibre and higher than the value of water leaf (*Talinum triangulare*) of 12% as reported by Aja *et al*, 2010. It is also higher than the crude fibre of red bell pepper of 7.4% as reported by Odewole and Olaniyan, (2016). The result of the crude protein of 7.4% is higher than the crude protein reported by Awogbemi and Ogunleye (2009) of Fluted pumpkin (*Telfairia occidentalis*) of 2.3%. The result from the nutritive composition showed sweet orange as a promising source of proteins and crude fibre. The average daily requirement of dietary fibre is 21–25 g per day for women and 30–38 g per day for men (Food and Nutrition

The result of Nutrient composition of dried milled sweet orange peels using proximate analysis is shown in Figure 2. The nutritive composition of sweet orange peels shows crude protein of 7.15% and crude fibre of 12.7% (Figure 2). The result of crude protein indicating that they could serves as very high protein supplements in addition to contributing to the formation of hormones which controls a variety of body functions such as growth, repair and maintenance of body protein.

Board, Institute of Medicine, 2001). Nassaret *al.* (2008) suggested that 15 % of orange peel and pulp could be incorporated as an ingredient in making biscuits, as they are a suitable source of dietary fibre with associated bioactive compounds (flavonoids, carotenoids etc.). It also contains a variety of other nutrients such as proteins, crude fibre and some minerals.

## IV. CONCLUSION

In this study some physical properties and chemical characteristics of sweet orange peels were determined. It showed sweet orange rinds as a primary waste. The study

provided relevant data which are required for the design of processing equipment for sweet orange rinds.

Based on the chemical composition of sweet orange rinds, the crude fibre and protein of sweet orange rinds can serve as non-caloric bulking agents. They are also capable of offering significant low-cost nutritional dietary supplement to livestock and human beings. Sweet orange rinds could be incorporated as an ingredient in processing of foods and in livestock feeds. These uses will promote sustainable disposal of sweet orange rinds residues.

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