Original Article



# Effect of Orange Rind Powder Incorporation on The Physical, Nutritional and Sensorial Qualities of Cookie

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## Abstract

Currently, the awareness of the role of functional ingredients in diets is on the increase, which prompts the demand for functional foods. This study aimed at incorporating varying percentages of the orange rind powder with wheat powder to get the most suitable combination for nutritionally improved cookies. Sweet orange samples were collected, washed thoroughly and peeled. The peels were cut into smaller pieces and oven dried (35 $^{o}$C) to a constant weight. The dried peels were pulverized and sieved to obtain a fine powder. The cookies were prepared using wheat mixed with 5, 10, 15, and 20 % orange rind powder and conventional baking ingredients. The prepared cookies were evaluated using standard methods for nutritional composition and sensory properties using 9-point hedonic scale. Data obtained were statistically analyzed using ANOVA by SPSS software at 5 % level of significance. The results obtained showed that ORP incorporated cookies contained lower amount of moisture, crude protein, fat and carbohydrate but higher fibre and ash compared to the cookies without ORP. The higher fibre and ash content of ORP incorporated cookies signified that orange rinds contained more fibre and ash. The fibre and ash content were in the range 4.48 – 14.86 % and 1.73 – 4.13 % respectively, whereas that of the control (100 % WF) were 1.31 and 1.23 %, respectively. Orange rind powder can be incorporated with wheat flour in cookie production up to 10 % inclusion for the development of fibre and mineral rich functional cookies without adverse effect on sensory characteristics. Therefore, agro waste (orange rinds) can be utilized for value added products.

**Key words:** Orange rind powder, cookie, nutritional quality, sensory quality.

## Introduction

The continuous rise in the demand for cereal grains and oilseeds by both man and animals has led to increase in the cost of confectionaries like biscuits, cookies, etc. To maximize profit by food industries in developing countries, an adequate low-cost waste management system must be developed. This has led to efforts by researchers to discover non-conventional industrial resources to cope with the ever-increasing demand for these conventional industrial resources. Large quantities of agricultural by-products which are regarded as non-conventional feed sources are produced in Nigeria. The use of these agricultural by-products for livestock and human foods has been reported in developed countries of the world. Also, this eliminates the need for costly waste management programmes which have become very important in recent years as the world's human population and the amount of crop and food by-products increase, particularly in developing countries (Sylvester and Ikudayisi 2021).

Cookie, also known as flat cake, is a crisped baked food product consumed by many people across the world (Deepti et al., 2018). Sweet orange (*Citrus sinensis*) is one of the most produced and consumed fruit of the citrus species. The fruits are usually eaten fresh but also used for making canned orange juice, frozen juice concentrate, jams, jellies and others. Other citrus fruits widely consumed are *Citrus limonum* (lemon), *Citrus vitus* (grape), *Citrus aurantifolia* (lime) and *Citrus reticulate* (tangerine or mandarin). Citrus fruits are potentially rich source of dietary fibre, vitamins, minerals, flavonoids, phenolic compounds, carotenoids, essential oils, sugars, ascorbic acid and some trace elements (Khan et al., 2021). Citrus peel can act as potential natural resources of antioxidants, as it contains considerable quantity of ascorbic acid, catechol, dimethoxy phenol, cyclohexane, coumarin, acetic acid, stigmasterol, sitosterol and vitamin E (Hassan *et al*., 2021). Fruit rinds, which are generally discarded as waste are of potential nutraceutical resources (Varmie and Thakur 2021). It is important to emphasize that orange peel is valued as a functional food. Citrus peels may therefore boost health and help ward off disorders linked to food, such as osteoporosis, metabolic syndrome, type II diabetes, coronary heart disease, obesity, and hypertension. It can serve as significant low-cost nutritional dietary supplements (Teke et al., 2023).

Pharmaceuticals industries incorporate various sources of dietary fibre in products due to its high health benefit properties. They act mainly to change absorption of other nutrients and chemicals in the body. Soluble fibre also reduces sugar response after food intake. They are involved in numerous physiological processes such as the control of the release of insulin for the breakdown of glycogen (Thliza et al., 2021a). Adequate amount of dietary fibre intake slows down overweight in adults, toddlers and lowers high blood pressure as well as various gastrointestinal disorders (Varmie and Thakur 2021). It has also been revealed that insoluble fibre aids digestion and adds bulk to stool. It hastens passage of faecal material through the gut, thus helping to prevent constipation. 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 diarrhoea, abdominal pain, flatulence and mucus or blood in the stool (Mahmood et al., 2019).

With the knowledge of these enormous biological importance of dietary fibre in the body system, many literatures had revealed the application of citrus specie in composite with various other powdered fruits and vegetable waste as valuable nutritional ingredient in the production of biscuits and cookies, but established literature on the effect of orange rind powder on the physical, nutritional and sensory qualities of cookies are rare. Hence, this study focused on how orange rind powder incorporation at levels of 5%, 10%, 15% and 20% influence the physical, nutritional and sensory qualities of wheat-based cookies.

## MATERIALS AND METHODS

### Sample Collection and Preparation

Sweet orange fruits (Citrus sinensis), wheat flour, sugar, margarine, eggs and baking powder were purchased from Wurukum and Modern markets in Makurdi, Benue State-Nigeria. Sample preparation was carried out at the Centre for Food Technology and Research (CEFTER) laboratory, Benue State University Makurdi-Nigeria. The Citrus fruits were washed thoroughly with water to remove dirt and adhering extraneous materials. It was peeled manually using a table knife. The peels (rinds) were cut into tiny pieces, oven dried (35 $^{o}$C) to constant weight. It was milled in attrition mill and sieved with muslin cloth to obtain fine flour powder (Obafaye and Omoba, 2018) (Figure 1).

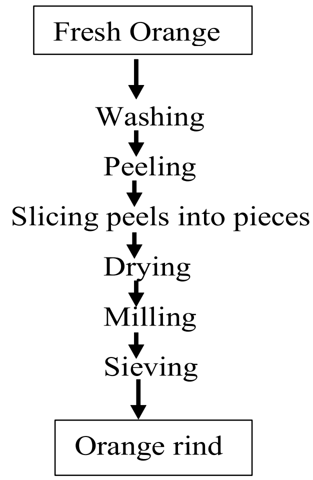


**Figure 1:** Flow chart for orange rind powder preparation

**cookie formulation and preparation**

cookies were formulated as described by thliza et al. (2021b) with varying amount of orange rind powder as shown in Table 1. The ingredients were weighed out for cookie preparation at the CEFTER laboratory.

**Table 1:** Formulation of cookie

| | Ingredient (g) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Sample** | **WF** | **ORP** | **Margarine** | **Beaten egg** | **BP** | **Sugar** | **Salt** | **PM** | **Water** |
| Control | 100 | - | 22 | 10 | 1.8 | 20 | 0.3 | 5 | 45 mL |
| Cookie A | 95 | 5 | 22 | 10 | 1.8 | 20 | 0.3 | 5 | 45 mL |
| Cookie B | 90 | 10 | 22 | 10 | 1.8 | 20 | 0.3 | 5 | 45 mL |
| Cookie C | 85 | 15 | 22 | 10 | 1.8 | 20 | 0.3 | 5 | 45 mL |
| Cookie D | 80 | 20 | 22 | 10 | 1.8 | 20 | 0.3 | 5 | 45 mL |

KEY: WF = wheat flour, ORP = orange rind powder, BP = baking powder, PM = powdered milk.

The dry ingredients were homogenized using a commercial sigma blender. The margarine was then rubbed in and mixed thoroughly to obtain uniformly mixed dough. The dough was kneaded and allowed to rest for about 5 min. It was rolled in a uniform shape of 6 mm thickness and cut into shape, using cookie cutter. The cut-out dough was placed on well-greased baking trays and baked for 20 min. in an oven pre-heated at 200 °C. They were allowed to cool, then packaged in high density polyethylene bags in an airtight container for analyses (Figure 2) (Thliza et al., 2021a).

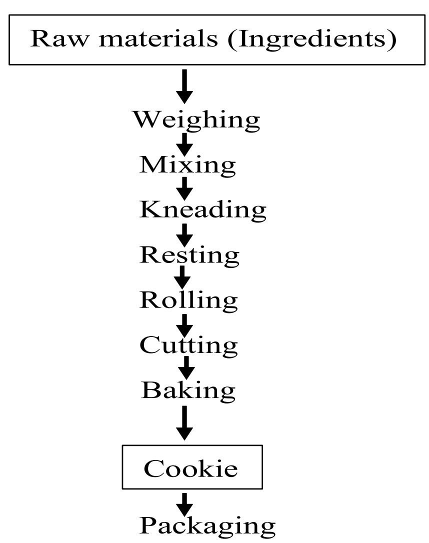


**Figure 2:** Flow chart for preparation of cookie

**Proximate Composition**

Most of the proximate composition of the samples were carried out as described by Nwaokobia *et* al., 2018).

**Determination of Moisture Content**

Moisture content was determined by the weight loss method. Two grams (2 g) of the sample was weighed into a crucible of known weight and placed in the oven at 105 $^{o}$C for 4 h. The sample was removed and cooled in a desiccator. This was done repeatedly until a constant weight was obtained. The moisture content was calculated as shown below.

$$\%\text{ Moisture content} = \frac{\text{Weight loss}}{\text{Weight of sample}} \times 100$$

**Determination of Ash Content**

The ash content was determined after incineration of 2 g of the sample in a muffle furnace at 550 $^{o}$C for 2 h until a light gray ash was obtained. It was cooled in a desiccator and weighed. The ash content was calculated using the formula

$$\%\text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

**Determination of Crude Protein**

The protein content was determined by the micro-Kjeldahl method which measures the total nitrogen content of sample. One gram (1 g) of the sample was digested in Kjeldahl digesting system at 380 $^{o}$C with concentrated sulfuric acid. The digested sample was cooled and transferred into a distillation flask with 20 mL distilled water. It was neutralized by the addition 5 mL of 60 % sodium hydroxide solution. The distillate was collected into a flask containing 5 mL of 2 % boric acid solution. Distillation continued until about 30 mL distillate was collected. The distillate with two drops of methyl orange indicator was titrated against 0.1N of HCl, prepared by diluting calculated volume of 2.1 mL HCl in 250 mL distilled water in a volumetric flask. A blank titration was carried out too. The percentage nitrogen content was calculated as:

$$\%\text{ Nitrogen} = \frac{\text{Vs} - \text{Vb x N x 14}}{1000 \times \text{Weight of sample}} \times 100$$

Where: Vs and Vb = volume of acid required to titrate the sample and the blank respectively.

N = Normality of the acid

The protein content was calculated as:

% Crude protein = % N x 6.25

Where 6.25 is a conversion factor.

**Determination of Crude Fat Content**

The fat content was determined using the Soxhlet extraction method. A Soxhlet extractor with a reflux condenser and a 500 mL round bottom flask with 300 mL petroleum ether was setup. Two grams (2 g) of the sample was weighed into a thimble and sealed with cotton wool. The assembled Soxhlet apparatus was allowed to reflux for 6 h and the petroleum ether evaporated into a container for reuse. After the flask was free of ether, it was dried at 105 $^{o}$C for 1 h in an oven. It was then cooled in a desiccator and weighed. The percentage fat content was calculated as:

$$\%\text{ Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

**Determination of Crude Fibre**

The crude fibre was determined by using petroleum ether to defat 2 g of sample. The defatted sample was air-dried and placed in a beaker containing 200 mL of 1.25 % $H_2SO_4$, boiled for 30 min in a digestion apparatus with periodic rotation to keep solid from adhering to the beaker. The mixture was left to stand for 1 min. It was then filtered through muslin cloth on a fluted funnel and the insoluble matter washed with boiling water until it was freed of acid. The residue was returned into a beaker with 200 mL boiling NaOH and allowed to boil briskly for 30 min. The solution was allowed to cool for 1 min., filtered and washed with 1 % HCl and then with boiling water to free it of acid. The final residue was drained, transferred to silica ash crucible (porcelain crucible), and dried in the oven at 100$^{o}$C to a constant weight. Incineration to ash was done at 600 $^{o}$C for 30 min., cooled in a desiccator and weighed. The crude fibre content was calculated as:

$$\%\text{ Crude fibre} = \frac{\text{Weight of oven dried residue-Weight after incineration}}{\text{Weight of sample}} \times 100$$

**Determination of Carbohydrate Content**

Carbohydrate content of the samples was calculated by difference using the expression:

% Carbohydrate = 100 - (% moisture + % ash + % fat + % protein +% fibre)

**Determination of Calorific Content**

Calorific content was calculated using water factor method as described by Youssef and Mousa (2012). The values obtained for protein, fat and carbohydrate were used to calculate the calorific content of the samples as expressed below:

Calorific value (Kcal/100g)
= (P × 4.0) + (F × 9.0) + (C × 3.75)

Where: P = % protein content, F
= % fat content and C = % carbohydrate content

**Determination of pH**

The potential of hydrogen (pH) of the prepared cookies was determined using a pH meter. Two grams (2 g) 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, then reading taken.

**Sensory Evaluation**

Sensory evaluation of the prepared cookies for colour, flavour, texture, taste and overall acceptability were carried out on a 9-point hedonic scale by twenty panelists from Centre for Food Technology and Research (CEFTER) and Chemistry Department of Benue State University, Makurdi. Sensory attributes were rated on a scale of 1 (dislike extremely) – 9 (like extremely) (Youssef and Mousa, 2012).

**Data Analysis**

Data were subjected to analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 24 at 5 % level of significance.

**Results And Discussion**

The result of proximate composition of wheat flour and orange rind powder were presented in Table 2.

**Table 2**: Proximate composition of wheat flour and orange rind powder (g/100 g) dry weight basis

| Parameter (%) | Amount (%) | |
|---|---|---|
| | **Wheat flour** | **Orange rind powder** |
| Moisture | 12.32±0.04 | 7.91±0.04 |
| Crude protein | 13.88±0.05 | 8.25±0.01 |
| Crude fat | 2.17±0.02 | 2.08±0.02 |
| Crude fibre | 1.24±0.01 | 18.24±0.02 |
| Total ash | 2.21±0.03 | 3.77±0.03 |
| Carbohydrate | 68.18±0.09 | 59.75±0.067 |

Values are in Mean±SD of triplicate determination.

From Table 2, it was observed that wheat flour had higher moisture content, crude protein, crude fat and carbohydrate of 12.32, 13.88, 2.17, and 68.18 % compared to orange rind powder (ORP) with 7.91, 8.25, 2.08, and 59.75 % respectively. Crude fiber and total ash were higher in orange rind powder (18.24 and 3.77 %) compared to wheat flour (1.24 and 2.21 %). This implied ORP contained more fibre and ash.

**Proximate Composition of Cookies**

The proximate composition of cookies supplemented with ORP are as shown in Table 3.

**Table 3**: Proximate composition of whole wheat and supplemented cookies

| Parameter (%) | Cookies [WF: ORP] | | | | |
|---|---|---|---|---|---|
| | **100:0** | **95:5** | **90:10** | **85:15** | **80:20** |
| Moisture | 7.08$^{a}$±0.08 | 7.20$^{a}$±0.09 | 8.01$^{b}$±0.07 | 7.83$^{b}$±0.05 | 8.00$^{b}$±0.02 |
| Crude protein | 14.09$^{c}$±0.19 | 15.12$^{c}$±0.05 | 10.78$^{a}$±0.10 | 10.23$^{a}$±0.20 | 9.25$^{a}$±0.07 |
| Crude fat | 15.65$^{a}$±0.12 | 13.25$^{b}$±0.20 | 13.10$^{b}$±0.11 | 12.64$^{b}$±0.15 | 13.67$^{b}$±0.13 |
| Crude fibre | 1.31$^{b}$±0.02 | 4.48$^{a}$±0.05 | 9.37$^{c}$±0.03 | 11.89$^{c}$±0.07 | 14.86$^{d}$±0.17 |
| Total ash | 1.23$^{c}$±0.03 | 1.73$^{c}$±0.02 | 3.79$^{b}$±0.01 | 3.92$^{b}$±0.02 | 4.13$^{b}$±0.05 |
| Total carbohydrate | 60.63$^{b}$±0.23 | 58.22$^{b}$±0.17 | 54.95$^{a}$±0.09 | 53.49$^{a}$±0.02 | 50.09$^{c}$±0.35 |
| Energy (Kcal/100g) | 424.57$^{a}$ | 398.06$^{b}$ | 361.08$^{c}$ | 355.27$^{d}$ | 347.87$^{e}$ |

Values are in Mean±SD of triplicate determination.

Values within the same row with different superscript are significantly different ($p<0.05$)

The result indicated that moisture content in control cookie (100 % WF) was 7.08 which is not significantly different ($p<0.05$) from 5 % ORP cookie (7.20), but differ significantly from 10, 15, 20 % ORP cookies with moisture content ranging from 7.83 to 8.01 %. This may be attributed to difference in heat absorption and percent moisture intake during cooling of cookies. Low moisture content of orange-based cookies would ensure shelf-life stability. This implies cookie produced from 10, 15 and 20 % ORP will have a shorter shelf-life.

The protein content of cookies with 10 to 20 % ORP inclusion were significantly different (10.78, 10.23, 9.25 %) as compared to the control and 5 % ORP cookies (14.09 and 15.12 %). It was observed that increased ORP inclusion reduced the protein content of cookies. The low protein content of the ORP (Table 2) lead to the lower protein content of its cookies. However, the protein content of the cookies was higher than 7.44% reported by Youssef and Mousa, (2012) for biscuits containing orange peel flour. By implication, cookie produced from 10, 15 and 20 % ORP could not meet or provide acceptable protein nutrients needed by the body system when consumed.

The same trend was also observed for fat content where the control had 15.65 % fat which was significantly different from the supplemented cookies with a range between 12.64 to 13.67 %. This could be attributed to the low fat content of the ORP (Table 2) as it outweighs the wheat flour.

There was a significant progressive increase in the fibre content with increase inclusion of ORP ranging 4.48 - 14.86 %. There was significant difference in fibre content of the control cookie (1.31 %). This signified that ORP largely contained more fibre than wheat flour as confirmed in Table 2.

The ash contents of the cookies ranged from 1.23 % to 4.13%, with the control having the lowest value of 1.23 % while 20% ORP cookie had the highest (4.13%). Increase ash content with addition of ORP is attributed to the higher ash content of the ORP as confirmed in Table 2. This implies the supplemented cookie are very useful in digestive health.

The result of carbohydrate content and energy showed gradual decrease with increase in inclusion of ORP. The control showed highest in carbohydrate and energy (60.63 %, 424.57 Kcal/ 100 g), while 20 % ORP cookies showed the lowest (50.09 %, 347.87 Kcal/100 g). 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 cookies may thus have contributed to its higher energy value in relation to those of with varying amount of the orange rind powder. This explains why biscuits and cookies belong to the class of energy giving food which is taken mostly in between meals by both young and old (Sogari et al., 2018). This is in line with the CODEX Alimentarius Commission (2012) guideline for ready-to-use industrial foods and the United States Department of Agriculture commodity requirements for high energy biscuits used in the international food assistance programmes which specified that maximum moisture content should be 4.5 %, minimum protein of 10 g, minimum fat of 12 g, minimum fibre of 2.3 g, maximum ash of 3.5 g and the minimum energy value of 463 Kcal.

The obtained results for the proximate composition of cookies were like results reported by Kakali et al. (2014), Zaker et al. (2016) and Thliza et al. (2021a).

**Sensory Evaluation of Cookies**

Table 4 presents the sensory evaluation of cookies prepared with different percentage of ORP and wheat cookies without ORP.

**Table 4:** Sensory analysis of whole wheat and supplemented cookies

| Cookies [WF:ORP] | Colour Flavour | Taste | Texture | Overall | Acceptability |
|---|---|---|---|---|---|
| 100:0 | 8.20$^{a}$±0.41 | 8.42$^{e}$±0.61 | 8.48$^{b}$±0.44 | 8.31$^{c}$±0.54 | 8.50$^{d}$±0.67 |
| 95:5 | 7.95$^{a}$±1.28 | 8.10$^{e}$±1.11 | 8.13$^{b}$±0.75 | 8.19$^{c}$±0.50 | 8.09$^{d}$±0.81 |
| 90:10 | 7.99$^{a}$±1.09 | 8.23$^{e}$±0.89 | 8.25$^{b}$±1.25 | 8.31$^{c}$±0.76 | 8.22$^{d}$±1.38 |
| 85:15 | 6.39$^{b}$±0.76 | 7.86$^{e}$±0.98 | 7.12$^{c}$±1.15 | 7.82$^{c}$±1.52 | 7.10$^{a}$±1.35 |
| 80:20 | 4.97$^{c}$±0.32 | 6.08$^{a}$±1.05 | 5.82$^{d}$±0.93 | 4.99$^{b}$±0.09 | 6.68$^{e}$±1.00 |

Values are in Mean±SD of triplicate determination.
Values within the same row with different superscript are significantly different ($p<0.05$)

The data revealed that incorporation of orange rind powder had a significant improvement in colour, flavour, taste and textural profile of the prepared cookies up to inclusion of 10% ORP as the sensory values are not significantly different ($p<0.05$) from those exhibited by the control. Further increase in addition of ORP to the tone of 15 and 20 % drastically affected the colour, flavour, taste and texture resulting in decreased values by the panellists. The control had highest ratings in all the sensory attributes. The colour scores showed that there was no significant difference ($p<0.05$) among samples, but characteristic bitter taste of ORP affected the taste of cookies and overall acceptability adversely beyond 10 %. Based on overall acceptability of cookies, the incorporation of orange rind powder in preparing cookies up to the level of 10 % is superior to all other samples. Similar results were reported by Zaker et al. (2016).

**pH of Cookies**

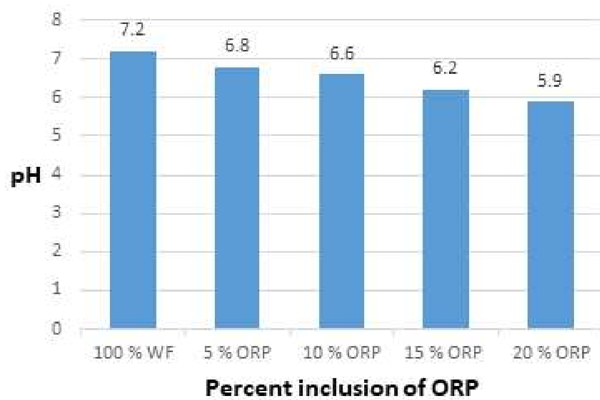


**Figure 3:** pH of whole wheat and supplemented cookies

Figure 3 showed changes in pH of cookie samples. The pH of all the samples decreased steadily from 7.2 (control) through 6.8, 6.6, 6.2 and 5.9 for 5, 10, 15 and 20% ORP substitution respectively. Samples are therefore low acidic food. The pH result obtained from this study implied a more stable shelf-life than the control sample. This stability in shelf-life result from inhibition of spoilage by different mold species (Cauvain 2017). The pH value of cookies decreased, or acidity is increased with increase in orange rind. This is due to the increase in acidic content arising from soluble sugars and pectin as the main components of orange rind. Similar results was reported by Ramashia et al. (2021).

**Conclusion**

The cookies prepared from incorporation of ORP up to 10 % had appreciable dietary fibre and ash than the control cookie, but with physical, sensorial qualities and overall acceptability as the control cookie. The study has shown that flour can be produced from the rinds of sweet orange. Hence, this would minimize the cost of cookie production. Consequently, it curbs associated environmental pollution by orange rinds. Further, it serves to fare malnutrition and hunger amongst the population, especially vulnerable groups and improve the nutritional status of growing children as they are the major consumers of cookies.

**Conflicts of Interest:** There is no conflict of interest to declare. All authors have read and agreed to the published version of the manuscript.

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