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Production and Storage Properties of Biscuit from Orange Peels and Pulps

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Abstract *Citrus sinensis* (Sweet orange) fruits were washed, peeled manually, the juice extracted and the seeds were removed. The peels and pulps were sliced into thin slices of about 2 cm thick, dried at room temperature of about 30 ± 2°C to constant weight, milled and sieved to obtain orange peel and orange pulp flours, respectively. The orange peel and pulp flours, respectively were used to substitute wheat flour 2.5, 5.0 and 7.5 % respectively. The flours were analyzed for their chemical composition. Biscuits were prepared from the flour blends and evaluated for their chemical composition, sensory and storage properties. Biscuit samples was stored at 30 ± 2°C and 80 to 90 % relative humidity. Changes in pH, moisture and peroxide value of the biscuits were assessed. The results showed that the orange pulp flour was significantly higher ($p<0.05$) in ash and moisture content but lower in fat and carbohydrate contents than the orange peel flour. The mineral contents of the flours were not significantly different ($p>0.05$).The biscuit samples containing 10 % orange pulp had higher fibre content than the biscuit containing 10 % peel flour. Moisture contents of biscuits fluctuated during storage, values ranged between 5.56 and 8.85 %. The peroxide values of the biscuits increased slightly after some days of storage.

Keywords Biscuit, Orange Peels, Orange Pulps, *Citrus sinensis*, Sweet orange

Introduction

Orange peel and pulp contain phytochemicals such as polymethoxylated flavones (PMF) and hesperidin just to mention few, which have hormonal and antioxidant actions and are also involved in enzyme stimulation [1].

Until recently, analysis of food was limited to sensory and its nutritional value. However, there is growing evidence that other components of food may play an integral role in the link between food and health [2]. 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 contained in many foods [3]. Many botanical and herbal extracts such as ginseng, garlic oil etc have been developed as nutraceuticals. The use of nutraceuticals to accomplish desirable therapeutic outcomes with reduced side effects as compared with other therapeutic agents has met with great success [4-5]. The peel and pulp of orange fruits have been noted to contain some bioactive substances believed to possess nutraceutical potentials [6]. Thus, the incorporation of orange peel and pulp into wheat flour for the production of biscuit would enhance greater utilization of phytochemicals in Nigerian diets.

Biscuit is a confectionary, dried to very low moisture content [7]. Biscuit is a snack food which can be eaten in-between meals or at any time of the day and by any age bracket. An increasing proportion of the household food budget in Nigeria is spent on snacks in which convenience and quality are perceived as most important [8]. Generally, biscuits contain fat (18.5 %), carbohydrate (78.23%), ash (1.0 %) and salt (0.85 %) [9]. They are generally characterized by a low moisture content [7], The shelf life is several months under correct storage conditions [10]. However, biscuits must be packaged in containers which prevent moisture uptake [7].

The Orange tree and fruit

Orange belongs to the kingdom plantae and division magnoliophyta. It is of the class magnoliopsida and order sapindalas. Its family is Rutaceae, Genus citrus and specie C. sinensis. It has the binomial name *Citrus sinensis* (L) Osbeck.

Orange trees have dark green, shiny leaves and small white flowers with five petals. The flowers smell sweet thereby attracting bees. It is an ever green flowering tree generally growing 9 to 10 m in height. The leaves are arranged alternately, they are ovate in shape with crenulate margins and are 4 to 10 cm long. Orange fruit is considered a hesperidium, a kind of modified berry, because it has numerous seeds, fleshy and soft, derives from a single ovary, and is covered by a rind created by a leathery thickening of the ovary wall [11]. Inside, the fruit is divided into segments, which have thin tough skins that hold together many little sections with juice inside. Inside the segments of most oranges are the seeds. An orange seed is called a pip. The white thread-like material attached to the inside of the peel is called pith [11]. Orange skin is often called "orange peel". Orange fruit season begins from October and lasts until February.

Varieties of Oranges

Orange, Citrus sinensis is classified into four groups with distinct characteristics as Common oranges, Blood oranges, Navel oranges and Acidless oranges [12-13]. Common oranges (also called "white", "round" or "blond" oranges) make up about two thirds of all oranges grown and includes the Valencia or Murcia orange which is sweet and used for juice extraction. It is a late season fruit and the Hamlin which is an early-season orange grown in Florida and Brazil for commercial use [13].

Navel oranges are characterized by the growth of a second fruit at the apex, which protrudes slightly and resembles a human navel. They are primarily eaten as the skin is thicker and easier to peel than a common orange. They are less juicy, available from November through April, with peak supplies between January and March [14].

Blood oranges are widely grown in Spain and Italy. They are characterized by dark red pigmentation. They are considered, in general the most delicious orange [14]. Other varieties of blood oranges are Tarocco, Moro, Maltese etc.

Acidless oranges are early season fruit with very low levels of acid. They are also called sweet oranges in the US, with similar names in other countries [14]. The lack of acid, which protects orange juice against spoilage in other groups, renders them generally unfit for processing, due to spoilage.

Chemical Composition of Orange Fruit

Fruit composition is influenced by a large number of natural factors including variety of fruit, geographical location, climatic zone, soil, degree of maturity etc. The composition of juice products may be influenced by technology used in processing and packaging [15]. The edible portion is the endocarp. Surrounding the endocarp is the peel, which comprises 20 to 50 % of the weight of the fruit and consists of flavedo and albedo. The flavedo, or outer peel is a layer of tissue underlying the epidermis and contains the chromoplast and oil sacs. The albedo, or inner peel, is a layer of spongy white tissue which is connected to the core and supplies the water and nutrients from the tree which are necessary for fruit growth and development [10].

The proximate composition of the edible portion is water, 86%, protein, 0.6%, fat, 0.1%, micronutrients per 100g: calcium, 24 mg, iron, 0.3 mg, vitamin A, 120 iu, thiamine, 0.06 mg, riboflavin, 0.02 mg, niacin, 0.1mg and ascorbic acid, 36mg. The pH of the orange is around 3.5, the main enzyme system is a methyl esterase which hydrolyses polygalacturonic acid polymethyl esters. The principal pigments which develop on ripening are carotenoids, mainly xanthophylls 5, 6 and 5, 8 – epoxides. The major volatile components of whole oranges are d-limonene, beta-mycrene, alpha pinene, acctaldehyde, octanal, ethanol and ethyl acetate [10].

General uses of Orange

Orange tree is a very useful tree, since every part of it is useful for one purpose or another. Some of the uses of orange include:

1. Production of conserve (marmalade). All parts of the orange fruit is used to make marmalade. The pith and pips are separated and placed in a muslin bag where they are boiled in the juice.
2. Essential oils neroli, from the flowers and petitgrain from the leaves, are used in perfumery [10].
3. The petals of orange blossom can also be made into a delicately citrus scented version of rosewater. Orange flower water is a common part of both French and middle Eastern cuisines, most often as an ingredient in desserts and baked goods.
4. In Spain, fallen blossoms are dried and then used to make tea.
5. Orange leaves can also be boiled to make herbal tea.
6. Juice extracted from sweet orange leaves are used to control ulcers, sores etc.
7. Orange peel is used by gardeners as a slug repellent.
8. The peels are also used for making soaps and perfumes.
9. Orange oil is used for flavouring.
10. Cooking oil is extracted from the seeds.
11. Orange wood is a flavouring wood in meat grilling, as much as oak, pecan and hickery are used.
12. Orange wood sticks are used as cuticle pushers in manicure and pedicure.

Health Benefits of Orange

The fruit is low in calories, contains no saturated fats or cholesterol, but is rich in dietary fiber, pectin, which is very effective in reduction of excess body weight. Pectin by its action as bulk laxative helps to protect the mucous membrane of the colon by decreasing its exposure time to toxic substances as well as by binding to cancer causing chemicals in the colon. Pectin has also been shown to reduce blood cholesterol levels by decreasing its re-absorption in the colon by binding to bile acids in the colon [16].

Oranges like other citrus fruits, is an excellent source of vitamin C. Vitamin C is a powerful natural antioxidant. Consumption of foods rich in vitamin C helps the body develop resistance against infections agents and scavenge harmful, pro-inflammatory free radicals from the blood. It also offers protection against rheumatoid arthritis, asthma and osteoarthritis.

Orange contains a variety of phytochemicals. Hesperitin and Narigenin are flavonoids found in orange. Narigenins is found to have a bio active effect on human health as anti inflammatory, anti tumour and blood clot inhibiting properties as well as strong antioxidant effects [17].

Oranges also contain very good levels of vitamin A, which is required for maintaining healthy mucus membranes and skin and it is essential for vision. It is also a very good source of B-complex vitamins such as thiamin, pyridoxine and folates. These vitamins are essential in that the body requires them from external sources to replenish. Orange fruit also contains a very good amount of nutrients like potassium and calcium. Potassium is an important component of cell and body fluid that help control heart beat rate and blood pressure through countering sodium action [16]. Fibre in the fruit helps to prevent atherosclerosis (hardening of the arteries). A class of components found in the citrus peels, called polymethoxylated flavones (PMFs), have the capability to reduce cholesterol levels [18].

Orange Peel

Peel is the thick skin of some fruits and vegetables. Orange peel contains soluble sugars 16.9%, cellulose 9.21%, hemicellulose, 10.5%, and pectin 42.5% [19]. Flavonone in oranges, the hesperidin molecule, has been singled out in phytonutrient research on oranges. Most of the phytonutrients are found in the peel and inner white pulp of the orange rather than in the juice [20].

Although not as juicy or delicious as the inside of an orange, the peel is edible, and has been consumed particularly in environments where there is scarcity of resources and where maximum nutritional value must be derived and minimal waste generated [21]. However, grating a tablespoon of orange peel each day and using it to flavor tea, salads, salad dressings, soups etc may be a practical way of achieving some cholesterol lowering benefit. Frequently, the extracted essential oils from the orange peels were used for the treatment of indigestion and other illnesses.

During the middle ages, cooks preferably used dried orange peels as flavouring rather than serve the fruit or the juice [22]. Orange peels can be made into candies by boiling it in sugar water until they become almost translucent [22]. Dried orange peels can be placed in a cloth bag and placed in closets and cupboards to reduce musky odours [22]. Orange peels are used to deodorize a garbage disposal unit. Placing orange peel at the bottom of trash can before putting the bags in is said to reduce odour and help discourage insect infestation [22]. Orange peels are also combined with carbon dioxide to make a kind of plastic [22]. Limonene, which comprises 95 % of the oils in an orange peel is used in all sorts of applications including the manufacture of plastics [22]. It is flammable, thus, dried and used for kindling fire. However, they burn slower and steadier than the usual kindling materials like newspapers. As they burn they emit a nice odour [22].

Orange Pulp

In addition to the skin, which is an important source of fibre in most fruits, the pulpy part of the fruit is also a source of fibre, and other nutrients. The orange pulp contained total pectin 26.0 to 45.6 %, neutral detergent fibre, 15.8 to 31.0 % and crude fibre, 9.9 to 20.6 % [23]. The white pulpy part of the orange is the primary source of its flavonoids. When the pulpy white part of the orange is removed in the processing of orange juice the flavonoids in the orange are lost in the process. This loss of flavonoids is one of the many reasons for eating the orange in its whole food form [24].

Dietary fibre is the indigestible portion of plant foods. It is metabolically inert, absorbing water as it moves through the digestive system, easing defecation [25]. The main action 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 lower cholesterol levels in the blood [26].

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 [25]. Dietary fibre is nevertheless regarded as important for the diet, with regulatory authorities in many developed countries recommending increases in fibre intake [27-28]. The short chain fatty acids produced are involved in numerous physiological processes promoting health [29]. These include:

- Stabilize blood glucose levels by acting on pancreatic insulin release and liver control of glycogen breakdown.
- Suppress cholesterol synthesis by the liver and reduce blood levels of low density lipoprotein cholesterol and triglycerides responsible for arthrosclerosis [29].
- Lower colonic pH (raises the acidity levels in the colon) which protects the lining from formation of colonic polyps and increases absorption of dietary minerals [30].

Much use has not been made of the orange pulp separately, but it can be used creatively in the kitchen. Recipes using orange pulp include oranges and kiwi cocktail recipe and fruit salad with orange pulp dressing etc.

Chemical Composition of Biscuits

The major raw materials used for preparation of biscuits are flour, water, sugar, egg, milk and milk products. The average ingredients composition of biscuit is flour 44 %, sugar 23 %, milk 3 %, fat11 % and egg 4 %. The minor ingredients are added in trace amount.

The average chemical composition of biscuits is protein 5.58 %, fat 28.05 %, ash 0.47 %, fibre 1.46 % and carbohydrates 57.27 %. The average energy content of biscuits is 578 kcal/100g [31].

Physical Properties of Biscuits

Biscuits are baked products usually produced in a large variety of shapes, sizes, texture and flavours. They are a dry product, usually with a golden brown crust and crisp, pale brown crumb for rapid baking. The thickness of the biscuits is usually not more than 3-4 mm [10].

Types of Biscuits

The minor ingredients used in biscuit manufacture, always give names to the biscuit [31] Popular types of biscuit include:

Sweet biscuit: The sugar content in such biscuits is high making them taste very sweet

Sweet and sour biscuit: Combination of salt and sugar makes the biscuit quite tasty.

Salty biscuit: Salt content is higher than sugar

Sandwich biscuits: These are cream biscuit which are sandwiched in shells and are found in various flavours like vanilla, mango, milk, etc.

Crackers biscuit: These are puffy biscuits which are leavened by certain chemicals and are soft.

Chocolate biscuit**:** Chocolate is put into the biscuit as chips.

Ingredients in biscuit making

Flour: This is the powder obtained from grinding a cereal grain. Wheat flour is by far the most common. All flours are composed largely of starch and protein, but wheat flour is distinctive in that it has very high levels of a class of proteins known collectively as gluten. When dough is made from wheat flour and water, the gluten develops into a thick, cohesive, elastic mass, when placed in an oven, it puffs up to many times its original volume and sets with a light airy texture [32]. The characteristics and general quality of flour depends on.

1. The wheat variety and conditions under which the wheat has grown. This affects the quality and quantity of gluten in the grain.
2. The milling process: This determines the degree of separation of the bran and endosperm, as well as the particle size of the flour.
3. Additives and special treatments used by the miller to produce flour mixes with special characteristics.

Fat**:** Fat has five major roles in baking. How well it will perform each of these functions depends largely on the slip point, the temperature at which the fat just begins to melt. In general the slip point should be at least 5 ^{0}C above the proving temperature of the dough. The roles of fat are as follows:

Shortening: Fat weakens or shortens a dough by weakening its gluten network, resulting in the baked product being soft, breaking easily and having a more tender mouth feel.

Creaming: Fat can trap air during beating and mixing producing a batter that consist of masses of tiny air bubbles trapped within droplets of fat.

Layering: In puff pastry, fats which are soft over a wide temperature range are used. These can be spread between pastry layers and will separate them during cooking giving a layered pastry.

Flavour: Usually the fats used should have a bland flavour to prevent them from changing the flavour of the finished products [7].

In addition, the fat chosen needs to be able to form an emulsion, with the other ingredients in the batter or dough [33].

Sugar**:** Sugar is most commonly thought of as a sweetener, but in baked goods it is also involved in several other processes. Sugar undergoes a series of complex browning reactions above 160 ºC, and the products of these form the brown crust of many baked goods. The reactions are known as maillard reactions, and are essentially amino acid catalysed caramelisation reactions in which a sugar aldehyde or ketone is converted to an unsaturated aldehyde or ketone. In non-fermented goods such as biscuits, large quantities of sugar can be added. This improves the keeping quality of the biscuits as well as sweetening them. The sugar usually used is pure sucrose such as castor sugar. Occasionally impure forms such as golden syrup, honey and brown sugar are used to give the baking a particular flavour.

Baking Powder: Baking powder is essentially a mixture of $NaHCO_3$ (sodium bicarbonate) and a weak solid acid or acid salt. When the mixture dissolves in water and the temperature is raised, CO_2 is released according to the equation

$$NaHCO_3 + H^+ \xrightarrow{\text{(from the acid)}} Na^+ + H_2O + CO_2$$

When baking powder is used rather than baking soda, the by-products are less alkaline and thus they have no undesirable effects on the taste of the product.
Salt: Salt is added to enhance the flavour of baked goods and to toughen up the soft mixture of fat and sugar that is to make dough more elastic [33].

Material Procurement
The sweet orange fruit was purchased from Maiduguri town of Borno state Nigeria. Wheat flour, sugar, margarine, eggs and baking powder were purchased from Monday market Maiduguri Township, Borno State.

Preparation of orange peel and pulp flours
The fruits were washed thoroughly with slightly acidified water to remove dirt and adhering extraneous materials, it was manually peeled with a sharp laboratory knife. Juice extractor was used to extract the juice and the seeds removed. The peel and pulp were cut into tiny pieces and then dried at room temperature to a constant weight, milled in a pistol and mortal and sieved with muslin cloth to obtain the fine flour samples.

Flour blending
2.5 , 5.0 and 7.5 percentages of the orange peel flour/pulp flour was used to substitute 85, 80 and 75 % of wheat flour respectively in a food blender operated at full speed for 10 minutes.

Production of biscuit
The basic recipe that was used for biscuit production is shown in Table 1.below,

Table 1: Recipe for biscuit production [7]

Ingredient	Amount (g)
Flour	100
Margarine	22
Beaten egg	10
Baking powder	1.8
Water	45(ml)
Sucrose	20
Salt	0.3
Powdered milk	5

The ingredients were weighed out. Dry ingredients were mixed together. The fat was rubbed in and mixed until dough was formed. The resultant dough was kneaded and rested for about 5 minutes. The rested dough was rolled out into sheets using a roller and cut into shapes, using biscuit cutters. The dough was placed on well greased baking trays and baked for 10 to 15 minutes in an oven pre-heated to 200 °C, allowed to cool, then packaged in high density polyethylene bags in an air tight container.

Sensory evaluation
The biscuit samples prepared with 2.5, 5 and 7.5 % orange peel and pulp flours including the control made from 100 % wheat were subjected to sensory evaluation and were assessed by a five member panel from the department of Industrial Chemistry University of Maiduguri. Quality attributes such as colour, flavour, texture, taste and overall acceptability were evaluated on a 9-point hedonic scale (1= dislike extremely and 9 = like extremely) as described by Ihekoronye and Ngoddy [34].

Storage stability studies
The accepted biscuit samples after the initial sensory evaluation was stored at ambient temperature for long. The samples were analyzed for pH, moisture content, peroxide value. The temperature and relative humidity of the storage environment was determined.

Determination of pH

The pH was determined by the use of a pH meter. Two grams of the sample was homogenized in 20 ml of de-ionized water in a beaker. The pH meter was standardized using buffer solutions of pH 4 and 9. The electrode was rinsed with de-ionized water and dipped into the homogenate and allowed sufficient time for stabilization before the reading was taken.

Determination of peroxide value

The titrimetric method of AOAC [35] was used. About 5 g of the sample and 30 ml glacial acetic chloroform solution was added in a flask and swirled to dissolve. About 0.5 ml of saturated potassium iodide was added to react with the peroxides after one minute, 30 ml of H_2O was titrated with 0.1N sodium thiosulfate ($Na_2S_2O_3$) with vigorous shaking, 0.5 ml of 1 % starch indicator added and the titration continued until the blue colour disappeared. A blank titration was carried out. The peroxide value for each was calculated with the formula as follow:

$$Peroxide\ Value = \frac{S \times M \times}{Weight\ of\ Sample} \times \frac{100}{1}$$

Where S = $McNa_2S_2O_3$ (blank)

M= Molarity of $Na_2S_2O_3$ solution

Results and Discussion

Proximate Composition of Flours

The proximate composition of orange peel, orange pulp and wheat flours can be seen in Table 2. The moisture content of orange pulp flour (13.85 %) was higher ($p<0.05$) than those of orange peel flour (7.91 %) and wheat flour (12.32 %). The pulp which is referred to as endocarp consists of series of segments, which contain thin walled juice vesicles, which are fibrous [34]. This fibrous structure probably caused the pulp to retain more moisture than the peel on drying.

The fat contents of the orange peel flour and orange pulp flour were 2.08 and 0.58 %, respectively. Wheat flour had higher fat content (2.17 %) than the orange flours. The low level of fat in the orange pulp and peel flours is expected as fruits and vegetables are not good sources of fats and oils [36]. Orange peels contain essential oils and this may have contributed to its higher fat content over the pulp. The 2.08 % fat obtained for the orange peel flour in this study was higher than 1.5 %, but lower than 4.09 % and 9.52 % reported previously for the peel of navel orange [37-38]. These variations may be attributed to varietal differences, origin and degree of ripeness of the fruits. The low fat contents of orange peel and orange pulp flours as well as the wheat flour is believed to enhance their storage stability as they are less likely to develop rancid flavour.

Table 2: Proximate composition of wheat, orange peel and orange pulp flours (%)

Flour	Crude					
Type	Moisture	Fat	Protein	Fibre	Ash	Carbohydrate
Wheat	12.32^{b}±0.03	2.17^{a}±0.02	13.88^{a}±0.03	2.21^{c}±0.02	1.24^{c}±0.02	68.18^{a}±0.07
Orange peel	7.91^{c}±0.04	2.08^{b}±0.02	8.25^{b}±0.01	18.24^{b}±0.02	3.77^{b}±0.03	59.76^{b}±0.06
Orange pulp	13.85^{a}±0.10	0.58^{c}±0.04	7.96^{c}±0.03	22.03^{a}±0.05	4.31^{a}±0.01	51.27^{c}±0.15

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

Wheat flour had the highest protein content of 13.88 % when compared to those of orange peel flour (8.25 %) and orange pulp flour (7.96 %). Orange peel and pulp are not known to be good sources of protein. Magda *et al*., [38] reported a lower protein value of 2.67 % for Navel orange pulp flour. This difference may be due to difference in the variety used and geographical location.

The crude fibre content of orange peel flour (18.24 %) and pulp flour (22.03 %) showed higher crude fibre contents when compared to other fruits such as mango (2.40 %) [39]. The crude fibre content of the pulp was higher than that of the peel. Fibre is the indigestible portion of plant foods. The main action of fibre is to change how other nutrients and chemicals are absorbed in the body [26]. Fibres bind to bile acids in the small intestine,

making them less likely to enter the body and this lowers cholesterol levels in the blood [26]. 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 [25]. The short chain fatty acids produced are involved in numerous physiological processes such as stabilizing blood glucose levels by acting on pancreatic insulin release and liver control of glycogen breakdown among others [29].

The ash contents of the samples ranged from 1.24 % in wheat flour to 4.31 % in orange pulp flour. The ash content of the orange peel flour was 3.77 %. Ash is a measure of mineral content of a food [40]. Orange peel and pulp flours may be considered rich in mineral constituents based on the levels of ash in them. Magda *et al*., [38] reported a slightly higher level of 4.24 % ash for Navel orange powder. Similarly, a higher ash value of 5.02 % for orange pulp was reported. Wheat flour had the lowest ash content ($p<0.05$), indicating that orange peel and pulp flours are richer in mineral constituents.

Carbohydrate content of wheat flour was 68.18 %, a value which was significantly higher ($p<0.05$) than the 59.76 % for orange peel flour and 51.27 % for orange pulp flour. Value of 70.19 % for carbohydrate content was previously reported by Magda *et al*., [38] for Navel orange peel powder.

Mineral composition of flours

The mineral composition of orange peel, orange pulp and wheat flours are shown in Table 3. There was no significant difference ($p>0.05$) among the flour samples in their calcium contents. However, wheat flour had the lowest calcium content of 43.67 mg/100g when compared with 44.67 mg/100g for each of the orange peel and pulp flours. The calcium contents of the orange peel and pulp flours were higher than 23.8 mg/100g reported for pomegranate [41] but lower than 111.3 mg/100g reported for mango seed flour [39]. Calcium is required for normal development and maintenance of bones and teeth, clotting of blood and normal heart action [34]. Calcium is also essential for conducting nerve impulses and stimulating hormone secretions [39].

Table 3: Sensory scores of biscuits supplemented with orange peel flour

Biscuits (OPEF:WF)	Colour	Flavour	Taste	Texture	Overall acceptability
5:95	8.05^{ab}±1.28	8.20^{a}b±1.11	8.40^{ab}±0.75	8.45^{ab}±0.76	8.35^{a}±0.81
10:90	7.95^{ab}±1.09	7.80^{ab}±0.89	7.25^{c}±1.25	7.95^{bc}±0.76	8.25^{a}±1.07
15:85	8.05^{ab}±0.76	8.30^{ab}±0.98	4.95^{e}±1.15	7.40^{c}±1.57	5.30^{c}±1.38
0:100	8.80^{a}±0.41	8.50^{a}±0.61	8.75^{a}±0.44	8.75^{a}±0.44	8.65^{a}±0.67

Values are means ± SD of 20 panelists. Means with different superscripts within the same column were significantly different ($p<0.05$). Biscuits were evaluated on a 9 point Hedonic scale (1= extremely disliked and 9 = extremely liked) OPEF = Orange peel flour. WF = Wheat flour.

Sensory evaluation scores of biscuits produced with 5, 10 and 15 % orange pulp flour are shown in Table 3. Significant differences ($p<0.05$) existed among samples. All the samples were rated high. Sample WHB (control) received the highest scores in all the sensory parameters evaluated. Samples containing10 % and 15 % orange pulp flour were rated least in colour. This low rating for colour may be due to the colour of the orange pulp flour (dark brown) which was incorporated into the biscuit. In the other parameters such as flavour, taste, texture and overall acceptability, sensory scores decreased as orange pulp flour incorporation increased. Biscuit containing 15 % orange pulp flour was the least scored in all the evaluated sensory parameters. The low rating for texture was probably due to its higher moisture content.

Table 4: Sensory scores of biscuits supplemented with orange pulp flour

Biscuits (OPUF:WF)	Colour	Flavour	Taste	Texture	Overall acceptability
5:95	8.00^{ab}±1.56	7.70^{b}±1.17	7.90^{bc}±1.37	7.50^{c}±1.32	7.90^{a}±1.12
10:90	7.30^{b}±1.46	6.15^{c}±1.27	6.30^{d}±1.22	6.10^{d}±1.37	6.40^{b}±1.39
15:85	7.40^{b}±1.73	5.60^{c}±1.14	5.80^{d}±1.36	5.70^{d}±1.38	6.00^{bc}±1.56
0:100	8.80^{a}±0.41	8.50^{a}±0.61	8.75^{a}±0.44	8.75^{a}±0.44	8.65^{a}±0.67

Values are means ± SD of 20 panelists. Means with different superscripts within the same column were significantly different ($p<0.05$). Biscuits were evaluated on a 9 point Hedonic scale (1= extremely disliked and 9 = extremely liked) OPUF = Orange pulp flour. WF= Wheat flour.

Proximate composition of biscuits

The proximate composition of biscuits supplemented with orange peel and pulp flours are shown in Table 4. 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 % 0range peel flour were 7.08 and 8.44 %, respectively. The highest moisture content of the biscuit containing orange pulp may be attributed to the higher moisture content of the orange pulp flour. The moisture contents of these biscuits were higher than 6.40 % reported by Youssef and Mousa [42] for biscuit supplemented with 10 % Baladi orange flour. Biscuits are generally low in moisture. The low moisture levels of the orange based biscuits would ensure shelf stability. The moisture content of a food is of significance to shelf life and packaging.

Table 5: Proximate composition of biscuits supplemented with orange peel and orange pulp flours (%)

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

The biscuit produced from 100 % wheat flour had fat content of 16.78 %. The incorporation of orange peel and pulp flours decreased the fat content of wheat flour biscuit to 13.87 % and 11.28 %, respectively. This could be attributed to 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 of the higher fat content of the orange peel flour. Fats are integral part of biscuit, being the second largest component after flour in soft dough biscuits [7]. 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 CO_2 bubbles from escaping from the dough too soon [43]. Biscuits are a rich source of fat and carbohydrate, hence are energy giving foods [44].

The protein content of the biscuit prepared with 10 % orange pulp flour was 12.84 %, a value lower than 15.19 % for wheat flour biscuit and 13.06 % for the biscuit containing 10 % orange peel flour. The low protein content of the orange peel flour may have contributed to the lower protein content of its biscuit. The protein content of the biscuit containing 10 % orange peel flour was higher than 7.44 % [42] and 10.98 % [38] reported for biscuit containing orange peel flour. These differences may be attributed to the differences in the recipes used for the production of the different biscuits.

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 [45]. 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 [45].

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. The ash content of the orange peel based biscuits compared well with 2.12 % reported by Magda *et al*., [38] for biscuits containing 10 % orange peel powder.

The 100 % wheat flour biscuit had the highest carbohydrate content of 60.73 %. This value 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 Kcal 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. The higher protein, fat and carbohydrate contents of the wheat biscuits may thus have contributed to its higher energy value in relation to those of the orange based biscuits. Biscuit is an energy food which is taken mostly in between meals by both young and old [46].

Conclusion

This study showed that flours can be produced from sweet orange peel and the pulp. An acceptable biscuit can be manufactured with it. Acceptable biscuits were produced from wheat flour supplemented with 10 % orange peel flour and 10 % orange pulp flour, respectively. The biscuits contained high amounts of crude fibre, flavonoids and minerals (calcium, copper, iron, zinc, sodium and potassium) etc. Baking reduced the antinutrient contents of the biscuits. Ethanol extracts of the flours and biscuits had higher antioxidant activities than the water extracts. The biscuit containing orange peel flour had higher antioxidant activity than that containing orange pulp flour.

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