CHEMICAL COMPOSITION OF BISCUITS SUPPLEMENTED WITH ORANGE PEEL AND PULP FLOURS

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ABSTRACT

Sweet orange (Citrus sinensis) fruits were washed, peeled manually, the juice was extracted using kitchen juice extractor and the seeds were removed. The peels were separated from the pulps and sliced into thin slices of about 2 cm thick, sun dried separately till constant weight was achieved. They were milled and sieved to obtain orange peel and orange pulp flours, respectively. The orange peel and pulp flours were used to substitute 10% wheat flour. Biscuits were produced from the flour blends and 100% wheat biscuit was produced and evaluated for chemical composition (proximate analysis, mineral and phytochemical compositions). The results showed that the orange pulp biscuit was significantly higher (p < 0.05) in moisture and fibre, while orange peel biscuit was higher in ash. The pulp and peel biscuits had lower levels in fat, protein, carbohydrate and energy content. There were no differences (p > 0.05) in mineral content of the orange peel and pulp biscuits, though higher values were recorded for calcium and sodium when compared to 100% wheat biscuit. The orange peel biscuit had higher (p < 0.05) levels of all the phytochemicals (saponins, alkaloids, flavonoids, anthocyanins and carotenoids) assessed. Edible biscuits can be produced from blends of wheat and sweet orange peel and pulp flours which are sources of bioactive compounds that possess nutraceutical properties.

Key words: fibre, biscuit, phytochemicals, flavonoids, convenience

INTRODUCTION

Sweet orange is an important fruit in the tropical and sub-tropical regions of the world (Waleed, 2019). The fruits are usually eaten fresh but are also used for making canned orange juice, frozen juice concentrate, jams and jellies, among others. Orange processing industries generate huge amounts of orange pulp and peel as by-products from the industrial extraction of orange juices (de Castro et al., 2020). The amount of peel and pulp obtained from citrus fruit processing accounts for 50% of the original amount of the whole fruit (Schalow et al., 2018). These peel and pulp contain among other things, high levels of vitamin C, dietary fibre and some bioactive substances believed to have positive health implications. These facts not withstanding citrus peels and pulps are most often discarded. Dietary fibre has been used for the treatment of various gastrointestinal disorders and health benefits including lowering cholesterol levels, reducing risk of colon cancer and losing weight (Gill et al., 2020). Dietary fibre has also been reported to have some nutraceutical potentials (Kushwaha and Maurya, 2019). Until recently, analysis of food was limited to sensory and nutritional value. However, there is growing evidence that other components of food may play an integral role in the link between food and health (Kushwaha and Maurya, 2019). Food consumers are increasingly interested in the health benefits of food and have begun to look beyond the basic nutritional benefits to the potential disease prevention and health-enhancing compounds in food and food products (Langhans, 2018).

Biscuit is a confectionary, dried to very low moisture content (Okaka, 1997). Biscuit is a snack food which can be eaten in-between meals or at any time of the day and by any age bracket. Households spend so much on food in Nigeria and on snacks in which convenience is perceived to be the reason. Peel is the skin of some fruits and vegetables. Orange peel contains soluble sugars 16.90%, cellulose 9.21%, hemicelluloses 10.50%, and pectin 42.50% (Beatriz et al., 2008). Most of the phytoneutrients are found in the peel and inner white pulp of orange rather than in the juice (Brett, 2011). Hesperidin molecule has been singled out in phytonutrient research on oranges and the highest concentration can be found in the white parts of the peel and the pulps of citrus fruits (Chiba et al., 2003). The peel is edible, and is consumed mostly in environments where there is scarcity of resources and where maximum nutritional value must be derived and minimal waste generated (Gargulinski, 2011). However, grating a tablespoon of orange peel each day and using it to flavour tea, salads, salad dressings, soups among others may be a practical way of harnessing the health benefits in them.
In addition to the peel, the pulp of sweet orange is a source of fibre, and other nutrients. The pulp contains total pectin 26.0 to 45.60%, neutral detergent 15.8 to 31.00% and crude fiber 9.9 to 20.60% (Porzio and Blake, 1983). The white pulpy part of sweet orange is the primary source of flavonoids, and is often discarded during processing of orange juice. This loss of flavonoids underlies eating the orange in its whole food form. Dietary fibre is the indigestible portion of plant foods, it is metabolically inert, absorbing water as it moves through the digestive system, easing defecation (Weickert and Pfeiffer, 2008). One of the actions of dietary fibre is to change the nature of the contents of the gastrointestinal tract, and to change how other nutrients and chemicals are absorbed. Soluble fibre binds to bile acids in the small intestine, making them less likely to enter the body, this in turn lowers cholesterol levels in the blood (Anderson et al., 2009). Soluble fibre also attenuates the absorption of sugar, reduces sugar response after eating, normalizes blood lipid levels and once fermented in the colon, produces short-chain fatty acids as by products with wide-ranging physiological activities (Weickert and Pfeiffer, 2008).

Phytochemicals are non-nutritive plant chemicals that have protective or disease preventive properties. They are non-essential nutrients, meaning that they are not required by the human body for sustaining life. It is well known that plant produce these chemicals for own protection, but recent research demonstrate that they can also protect humans against diseases. There are more than a thousand known phytochemicals some of the well-known phytochemicals are lycopene in tomatoes, isoflavones in soy and flavonoids in fruits (Weingartner et al., 2008). Foods containing phyto-chemicals are already part of our daily diet. In fact, most foods contain phytochemicals except for some refined foods such as sugar or alcohol. Some foods such as whole grains, vegetables, fruits, herbs, etc. contain many phytochemicals. The easiest way to get them is to eat more fruits and vegetables (Weingartner et al., 2008). Thus, considering the economic, nutritional health advantages of these local food sources, its promotion deserves attention from individuals and government agencies (Ojinnaka et al., 2013). There is empirical evidence that phytochemicals in fruits and vegetables may reduce cancer risk, possibly due to dietary fibres, polyphenol antioxidants and anti-inflammatory effects (Brown and Arthur, 2001). An important cancer drug, Taxol, is a phytochemical initially extracted and purified from the pacific yew tree (Brown and Arthur, 2001). In the light of these, the present work was undertaken to assess the nutritional (chemical) effect of inclusion of the commonly discarded orange peel and pulp in biscuit which is a convenient food taken by all age groups to increase the intake of these phytochemicals thereby improving human health.

**MATERIALS AND METHODS**

**Procurement of Materials**

Sweet orange fruits (56 kg) were purchased from Nkwo market Ibagwa in Igboeze South Local Government Area of Enugu State. Wheat flour, sugar, margarine, eggs and baking powder were purchased from Ogige Market in Nsukka town also at Enugu State of Nigeria.

**Preparation of Orange Peel and Pulp Flours**

The fruits were washed thoroughly in portable water, to remove dirt and adhering extraneous materials, peeled manually with a sharp kitchen knife. Plastic kitchen juice extractor was used to extract the juice and the seeds removed. The peel and pulp were cut into tiny pieces of about 2 cm thick and sun dried to constant weight milled in attrition mill and sieved with muslin cloth with a pore size of 2 mm to obtain the flour samples. The flow diagram for the preparation of orange peel and pulp flours is shown in Figure 1.

**Flour Blending**

Orange peel flour 10 g and wheat flour 90 g was weighed into a food blender. The blender was operated at full speed for 10 min. to ensure proper mixing of both flours. The same process was repeated for orange pulp flour and wheat flour.

**Production of Biscuit**

The basic recipe that was used for biscuit production is shown in Table 1. The ingredients were weighed out and dry ingredients were mixed together. The fat was rubbed in and mixed with water until dough was formed. The resultant dough was kneaded and rested for about 5 min. The rested dough was rolled out into sheets and cut into shapes, using biscuit cutter. The dough was placed on greased baking trays and baked for 20 min. in an oven pre-heated to 180°C allowed to cool then packaged in high density polyethylene bags in an airtight container. The flow diagram for the production of biscuit is shown in Figure 2.

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**Figure 1:** Preparation of orange peel and pulp flour  
**Figure 2:** Production of biscuit
Chemical Evaluation
Proximate analyses

The proximate composition of biscuit samples was determined using the method of AOAC (2010).

Determination of moisture content

Moisture content was determined by the hot air oven method. Stainless steel moisture dishes were cleaned and dried in the oven (Memmert UN30), at 100°C for 1 h to achieve constant weights. The moisture dishes were cooled in a desiccator and then weighed. Two grams of each sample were weighed into respectively labeled moisture dish and dried at 100°C, for 1 h, removed from the oven and placed in a desiccator to cool to room temperature before weighing. The moisture dishes were put back into the oven, dried and weighed intermittently until a constant weight was attained. The loss in weight from the original sample weight was calculated as the moisture content using the expression:

\[
\% \text{ moisture content} = \left( \frac{W_1 - W_2}{W_2} \right) \times 100 \times \frac{1}{1},
\]

where \( W_1 \) is weight of empty moisture dish, \( W_2 \) is weight of moisture dish + sample before drying, and \( W_3 \) is weight of moisture dish + sample after drying.

Determination of ash content

Two grams of each sample was weighed into crucibles that had been previously washed, dried and weighed. The crucibles were placed in a muffle furnace (Vecstar LF3 and USA) and ignited at 550 ± 2°C for 4 h., cooled and weighed. The ash content was calculated with the expression:

\[
\% \text{ ash content} = \left( \frac{W_1 - W_3}{W_2} \right) \times 100 \times \frac{1}{1},
\]

where \( W_1 \) is weight of empty crucible, \( W_2 \) is weight of crucible and sample before ashing, \( W_3 \) is weight of crucible and sample after ashing.

Determination of fat content

The fat content of the samples was determined using the standard AOAC (2010) method. A previously dried, cooled and weighed 250 ml round bottom flask was fixed to a Soxhlet extractor with a reflux condenser. Two grams of sample was weighed into labelled thimble and petroleum ether 60-80°C boiling point (150 ml) filled into the round bottom flask. The extraction thimble was plugged with cotton wool. The Soxhlet apparatus after assembling was allowed to reflux for 6 h. The thimble was removed with care and the petroleum ether was recovered for reuse. The round bottom flask containing the pet ether extract was removed and dried at 70°C for 1 h in an oven (Memmert UN30 Germany), cooled in a desiccator and weighed. Fat content was calculated as:

\[
\% \text{ fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100 \times \frac{1}{1}.
\]

Determination of fibre content

Two grams of each sample was weighed and defatted using petroleum ether (boiling point of 40 to 60°C). The defatted sample was boiled for 30 min. in 200 ml of 1.25% \( \text{H}_2\text{SO}_4 \) and the solution filtered through a funnel fitted with muslin cloth. It was washed with boiling water until it was free of acid. The residue was boiled for another 30 min. with 100 ml of 0.02 M \( \text{NaOH} \). It was further washed with boiling water then with 1% hydrochloric acid and finally with boiling water to ensure that it was free of acid. The final residue was transferred into a crucible and dried in the oven for 1 h. The crucible with its content was cooled in a desiccator and weighed. The residue was transferred into crucible and dried at 100°C to a constant weight. Incineration to ash was done at 600°C for 30 min., cooled in a desiccator and weighed. The difference in weight between oven dry weight and weight after incineration was taken as the fibre content of the sample. Percent crude fibre was expressed as:

\[
\% \text{ crude fibre} = \left( \frac{\text{wt of dried sample} - \text{wt of sample after incineration}}{\text{initial wt of sample}} \right) \times 100 \times \frac{1}{1}.
\]

Determination of crude protein content

Protein was determined using the Kjeldahl method. Two grams of each sample was weighed into a Kjeldahl flask and added anhydrous sodium sulphate (5 g of Kjeldahl catalyst), concentrated \( \text{H}_2\text{SO}_4 \) (25 ml) and few boiling chips. The samples were digested in the fume chamber to clear sample solution. Each sample digest was allowed to cool and then transferred into a 250 ml volumetric flask and made up to volume with distilled water. Five ml of 2% boric acid solution with few drops of methyl red indicator was introduced into a distillate collector (100 ml conical flask) and placed under the condenser in a distillation unit. Five ml of each sample digest was pipetted into the distillation unit, washed down with distilled water followed by addition of 5 ml of 60% \( \text{NaOH} \) solution to the digest. The sample was heated until 50 ml of the distillate was collected in the receiving flask. The distillate was titrated against 0.01 N \( \text{HCl} \) to a pink coloured end point. For the blank dilute digest from filter paper was also distilled and the distillate titrated against 0.01N \( \text{HCl} \). Total nitrogen (%) was estimated using the expression:

\[
\% \text{Crude protein} = \left( \frac{T - B}{N} \times 250 \times 0.0141 \times 6.25 \times \frac{1}{w} \right) \times 100 \times \frac{1}{1}.
\]

Crude protein is % \( N \times 6.25 \), where \( T \) is titre, \( B \) is blank, \( N \) is normality, and \( w \) is weight of acid.

Table 1: Recipe for biscuit production

| Ingredient      | Amount (g) |
|-----------------|------------|
| Flour           | 100.0      |
| Margarine       | 22.0       |
| Beaten egg      | 10.0       |
| Baking powder   | 1.8        |
| Water (ml)      | 45.0       |
| Sucrose         | 20.0       |
| Salt            | 0.3        |
| Powdered milk   | 5.0        |

Source: Okaka (1997)
**Determination of carbohydrate content**

Carbohydrate content of each sample was calculated by difference. The difference between 100 and the sum of percentages of moisture, protein, fat, fibre and ash of each sample was calculated and the result expressed as:

\[
\% \text{ carbohydrate} = 100 - (\% \text{ moisture} + \% \text{ crude protein} + \% \text{ crude fibre} + \% \text{ ash} + \% \text{ fat}).
\]

**Determination of energy value**

The values obtained for protein, fat and carbohydrate were used to calculate the energy value of the samples using the Atwater factor as described by AOAC (2010). The energy value was calculated as:

\[
\text{Energy value (kCal} 100^{-g}) = P \times 4.0 + F \times 9.0 + C \times 3.75;
\]

where P, F, and C are the % content of protein, fat and carbohydrate in the sample, respectively.

**Determination of copper content**

The samples were treated as described above. The sample was treated with 2 ml hydroxylamine-hydrochloride to reduce copper to the cuprous condition and with 0.2 ml sodium citrate to complex metallic ions. The pH was adjusted to 4 and the resultant complex extracted into methanol. Standard copper solution was prepared by dissolving 20 μg Cu into 50 ml de-ionized water. Fifteen ml of HNO\(_3\) was added and heated in a fume cupboard to a colourless solution after addition of 5 ml H\(_2\)O\(_2\), at 400-450°C for 2 h. The ashed samples were adjusted to 50 ml in a volumetric cylinder with distilled water.

**Determination of iron content**

Five ml of the sample as prepared above was transferred into 50 ml volumetric flask. Then 10 ml of ammonium acetate buffer solution and 2 ml phenonthroline solution were added, and the mixture diluted to the mark with distilled water. The reagents were mixed thoroughly and allowed to stand for 10 min. for maximum colour development. Standard solution was prepared by measuring 1 g of pure iron wire into 100 ml conc. HNO\(_3\), in a water bath and was diluted to 1000 ml with distilled water. From this stock, standard solutions of 0.0, 0.5, 1.0, 2.0 and 4.0 ppm were prepared and used for equipment calibration. Total iron was determined with appropriate iron lamp.

**Determination of calcium content**

The samples were wet-ashed as described above. Five ml of each of the sample digests was measured into a conical flask using a syringe and then pipetted 1.0 ml of SrCl\(_2\) solution containing 10,000 mg/ml to yield a 1,500 mg/ml of Sr\(^{2+}\) in the final solution. Calibration curve was prepared for the element using standard solution, which was prepared by dissolving 2.497 g of oven-dried CaCO\(_3\), diluted to 100 ml with de-ionized water. From this stock solution, calcium standard solutions were prepared with the concentrations of 0.0, 3.0, 8.0 and 9.0 ml. Calcium concentration in the sample was determined using AAS with calcium filter.

**Determination of zinc content**

Five ml of each of the samples was first digested with 20 ml of acid mixture (650 ml conc. HNO\(_3\); 80 ml perchloric acid (PCA); 20 ml conc. H\(_2\)SO\(_4\)) and aliquot of the diluted clear digest was used for the measurement of absorbance with AAS using filters that match the element. The samples were heated until a clear digest was obtained and then diluted to the 500 ml mark with distilled water. Standard zinc solution was prepared by dissolving 1 g zinc metal in 20 ml HCl and diluted to 1,000 ml with de-ionized distilled water; (1 ml = 1 mg Zn).

Distilled water was acidified with 1.5 ml conc. HNO\(_3\) and left for one min. The instrument was zeroed. Standard was atomized and the burner adjusted both up and down and sideways until a maximum response was obtained, and absorbance of the sample determined. The actual zinc content was used for its determination.

**Determination of sodium content**

Sodium was determined using the method described by AOAC (2010), using atomic absorption spectrophotometer (AAS). Five ml of the sample was measured using a syringe into a 250 ml Erlenmeyer flask, acidified with nitric acid and evaporated to dryness using a steam bath. Fifteen ml of the sample was transferred into a 500 ml volumetric cylinder with distilled water. From this stock, standard solution with concentrations 0.0, 0.1, 0.2, and 0.3 ppm was prepared and then used for the calibration of the instrument. The actual sodium concentration was determined using sodium lamp at 767 nm.

**Determination of potassium content**

Potassium was determined using AAS as described by AOAC (2010). Five ml of each of the samples was first digested with 20 ml of acid mixture (650 ml conc. HNO\(_3\); 80 ml perchloric acid (PCA); 20 ml conc. H\(_2\)SO\(_4\)) and aliquots of the diluted clear digest were used for the measurement of absorbance with AAS using filters that match the element. The samples were heated until a clear digest was obtained and then diluted to the 500 ml mark with distilled water. Standard potassium solution was prepared by dissolving 1 g sodium ions in 20 ml HCl and subsequently diluted to 1,000 ml. From this solution, standard solution with concentrations 0.0, 0.1, 0.2, and 0.3 ppm was prepared and then used for the calibration of the instrument. The actual potassium concentration was determined using potassium lamp at 285 nm.
that match the element. The samples were heated until clear digest was obtained and then diluted to the 500 ml mark with distilled water. Then, 91.0% (w/v) lithium chloride was added. A standard stock solution containing 100 mg/ml of K\(^+\) ions was prepared by dissolving 1.907 g KCl in water. The solution was made to 500 ml mark with distilled water. From the stock solution, a standard solution of 0.0, 2.0, 4.0 and 6.0 ppm was prepared, to which a standard stock solution of 1% lithium-chloride was added. The potassium standard was used to calibrate the instrument while the actual potassium concentration of the samples was determined using potassium filter at 385 nm.

**Phytochemical Analysis**

Quantitative assay for flavonoids, saponins, carotenoids, tannins, alkaloids, anthocyanins, were carried out using standard methods as stated below.

**Determination of flavonoids**

This was determined according to the method of Harborne (1980). Five g of the sample was boiled in 50 ml of 2 M HCl solution for 30 min. under reflux. It was allowed to cool and subsequently filtered through a filter paper. A measured volume of the extract was recovered by filtration using weighed filter paper. The resulting difference was the weight of the flavonoid in the sample.

**Determination of carotenoids**

This was carried out in accordance with the method described by Onyeka and Nwambekwe (2007). A measured weight of the sample was homogenized in methanol using a blender (1:10, sample: methanol). The homogenate was filtered to obtain the initial crude extract using about 20 ml of distilled water in separating funnel. The other layer was recovered and evaporated to dryness at low temperature (35-50°C) in vacuum desiccator. The dry extract was then saponified with 20 ml of ethanolic potassium hydroxide and left overnight in a dark cupboard. After a day the carotenoid was taken up in 20 ml distilled water. The carotenoid extract (ether layer) was dried in a desiccator and treated with a light petroleum (Petroleum spar) and allowed to stand overnight in a freezer. The next day, the precipitated steroid was removed by centrifugation. The carotenoid extract evaporated to dryness in a desiccator, weighed and weight expressed as percentage of the sample weight.

**Determination of saponins**

The method of AOAC (2010) was used for the determination of saponin. Saponin was extracted using two different solvents. The first solvent, acetone was used to extract crude lipid from the samples while the second solvent was used for the extraction of saponin proper. Two grams of the sample was folded into a thimble and put in a soxhlet extractor and a reflux condenser fitted on top. Extraction was done with 200 ml of acetone in a 250 cm² capacity round bottom flask for 3 h after which the apparatus was dismantled and another 250 cm² capacity round bottom flask containing 200 ml of methanol fitted to the extractor and extraction carried on for another 3 h. The weight of the flask was taken before and after the second extraction in order to obtain the change in weight. At the end of the second extraction, the methanol was recovered by distillation and the flask oven dried to remove any remaining solvent in the flask. The flask was cooled in a desiccator and weighed. The percentage of saponin was calculated as follows:

\[
\% \text{ Saponin} = \frac{\text{weight of dry extract}}{\text{weight of sample}} \times 100;
\]

**Determination of alkaloids**

The gravimetric method of Harbone (1980) was used. Five gram of sample was dispersed into 50 ml of 10% acetic acid solution in ethanol. The mixture shaken well and allowed to stand for 4 h before filtering. The filtrate obtained was evaporated to one quarter of its original volume. Concentrated NH\(_4\)OH was added dropwise to precipitate the alkaloids. The precipitate was filtered with a weighed filter paper and washed with 1% NH\(_4\)OH solution. The precipitate in the filter paper was dried in the oven at 60°C for 30 min. and reweighed. The alkaloid content was calculated as follows:

\[
\% \text{ Alkaloid} = \frac{W_2 - W_1}{W} \times 100;
\]

where \(W\) is weight of sample, \(W_1\) is weight of empty filter paper (without the precipitate), and \(W_2\) is weight of filter paper plus precipitate.

**Determination of anthocyanins**

This was carried out in accordance with the method of Harborne (1980). Five grams of sample was hydrolyzed by boiling in 100 ml 2 M HCl solution for 30 min. The hydrolysate was filtered using filter paper. The filtrate was transferred into a separation funnel and equal volume of ethyl acetate was added to it, mixed well and allowed to separate into two layers. The ethyl acetate layer (extract) was recorded while the aqueous layer was discarded. The extract was separated to dryness in the crucible over steam bath. The dried extract was treated with concentrated amyl alcohol to extract the anthocyanins. After filtration, the alcohol extract and the filtrate was transferred to a weighed evaporating dish and evaporated to dryness. It was dried in the oven at 30°C for 30 min. and cooled in a desiccator. The weight of anthocyanin was determined and expressed as percentage of the original sample.

**Experimental Design and Statistical Analysis**

Completely randomized design was employed in the study. Using the software SPSS Version 22, data were subjected to analysis of variance. Where significant \((p < 0.05)\), means were separated by Duncan’s new multiple range test.
RESULTS AND DISCUSSION

Proximate Composition of Biscuits

The proximate composition of biscuits supplemented with orange peel and pulp flours are shown in Table 2. The biscuits which contained 10% orange pulp flour had the highest moisture content of 8.85%. The moisture contents of the wheat biscuit and the biscuit containing 10% orange peel flour were 7.08% and 8.44%, respectively. The highest moisture content of the biscuit containing orange pulp is attributed to the higher moisture content of the orange pulp flour. All the biscuit samples were below the acceptable limits of 13-15% as safe moisture content levels for storage of food and packaging. Biscuits are generally low in moisture. The low moisture levels of the orange based biscuits would ensure shelf stability.

The biscuit produced from 100% wheat flour had fat content of 16.78%. Addition of orange peel and pulp flours decreased the fat content of wheat flour biscuit to 13.87 and 11.28%, respectively. This should be because of the low fat content of the orange peel and orange pulp flours. The fat contents of the biscuit containing orange peel flour was higher than that of the biscuit containing orange pulp flour because the orange peel flour contained more fat when compared to orange pulp flour. Higher fat content (16.33%) was observed by Varsha et al. (2020). Fats are integral part of biscuit, being the second largest component after flour in soft dough biscuits (Okaka, 1997). Fats shorten dough by weakening the dough gluten network. This results in soft biscuit which breaks easily and with a more tender mouth feel. Fat also gives a softer texture to biscuits and helps prevent the CO₂ bubbles from escaping from the dough too soon (Hasmadi and Sandra, 2014). Biscuits are a rich source of fat and carbohydrate, hence are energy giving foods.

The protein content of the biscuit prepared with 10% orange pulp flour was 12.84%, this value is lower than 15.19% for wheat flour biscuit and 13.06% for the biscuit containing 10% orange peel flour. Orange peel and pulp flours are not non sources of protein when compared to wheat flour. The low protein content of the orange peel and orange pulp flour may have contributed to the lower protein content of its biscuit.

The addition of orange peel and orange pulp flours increased the fibre content of the biscuits significantly (p < 0.05). The 100% wheat flour biscuit had fibre content of 1.33%, a value which increased to 8.17 and 11.22% in biscuits containing 10% orange peel and 10% orange pulp flours, respectively. This is because orange peel flour and orange pulp flour contained more fibre than wheat flour. Insoluble fibre aids digestion and adds bulk to stool, it hastens passage of fecal material through the gut, thus helping to prevent constipation (Bruce, 2020). Fibre also may help reduce the risk of diverticulosis, a condition in which small pouches form in the colon wall (usually from the pressure of straining during bowel movements). People who already have diverticulosis often find that increased fibre consumption can alleviate symptoms, which include constipation and or diarrhea, abdominal pain, flatulence and mucus or blood in the stool (Lemond, 2018).

The ash contents of the biscuits ranged from 1.23 to 2.13%, with the 100% wheat flour biscuit having the lowest value of 1.23%. The higher ash content of biscuit produced with orange peel (2.13%) over that containing orange pulp (1.81%) may be attributed to the higher ash content of the orange peel flour. Ash content of food is an indication of its mineral content which are good for strong bones (Agu et al., 2014).

The 100% wheat flour biscuit had the highest carbohydrate content of 60.73%. This was followed by that of the biscuit prepared with 10% orange pulp flour (53.78%) and that prepared with 10% orange peel (52.19%). The energy content of the biscuit containing orange peel flour and orange pulp flour were 372.78 and 354.56 kCal, respectively. Biscuit produced with 100% wheat flour had the highest energy value of 439.52 kCal. The energy value of a food is related to its protein, fat and carbohydrate contents (Gillaspy, 2021). The higher protein, fat and carbohydrate contents of the wheat biscuits may have contributed to its higher energy value relative to the orange based biscuits. Biscuit is an energy food which is taken mostly in between meals by both young and old (Eyeenga et al., 2020).

Mineral Composition of Biscuits

The mineral composition of biscuits supplemented with orange peel and orange pulp flours are shown in Table 3. Calcium content of the biscuits was in the range of 45.00-51.00 mg 100-g⁻¹, with biscuit prepared from 100% wheat flour having the lowest value (45.00 mg 100-g⁻¹). Youssef and Mousa (2012) reported comparable value of 50 mg 100-g⁻¹ for biscuit containing 10% orange peel flour. The RDA

| Biscuit                  | Moisture (g/100g) | Fat (g/100g) | Protein (g/100g) | Fibre (g/100g) | Ash (g/100g) | Carbohydrate (g/100g) | Energy (kCal/100g) |
|--------------------------|-------------------|--------------|------------------|----------------|-------------|-----------------------|-------------------|
| Wheat                    | 7.08±0.08         | 16.78±0.07   | 15.19±0.04       | 1.33±0.19      | 1.23±0.03   | 60.73±0.21            | 439.52            |
| Wheat-orange peel        | 8.44±0.05         | 13.87±0.04   | 13.06±0.03       | 8.17±0.02      | 2.13±0.02   | 52.19±0.10            | 372.78            |
| Wheat-orange pulp        | 8.85±0.05         | 11.28±0.06   | 12.84±0.04       | 11.22±0.03     | 1.81±0.01   | 53.78±0.04            | 354.56            |

Values are means ± SD of triplicate determinations. Means within the same column with different superscripts were significantly different (p < 0.05). The wheat-orange peel and wheat-orange pulp biscuits contained 10% orange peel and 10% orange pulp flour, respectively.
for calcium for an adult is 200 mg (NRC, 1989). Calcium is an important mineral in the body. About 99% of the body’s calcium is contained in the bone, and the rest in teeth, other tissues and in circulation (Pu and Xue, 2016). Calcium is needed for the growth and maintenance of bones, teeth and muscles.

Biscuits containing 10% orange peel and 10% orange pulp flours had the same copper content of 0.26 mg 100-g⁻¹. This value was lower than 0.90 mg 100-g⁻¹ for the wheat flour biscuit. The copper content of the orange based biscuits compared well with 0.24 mg 100-g⁻¹ reported by Youssef and Mousa (2012). For orange peel and pulp based biscuits, the copper contents of the biscuit samples were well above the United States recommended daily allowance of 0.9 mg per day for adults (Broadley and White, 2007). The iron contents of biscuits ranged from 3.03-4.90 mg 100-g⁻¹. There was no significant difference (p > 0.05) between the biscuit containing 10% orange peel flour and 10% orange pulp flour in their iron contents.

However, the 100% wheat flour biscuit contained higher iron than the orange based biscuits. The iron content obtained in this study was higher than those reported for biscuits containing 10% orange peel flour and 10% orange pulp flour, respectively. The values for the orange based biscuits were higher than the values obtained by Youssef and Mousa (2012). Potassium content of the 100% wheat biscuit was 210.67 mg 100-g⁻¹, while 174.67 and 176.67 mg 100-g⁻¹ were obtained for the biscuits containing 10% orange peel flour and 10% orange pulp flour, respectively. The values for the orange based biscuits were higher than the values obtained by Youssef and Mousa (2012). The RDA for potassium is 200 mg for adults (NRC, 1989). Potassium is very important in maintaining the body fluid volume and osmotic equilibrium (Brinkman et al., 2021).

**Phytochemical Composition of Biscuits**

Phytochemical composition of biscuits supplemented with orange peel and pulp flours are shown in Table 4. Biscuits prepared with 10% orange peel flour had the highest contents of the phytochemicals assessed. The levels of these phytochemicals were significantly different (p < 0.05) from those in the other biscuit samples. Phytochemicals have biological significance but are not established as essential nutrients (FDA, 2010). They are biologically very active. They include anti-oxidants, and compounds that modify potential toxins and carcinogens.

Biscuit containing orange peel had significantly (p < 0.05) higher saponin content than the other samples. Saponins are a class of phytochemicals (bio-organic compounds) abundant in the plant kingdom. They are naturally occurring glucosides described by the soap-like foaming property. Consequently, they produce foams when shaken in aqueous solutions. Literature shows that saponins exhibit a biological role and medicinal properties such as cholesterol lowering action in animals and humans (Eskandar and Somayeh, 2015), antibacterial, antifungal, antiviral, insecticidal, anti-inflammatory, among others (Armelle et al., 2018).

### Table 3: Mineral composition of biscuits supplemented with orange peel and pulp flours

| Biscuit               | Calcium (mg/100g) | Copper (mg/100g) | Iron (mg/100g) | Zinc (mg/100g) | Sodium (mg/100g) | Potassium (mg/100g) |
|-----------------------|-------------------|------------------|----------------|----------------|------------------|---------------------|
| Wheat                 | 45.00±0.03        | 0.90±0.02        | 4.90±0.06      | 5.07±0.11      | 238.00±2.00      | 210.67±3.06         |
| Wheat-orange peel     | 50.39±1.55        | 0.26±0.21        | 3.04±0.51      | 1.11±0.06      | 262.67±6.43      | 174.67±5.03         |
| Wheat-orange pulp     | 51.00±2.00        | 0.26±0.03        | 3.03±0.06      | 1.12±0.03      | 260.00±2.00      | 176.67±5.03         |

Values are means ± SD of 3 replications. Means within the same column with different superscripts were significantly different (p < 0.05).
Alkaloids are a huge group of naturally occurring organic compounds which contain nitrogen atoms in their structure, which makes them alkaline. Based on structure alkaloids can generally be divided into indoles, quinolines, isoquinolines, pyridines, steroids among others (Kurek, 2019). They often have bitter taste and are probably responsible for the bitter taste of orange peels. They play important biological function in plants.

Flavonoids have been reported to function as pigments and antioxidants (Agati and Tattini, 2012). The most important flavonone in oranges is hesperidin which has been reported to lower high blood pressure as well as cholesterol in animal studies and have strong anti-inflammatory properties (CSIRO, 2004). In plants, they are not involved in photosynthesis, respiration or protein synthesis. When foods that contain phytochemicals are eaten, the phytochemicals will activate a group of enzymes that go round cleaning up the free radicals before they cause any harm to the body (Onimowo and Akabor, 2012). Some phytochemicals work as antioxidants (Onimowo and Akabor, 2012).

Studies have shown that the total antioxidant capacity of some market fruits and vegetables highly correlated with anthocyanin content (Dai and Mumper, 2010). Fruits and vegetables rich in anthocyanins had the total antioxidant activity, followed by those rich in flavonones and flavonols (Dai and Mumper, 2010). Carotenoids is a class of micronutrient that cannot be replaced in the diet of humans. There are well over 800 natural carotenoids that have been discovered in different colours such as red, yellow, orange among others (Lu et al., 2021). They are lipophilic natural pigments stored in chloroplast; they exist in green tissues as photosynthetic pigments. Almost all fruits contain carotenoids. Carotenoids are effective oxygen scavengers that have pro-vitamin A activity and thus can reduce oxidative stress (Roohbakhsh et al., 2017).

**CONCLUSION**

The study reveals that edible and acceptable biscuits can be produced from blends of wheat and sweet orange peel and pulp flours, which are sources of bioactive compounds with various nutraceutical properties. The consumption of the biscuits will help in improving health of consumers.

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**Table 4:** Phytochemical composition of biscuits supplemented with orange peel and pulp flours

| Biscuit              | Saponins | Alkaloids | Flavonoids | Anthocyanins | Carotenoids |
|----------------------|----------|-----------|------------|--------------|-------------|
| Wheat                | 0.02±0.00| 0.04±0.01| 0.52±0.03  | 0.85±0.03    | 0.80±0.03   |
| Wheat-orange peel    | 0.03±0.00| 0.05±0.00| 0.71±0.03  | 1.12±0.03    | 0.86±0.02   |
| Wheat-orange pulp    | 0.02±0.00| 0.03±0.00| 0.44±0.04  | 1.05±0.02    | 0.75±0.04   |

Values are means ± SD of 3 replications. Means within the same column with different superscripts were significantly different (p < 0.05)
