Journal of Food Technology Research
2020 Vol. 7, No. 1, pp. 69-77.
ISSN(e): 2312-3796
ISSN(p): 2312-6426
DOI: 10.18488/journal.58.2020.71.69.77

EFFECTS OF INCLUSION OF PROCESSED GRAPEFRUIT PULP ON WHEAT FLOUR BISCUIT

Roland Monday Kayode[1]
Victor Ephraim Edem[2+]
Niyi Julius Ogundun[3]
Rilwan Olaitan Ajibola[4]
Bukola Idowu Kayode[5]

[1,4,5]*University of Ilorin, Faculty of Agriculture, Department of Home Economics and Food Science, Division of Food Preservation, Biotechnology, Waste Management and Safety, Ilorin, Nigeria.*
[1]*Email: rowland@unilorin.edu.ng Tel: +2348035850545*
[4]*Email: ajibola.rilwan2016@gmail.com Tel: +2348032858301*
[5]*Email: kayodebukola2412@gmail.com Tel: +2348162179545*
[2]*Department of Natural and Environmental Sciences, Division of Microbiology, Crown-Hill University, Eiyenkorin, Ilorin, Kwara State, Nigeria.*
[2]*Email: victoredem001@yahoo.com Tel: +2348035118745*
[3]*Forest Research Institute of Nigeria, Jericho, Ibadan, Oyo State, Nigeria.*
[3]*Email: niyiogundun@gmail.com Tel: +2348033352168*


(+ Corresponding author)

Article History
Received: 20 January 2020
Revised: 26 February 2020
Accepted: 31 March 2020
Published: 29 April 2020

Keywords
Biscuit
Composite-flour
Fiber-fraction
Grapefruit-pulp
Sensory-qualities
Proximate-composition
Wheat-flour
Water-absorption-capacity
Oil-absorption-capacity.

ABSTRACT

Biscuits were produced from the composite flour of grapefruit pulp and wheat flour. The Grapefruit pulp was boiled, fermented and some unfermented separately. Nine composite flours were made from the fermented, boiled and unfermented grapefruit pulp at different ratios of 10:90, 20:80 and 30:70 respectively while the control was 100% wheat flour. The proximate composition ranged from 6.50-8.25% (moisture), 5.46-11.36% (protein), 1.5-9.75% (crude fiber), 0.5-1.75% (ash), 2.93-4.35% (fat), and 62.77-80.04% (carbohydrate). The water absorption capacity and oil absorption capacity ranged from 1.01-1.42 g water/g flour and 0.94- 1.56 g oil/g flour respectively. The values obtained for fiber fraction analysis ranged from 24- 44% (neutral detergent soluble), 11-39.75% (acid detergent fiber), 6.50-34.50% (lignin), 2.75-6.63% (silica), 2.5-7.5% (cellulose) and 5.00-20.50% (hemicellulose). The sensory scores of the biscuits indicated that sample 10BGP had the best overall acceptability among the composite flour pointing out high acceptability at up to 10% inclusion of grapefruit pulp flour to wheat flour. This research recommended the inclusion of boiled grapefruit pulp flour up to 10% with wheat flour for the production of biscuit.

Contribution/Originality: This study showed the variations in proximate composition, water and oil absorption capacities, fibre fraction, and sensory properties of biscuit as affected by different levels of grapefruit inclusion. The acceptable level of grapefruit pulp flour to wheat flour for biscuit production was established.

1. INTRODUCTION

The grapefruit (*Citrus paradisi*) is a subtropical citrus plant known for its sour to semi-sweet fruit. The grapefruit's name alludes to the cluster of the tree, which often appear similar to grape. Grapefruit is a rich source of vitamin C, providing more than 20% of the daily value in a 100g serving (Fellers, Nikdel, & Lee, 1990) contains fiber, most of which are present in the pulp (Cerda, Robbins, Burgin, Baumgartner, & Rice, 1988). The pink and red hues contain beneficial antioxidant lycopene (Lee, 2000). Platt (2000) reported that grapefruit helps to lower cholesterol in humans. In addition, the seeds have antioxidant properties (Amando, Maythe, & Beatriz, 1997). Most of the fiber in grapefruit are soluble which helps in lowering cholesterol, lengthens digestion time, which may aid in hunger control and helps slow the absorption of sugar.

Grapefruit can be eaten as food, or processed into grapefruit juice. The pulp of grapefruit can be processed to make it more palatable and be included in diet. Grapefruit pulp can be boiled or fermented to reduce the bitter taste, dried and milled. The processed grapefruit pulp can be combined with wheat flour to produce snacks like biscuits. Wheat is the most important staple food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crops (Adams, Lombi, Zhao, & McGrath, 2002).

Wheat is considered a good source of protein, minerals, B-group vitamins and dietary fiber. Although the environmental conditions can affect nutritional composition of wheat grains with its essential coating of bran, vitamins and minerals; it is an excellent health-building food. Wheat flour is used to prepare bread, produce biscuits, confectionary products, noodles and vital wheat gluten (Shewry et al., 2006). Biscuits have been produced from mixture of different flours of cereals and legume or root crops which is known as composite flour so as to satisfy specific functional characteristics and nutrients composition (Ubbor & Akobundu, 2009). Biscuit is a term used for a diverse variety of baked, commonly flour-based food products. It is a tasty nutritious snack consumed among all classes of people with tea or coffee. Among ready to eat snacks, biscuits and cookies are widely consumed throughout the world (Ishiwu, Nkwo, Iwouno, Obiegbuna, & Uchegbu, 2014).

2. MATERIALS AND METHODS

2.1. Source of Ingredients

Matured ripe grapefruits were purchase from a local store in Ilorin, Kwara State, Nigeria. Wheat flour, sugar, salt, fat, sodium bicarbonate (baking powder) and milk were purchased from Baboko new market in Ilorin, Kwara State, Nigeria, while all reagents used were obtained from the Departmental Laboratory of Food Science, University of Ilorin, Ilorin, Nigeria.

2.2. Processing of Grapefruit Pulp into Flour

The flowchart for grapefruit processing is shown in Figure 1. Grapefruits were sorted, cleaned and peeled. The grapefruit juice was extracted and the pulp was removed and subjected to three treatments. A portion of the pulp was fermented, drained, sundried, milled and packaged in airtight polythene bags. Another was boiled, drained, sundried, milled and packaged in airtight polythene bags.

The third treatment was sundried after pulp was removed, milled and packaged in airtight polythene bags. The dried grapefruit pulp flours were named with acronyms according to the treatment given as follows; Fermented Grapefruit Pulp (FGP), Boiled Grapefruit Pulp (BGP) and Unfermented Grapefruit Pulp (UGP). Nine composite flours were made from the fermented, boiled and unfermented grapefruit pulp at different ratios of 10:90, 20:80 and 30:70 respectively while the control was 100% wheat flour.

2.3. Proximate Analysis of Grapefruit Pulp and Wheat Composite Flour

The proximate compositions of grapefruit pulp and wheat composite flour samples were analyzed using the standard methods of AOAC (2005).

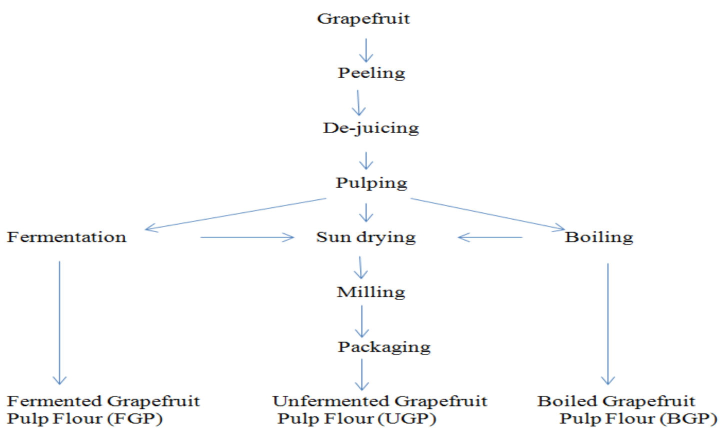

Figure-1. Flowchart for the production of grapefruit pulp flour.

2.4. Water Absorption Capacity of Composite Flour

This was determined using the method of AOAC (2010). One gram of the sample was dispensed into a weighed centrifuge tube with 10ml of distilled water and mixed thoroughly. The mixture was allowed to stand for 1 hour before being centrifuged at 3500rpm for 30 minutes. The excess water (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain dry. The weight of water absorbed was determined by difference. The water absorption capacity (WAC) was calculated as:

$$\text{WAC (\%)} = \frac{\text{Volume of water used} - \text{Volume of free water}}{\text{Weight of sample used}} \times 100$$

2.5. Oil Absorption Capacity of Composite Flour

This was determined using the method of AOAC (2010). One (1) gram of the sample was dispensed into a weighed centrifuge tube with 10ml of vegetable oil and mixed thoroughly. The mixture was allowed to stand for one (1) hour before being centrifuged at 3500rpm for 30 minutes. The excess oil (unabsorbed) was decanted and the tube inverted over an adsorbent paper to drain and dry. The weight of oil absorbed was determined by deducting the volume of free oil from volume of oil used and further dividing by weight of sample used. The oil absorption capacity (OAC) was calculated as:

$$\text{OAC (\%)} = \frac{\text{Volume of oil used} - \text{Volume of free oil}}{\text{Weight of sample used}} \times 100$$

2.6. Determination of pH

Degree of alkalinity and acidity (pH) was determined using hand pH meter. About 5g of the flour sample was weighed into a beaker containing 25 ml of distilled water and allowed to stand for 30minutes with constant stirring. The pH was then determined using pH meter (AOAC, 2000).

2.7. Determination of Total Titratable Acidity (TTC)

About 25 ml of sample was distilled under reflux for 20 min to expel carbon (iv) oxide. The condensate was then washed with water and titrated with 0.1 M NaOH using bromothymol blue as indicator (AOAC, 2000).

$$\text{Titratable Acidity (mg/Kg)} = \frac{V \times 0.07 \times 100}{25}$$

Where; V = Volume of acid used.

2.8. Pasting Properties Determination of Composite Flour

Pasting characteristics was determined with a Rapid Visco Analyzer (RVA), (Model RVA3D+, Network Scientific, Australia). About 2.5 g of samples were weighed into a dried empty canister; 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 500 to 950 ^{0}C with a holding time of 2 min flowed by cooling to 500 ^{0}C with 2 min holding time. The rate of heating and cooling was at a constant rate of 11.25 ^{0}C /min. Peak viscosity, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1988).

2.9. Fiber Fraction Analysis of Grapefruit Pulp and Wheat Composite Flour

The Van Soest (1982) method of forage evaluation was used for estimating the Neutral Detergent Soluble (NDS), Acid Detergent Fiber (ADF), Lignin, Silica, Cellulose and Hemicellulose.

2.10. Sensory Analysis of Biscuits Produced With Blends of Grapefruit Pulp and Wheat Flour

Sensory evaluation of biscuit produced from composite of grapefruit pulp and wheat flours was done by 20 panelist using nine-point hedonic scale and multiple comparison test as described by Ihekoronye and Ngoddy (1985). The scale ranged from like extremely (9) to dislike extremely (1). Each of the samples was rated for appearance, aroma, taste, texture, mouth-feel and overall acceptability using the method of Iwe (2001).

2.11. Statistical Analysis

The mean values of data obtained were subjected to multiple analyses of variance (ANOVA) at 5 % significance level ($p \leq 0.05$), using statistical package for social sciences (SPSS) version 20.0. The mean values were separated using Duncan's multiple range tests.

3. RESULTS AND DISCUSSION

3.1. Proximate Compositions

The proximate compositions of grapefruit pulp and wheat flour blends at different proportions are shown in Table 1.

Table-1. Proximate composition of grapefruit pulp and wheat flour blends.

Samples	Moisture%	Protein%	Ash%	Fat%	Fiber%	Carbohydrate%
10FGP	$7.25^{a} \pm 0.35$	$6.33^{i} \pm 0.01$	$0.75^{ab} \pm 0.35$	$3.77^{a} \pm 0.1$	$3.00^{d} \pm 0.70$	$78.89^{ab} \pm 0.71$
10UGP	$8.25^{a} \pm 2.47$	$5.46^{j} \pm 0.01$	$1.00^{ab} \pm 0.00$	$3.49^{a} \pm 1.86$	$1.75^{d} \pm 0.35$	$80.04^{a} \pm 0.24$
10BGP	$7.25^{a} \pm 0.35$	$8.87^{g} \pm 0.01$	$0.75^{ab} \pm 0.35$	$3.50^{a} \pm 0.38$	$3.25^{d} \pm 1.76$	$75.87^{abc} \pm 3.57$
20FGP	$8.25^{a} \pm 1.76$	$9.14^{f} \pm 0.06$	$1.00^{ab} \pm 0.00$	$4.35^{a} \pm 1.45$	$5.50^{c} \pm 0.00$	$71.75^{abc} \pm 0.37$
20UGP	$6.75^{a} \pm 1.76$	$7.45^{h} \pm 0.01$	$1.25^{bc} \pm 0.35$	$2.93^{a} \pm 0.39$	$8.50^{ab} \pm 2.12$	$73.12^{abc} \pm 0.41$
20BGP	$7.25^{a} \pm 0.35$	$9.84^{d} \pm 0.00$	$1.25^{bc} \pm 0.35$	$3.23^{a} \pm 0.01$	$7.25^{bc} \pm 0.35$	$71.17^{abcd} \pm 0.36$
30FGP	$7.00^{a} \pm 0.70$	$9.64^{e} \pm 0.02$	$1.75^{a} \pm 0.35$	$3.22^{a} \pm 1.52$	$8.00^{ab} \pm 0.00$	$70.38^{bcd} \pm 1.19$
30UGP	$7.75^{a} \pm 3.89$	$10.03^{c} \pm 0.04$	$1.25^{bc} \pm 0.35$	$3.69^{a} \pm 0.75$	$9.75^{a} \pm 1.06$	$62.77^{d} \pm 10.61$
30BGP	$6.50^{a} \pm 0.00$	$11.36^{a} \pm 0.02$	$1.75^{a} \pm 0.35$	$2.94^{a} \pm 1.13$	$8.25^{ab} \pm 0.35$	$69.19^{cd} \pm 1.11$
WHF	$8.25^{a} \pm 1.06$	$10.97^{b} \pm 0.40$	$0.5^{c} \pm 0.00$	$2.95^{a} \pm 0.36$	$1.5^{d} \pm 0.00$	$75.82^{abc} \pm 0.37$

Note: Means with the same superscripts along a column are not significantly different ($p \leq 0.05$); 10FGP = Fermented grapefruit pulp (10%) + wheat flour (90%); 20FGP = Fermented grapefruit pulp (20%) + wheat flour (80%); 30FGP = Fermented grapefruit pulp (30%) + wheat flour (70%); 10UGP = Unfermented grapefruit pulp (10%) + wheat flour (90%); 20UGP = Unfermented grapefruit pulp (20%) + wheat flour (80%); 30UGP = Unfermented grapefruit pulp (30%) + wheat flour (70%); 10BGP = Boiled grapefruit pulp (10%) + wheat flour (90%); 20BGP = Boiled grapefruit pulp (20%) + wheat flour (80%); 30BGP = Boiled grapefruit pulp (30%) + wheat flour (70%); WHF = Wheat flour (100%).

The moisture content of the composite flour ranged from 6.50- 8.25% with Sample 30BGP having the least value of moisture content indicating that the higher the inclusion of grapefruit pulp the lower the moisture content which may contribute to longer shelf life showing a better possibility of high storability due to lower moisture content which may not support the rapid growth of microorganism (Frazier & Westhoff, 1995). There was no significant difference in the moisture content of the samples with similar values reported by Emojorho and Akubor (2016).

The protein values of the composite flour ranged from 5.46 (10UGP) to 11.36% (30BGP). There was significant difference ($P<0.05$) in the protein values of the composite flour samples Table 1. Sample 30BGP had highest crude protein content compared to similar proportion of other treatments of grapefruit pulp and wheat composite flour which had lower values. Protein content is the best single test that can be applied to determine the quality of flour, because it has a direct correlation with baking quality (Matz, 1996; Stone & Savin, 1999).

The crude fiber content ranged from 1.50 to 9.75%. Sample WHF (100% wheat flour) had least fiber content while sample 30UGP had the highest. The high level of fiber may be significant in human nutrition. Reports have shown that fiber aids in lowering blood glucose level (Anderson et al., 2009). Health benefits of dietary fiber indicated protection against cardiovascular diseases, diabetes and obesity (Spiller, 2001). A generous intake of dietary fiber may reduce the risk for developing coronary heart disease, stroke, hypertension, diabetes, obesity, and certain gastrointestinal disorders (Marangoni & Poli, 2008). The total ash content ranged from 0.5 to 1.75 %. Sample WHF (control) had least total ash while samples 30FGP and 30BGP had higher total ash content compared with others. Ash content of food is an indication of the mineral content (Ajala, 2009). Minerals have been proven to provide structure to bones and teeth and participate in energy production, building of protein, blood formation and several other metabolic processes (Wardlaw, 1999). There was no significant difference ($p<0.05$) in the crude fat content of the composite flour of grapefruit pulp and wheat. The mean values ranged from 2.93 to 4.35%, while carbohydrate content ranged from 62.77% to 80.04% with Sample 30UGP having the least value of 62.77%.

3.2. Functional Properties of Flour Blends

Functional properties of the flour blend are shown in Table 2. The water absorption capacity ranged from 1.01-1.42 g water/g flour. The water absorption capacity (WAC) of the flour varied significantly ($p<0.05$) with sample 20BGP having the highest value of 1.42 g water/g flour. The variation in WAC could be due to the different sizes of the granules of the formulation which may enhance the ability of the flour to absorb water. Water absorption capacity of flour could be an important attributes of food materials; since low water absorption capacity is often a major to compactness of the molecular structure of foodstuffs, while high values of water content may contribute to loose structure of the starch polymers of food stuffs. The oil absorption capacity (OAC) ranged from 0.94 – 1.56 g oil/g flour. Absorption of oil by food products had contributed to improved mouth feel and retained food flavour. Onimawo and Egbekun (1998) stated that oil binding by protein is a function of the size, shape, pH, ionic strength, temperature, presence or absence of surfactant and solubility of the protein molecules.

Table-2. Functional properties, total titratable acidity and pH of composite flour made from grapefruit pulp and wheat.

Samples	WAC (g water/g flour)	OAC (g oil/g flour)	TTA (mg/Kg)	pH
10FGP	$1.23^{c}\pm 0.01$	$1.15^{e}\pm 0.01$	$0.112^{de}\pm 0.00$	$4.25^{e}\pm 0.07$
10UGP	$1.01^{g}\pm 0.01$	$1.33^{d}\pm 0.01$	$0.141^{d}\pm 0.00$	$5.15^{b}\pm 0.07$
10BGP	$1.29^{b}\pm 0.01$	$1.03^{f}\pm 0.4$	$0.102^{ef}\pm 0.01$	$4.50^{e}\pm 0.00$
20FGP	$1.18^{d}\pm 0.01$	$1.41^{c}\pm 0.01$	$0.076^{f}\pm 0.01$	$3.95^{f}\pm 0.07$
20UGP	$1.04^{fg}\pm 0.01$	$1.50^{b}\pm 0.01$	$0.280^{b}\pm 0.01$	$4.75^{c}\pm 0.07$
20BGP	$1.42^{a}\pm 0.03$	$0.94^{g}\pm 0.01$	$0.140^{e}\pm 0.00$	$4.20^{e}\pm 0.00$
30FGP	$1.18^{d}\pm 0.01$	$1.53^{ab}\pm 0.02$	$0.072^{f}\pm 0.00$	$3.85^{f}\pm 0.07$
30UGP	$1.14^{e}\pm 0.0$	$1.56^{a}\pm 0.01$	$0.413^{a}\pm 0.04$	$4.55^{d}\pm 0.07$
30BGP	$1.32^{b}\pm 0.01$	$1.11^{e}\pm 0.01$	$0.179^{c}\pm 0.01$	$3.95^{f}\pm 0.07$
WHF	$1.05^{f}\pm 0.01$	$1.04^{f}\pm 0.00$	$0.154^{g}\pm 0.11$	$5.80^{a}\pm 0.14$

Note: Means with the same superscripts along a column are not significantly different ($p\leq0.05$); 10FGP = Fermented grapefruit pulp (10%) + wheat flour (90%); 20FGP = Fermented grapefruit pulp (20%) + wheat flour (80%); 30FGP = Fermented grapefruit pulp (30%) + wheat flour (70%); 10UGP = Unfermented grapefruit pulp (10%) + wheat flour (90%); 20UGP = Unfermented grapefruit pulp (20%) + wheat flour (80%); 30UGP = Unfermented grapefruit pulp (30%) + wheat flour (70%); 10BGP = Boiled grapefruit pulp (10%) + wheat flour (90%); 20BGP = Boiled grapefruit pulp (20%) + wheat flour (80%); 30BGP = Boiled grapefruit pulp (30%) + wheat flour (70%); WHF = Wheat flour (100%).

The titratable acidity (TTA) and pH analysis of grapefruit pulp and wheat flour blends are shown in Table 2. The pH values ranged from 3.85 to 5.80. TTA mean values ranged from 0.072 to 0.413 mg/Kg. The low pH could indicate higher ionic strength and may lead to better keeping quality of the flour compared with the control having pH 5.80.

3.3. Pasting properties of the Flour

The pasting properties are shown in Table 3. The peak viscosity ranged from 160.80 – 242.65 RVU with sample 30UGP having the least and sample 10FGP having the highest peak viscosity. Peak viscosity has been reported as indices of the water binding capacity of starch (Ikegwu, Okechukwu, & Ekumankana, 2010). The low peak viscosity exhibited by sample 30UGP shows that the flour may not be suitable for products that require high gel strength and elasticity while being suitable in the preparation of complementary foods. The trough viscosity, which is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling ranged between 87.15 – 142.05 RVU. The breakdown viscosity is an index of the stability of starch. The low values suggest high stability of flour to withstand heat and shear stress. In other words, the higher the breakdown viscosity, the lower the ability of the flour to withstand heating and shear stress during cooking (Adebowale, Adeyemi, & Oshodi, 2005).

Table-3. Pasting properties of flour blends made from grapefruit pulp and wheat.

Sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak Time (min)	Pasting Temperature(°C)
10FGP	242.65^{a}±0.71	142.05^{a}±0.71	100.50^{a}±1.41	261.05^{a}±0.71	119.05^{b}±0.71	6.13^{b}± 0.01	70.95^{de}±0.01
10UGP	190.75^{h}±0.71	106.15^{f}± 0.71	84.60^{h}±1.41	207.20^{f}±1.41	101.25^{e}±0.71	6.07^{b}± 0.01	89.75^{a}± 0.21
10BGP	194.60^{g}±1.41	105.65^{g}± 0.71	88.95^{e}±0.71	175.20^{h}±1.41	69.80^{h}± 1.41	5.65^{d}± 0.07	70.25^{e}± 0.07
20FGP	220.40^{b}±1.41	121.95^{c}± 0.71	98.65^{b}±0.71	225.25^{c}±0.71	103.40^{c}±0.00	5.75^{c}± 0.02	70.00^{e}± 0.00
20UGP	200.90^{f}± 1.41	105.75^{g}± 0.71	95.15^{c}±0.71	188.05^{g}±0.71	82.35^{g}± 0.71	5.65^{d}± 0.07	87.85^{b}± 0.91
20BGP	212.95^{d}±0.71	121.25^{d}± 0.71	91.80^{d}±1.41	223.75^{d}±0.71	102.60^{d}±1.41	6.08^{b}± 0.01	72.58^{c}± 0.04
30FGP	207.70^{e}±0.00	120.95^{e}± 0.71	86.80^{g}±0.00	213.20^{e}±0.00	92.35^{f}± 0.71	5.68^{d}± 0.01	71.50^{d} ±0.71
30UGP	160.80^{i}± 1.41	87.15^{h}± 0.71	73.65^{i}± 0.71	148.55^{i}± 0.71	61.45^{i}± 0.71	5.54^{e}± 0.01	87.90^{b}± 0.00
30BGP	207.75^{e}±0.71	121.00^{e}± 1.41	86.75^{g}±0.71	213.20^{e}±0.00	92.35^{f}± 0.71	5.68^{cd}±0.01	71.50^{d}± 0.71
WHF	213.80^{c}±1.41	125.65^{b}± 0.71	88.15^{f}±0.71	247.55^{b}±0.71	121.95^{a}±0.71	6.34^{a}± 0.01	88.85^{ab}±0.07

Note: Means with the same superscripts along a column are not significantly different ($p \leq 0.05$); 10FGP = Fermented grapefruit pulp (10%) + wheat flour (90%); 20FGP = Fermented grapefruit pulp (20%) + wheat flour (80%); 30FGP = Fermented grapefruit pulp (30%) + wheat flour (70%); 10UGP = Unfermented grapefruit pulp (10%) + wheat flour (90%); 20UGP = Unfermented grapefruit pulp (20%) + wheat flour (80%); 30UGP = Unfermented grapefruit pulp (30%) + wheat flour (70%); 10BGP = Boiled grapefruit pulp (10%) + wheat flour (90%); 20BGP = Boiled grapefruit pulp (20%) + wheat flour (80%); 30BGP = Boiled grapefruit pulp (30%) + wheat flour (70%); WHF = Wheat flour (100%).

The final viscosity ranged from 148.55 – 261.05 RVU. Final viscosity has been used to define the particular quality of flour and may indicate the stability of the cooked paste when in actual use. It could also indicate the ability of flour to form various paste or gel after cooling. The final viscosity may give an idea of the ability of a material to gel after cooking. The setback values of composite flour ranged from 61.45 – 121.95 with 100% wheat flour having the highest value. The peak time ranged from 5.54 – 6.34 min. Peak time had been described as a measure of the cooking time (Adebowale et al., 2005). The pasting temperature ranged from 70 to 89.75 °C. The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability (Shimelis, Meaza, & Rakshit, 2006). Hence, pasting properties of these flours are important indices in predicting the pasting behaviour during and after cooking.

3.4. Fibre Fraction Composition

The mean values for fiber fraction composition of grapefruit pulp and wheat composite flour are shown in Table 4. The values of fiber fraction gave an idea of the degree of food digestibility. Crude fiber as determined is not chemically a uniform substance but a variable mixture, the major components of which are cellulose, hemicellulose and lignin (Van Soest, Robertson, & Lewis, 1991). The Neutral Detergent Soluble (NDS) of the composite flour ranged from 24 – 44 % with sample 10FGP having the highest value and sample 10UGP with the lowest. The Neutral Detergent Soluble (NDS) consists most part of the cell content. Acid Detergent Fiber (ADF) values ranged from 11-39.75%. Acid Detergent Fiber is important in fiber analysis to determine the percentage lignin and silica present in food. The lignin content of the composite flour ranged from 6.50 to 34.50% with sample 30FGP having the highest value; this could be as a result of the fermentation treatment on the grapefruit pulp while silica's mean values ranged from 2.75 to 6.63%. Both lignin and silica are essentially indigestible even by microorganisms. The cellulose and hemicellulose are content of the cell wall and contribute to the cell structure. The cellulose content of the composite flour ranged from 2.5 to 7.5%, while the hemicellulose ranged from 7.50 to 20.50%. The values were significantly higher compared with the control sample (5.00%).

Table-4. Fiber fraction composition of grapefruit pulp and wheat composite flour.

SAMPLE	NDS (%)	ADF (%)	Lignin (%)	Silica (%)	Cellulose (%)	Hemicellulose (%)
10FGP	$44.00^{ab}\pm0.00$	$23.50^{d}\pm 0.71$	$10.75^{f}\pm 0.35$	$5.50^{b} \pm 0.71$	$7.75^{a} \pm 0.35$	$7.50^{f}\pm 0.71$
10UGP	$24.00^{d}\pm 1.41$	$11.00^{g} \pm 0.71$	$6.50^{g} \pm 0.71$	$2.75^{d}\pm 0.35$	$2.50^{e} \pm 0.71$	$9.75^{e} \pm 0.35$
10BGP	$36.50^{c}\pm 0.71$	$18.25^{f}\pm 0.35$	$9.25^{f} \pm 0.35$	$3.75^{cd}\pm 0.35$	$5.75^{b}\pm 0.35$	$13.50^{bc} \pm 0.71$
20FGP	$39.50^{bc}\pm 0.71$	$30.00^{b} \pm 0.71$	$23.50^{c}\pm 0.71$	$3.75^{cd}\pm 0.35$	$3.10^{de}\pm 0.14$	$12.75^{cd} \pm 0.35$
20UGP	$25.50^{d}\pm 0.71$	$20.00^{e} \pm1.41$	$10.25^{f}\pm 0.35$	$6.63^{a} \pm 0.18$	$2.75^{de} \pm 0.35$	$20.50^{a} \pm 0.71$
20BGP	$47.00^{a} \pm1.41$	$22.00^{d} \pm 0.71$	$12.75^{e}\pm 0.35$	$2.75^{d}\pm 0.35$	$6.75^{ab}\pm 0.35$	$14.75^{b} \pm 0.35$
30FGP	$40.00^{bc}\pm 2.82$	$39.75^{a} \pm 0.35$	$34.50^{a}\pm 0.71$	$2.75^{d} \pm 0.35$	$3.50^{cde}\pm 0.71$	$11.75^{d} \pm 0.35$
30UGP	$42.00^{b} \pm 0.00$	$39.50^{a} \pm 0.71$	$30.50^{b}\pm0.71$	$5.50^{b} \pm 0.71$	$4.50^{c} \pm 0.71$	$13.50^{bc} \pm 0.71$
30BGP	$46.50^{a} \pm 2.12$	$31.25^{b} \pm 0.35$	$23.50^{c}\pm0.71$	$4.75^{bc}\pm 0.35$	$3.75^{cd} \pm 0.35$	$20.50^{a} \pm 0.71$
WHF	$26.00^{d} \pm 4.24$	$26.75^{c} \pm 0.35$	$21.00^{d}\pm1.41$	$4.50^{bc}\pm 0.71$	$2.75^{de}\pm 00.35$	$5.00^{g} \pm 0.71$

Note: Means with the same superscripts along a column are not significantly different ($p\leq0.05$); 10FGP = Fermented grapefruit pulp (10%) + wheat flour (90%); 20FGP = Fermented grapefruit pulp (20%) + wheat flour (80%); 30FGP = Fermented grapefruit pulp (30%) + wheat flour (70%); 10UGP = Unfermented grapefruit pulp (10%) + wheat flour (90%); 20UGP = Unfermented grapefruit pulp (20%) + wheat flour (80%); 30UGP = Unfermented grapefruit pulp (30%) + wheat flour (70%); 10BGP = Boiled grapefruit pulp (10%) + wheat flour (90%); 20BGP = Boiled grapefruit pulp (20%) + wheat flour (80%); 30BGP = Boiled grapefruit pulp (30%) + wheat flour (70%); WHF = Wheat flour (100%).

3.5. Sensory Evaluation

The mean sensory scores of the biscuits produced from grapefruit pulp and wheat composite flour at different proportions are shown in Table 5. The ratings of the various sensory attributes were significantly different ($p<0.05$). In terms of aroma qualities, sample 10BGP had the highest score of 8.55 while sample 30UGP had the least score of 6.90. There was no significant difference ($p<0.05$) in the texture except for sample 10BGP that had the highest score of 8.35. Colour attributes ranged from 6.45-8.15. Sample 30UGP had the least score of 4.00 for taste while the control (100% wheat flour) had the highest score of 8.90 followed by sample 10BGP with mean score of 8.00. Sample 10BGP had the highest overall acceptability. The substitution of wheat flour with grapefruit pulp flour above 10% for production of biscuits gives a bitter after taste which is undesirable.

Table-5. Sensory scores of biscuits made from composite flour of grapefruit pulp and wheat.

Sample	Aroma	Taste	Colour	Texture	Overall Acceptability
10FGP	$7.45^{bc}\pm 0.94$	$6.75^{b}\pm 0.79$	$6.80^{bcd}\pm 1.05$	$7.00^{b}\pm 1.07$	$7.00^{c}\pm 0.56$
20FGP	$7.40^{bcd}\pm 0.68$	$6.25^{bc}\pm 0.79$	$6.60^{cd}\pm 0.68$	$6.85^{b}\pm 0.87$	$6.45^{def}\pm 0.67$
30FGP	$7.25^{cd}\pm 0.72$	$5.80^{cd}\pm 1.28$	$6.80^{bcd}\pm 0.76$	$6.65^{b}\pm 0.81$	$6.45^{def}\pm 0.75$
10UGP	$7.30^{cd}\pm 0.80$	$5.95^{bcd}\pm 1.57$	$7.05^{bc}\pm 0.76$	$7.25^{b}\pm 1.07$	$6.80^{cd}\pm 0.83$
20UGP	$7.15^{cd}\pm 0.59$	$5.60^{cd}\pm 1.39$	$6.90^{bcd}\pm 0.72$	$7.00^{b}\pm 0.73$	$6.45^{def}\pm 0.76$
30UGP	$6.90^{d}\pm 0.64$	$4.00^{e}\pm 1.68$	$6.45^{d}\pm 0.83$	$6.80^{b}\pm 0.89$	$5.95^{f}\pm 0.99$
10BGP	$8.55^{a} \pm 0.51$	$8.00^{b}\pm 0.64$	$8.15^{a}\pm 0.93$	$8.35^{a}\pm 0.67$	$8.30^{a}\pm 0.57$
20BGP	$7.30^{cd}\pm 0.80$	$5.30^{d}\pm 1.41$	$7.10^{bc}\pm 0.72$	$7.25^{b}\pm 1.20$	$6.50^{def}\pm 0.69$
30BGP	$7.00^{cd}\pm 0.79$	$4.40^{e}\pm 1.67$	$6.80^{bcd}\pm 0.52$	$7.10^{b}\pm 0.97$	$6.25^{ef}\pm 0.97$
WHF	$7.85^{b}\pm 0.49$	$8.90^{a}\pm 0.64$	$7.35^{b}\pm 0.99$	$7.30^{b}\pm 0.92$	$7.60^{b}\pm 0.75$

Note: Means with the same superscripts along a column are not significantly different ($p\leq0.05$); 10FGP = Fermented grapefruit pulp (10%) + wheat flour (90%); 20FGP = Fermented grapefruit pulp (20%) + wheat flour (80%); 30FGP = Fermented grapefruit pulp (30%) + wheat flour (70%); 10UGP = Unfermented grapefruit pulp (10%) + wheat flour (90%); 20UGP = Unfermented grapefruit pulp (20%) + wheat flour (80%); 30UGP = Unfermented grapefruit pulp (30%) + wheat flour (70%); 10BGP = Boiled grapefruit pulp (10%) + wheat flour (90%); 20BGP = Boiled grapefruit pulp (20%) + wheat flour (80%); 30BGP = Boiled grapefruit pulp (30%) + wheat flour (70%); WHF = Wheat flour (100%).

4. CONCLUSION

The composite flour made from grapefruit pulp and wheat has increased nutritional value and dietary fibre. The sensory scores of the biscuits made indicated that sample 10BGP had the best overall acceptability among the flour treatments, pointing out high acceptability at up to 10% inclusion of grapefruit pulp-wheat flour for the production of biscuit.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: All authors contributed equally to the conception and design of the study.

REFERENCES

Adams, M. L., Lombi, E., Zhao, F.-J., & McGrath, S. P. (2002). Evidence of low selenium concentrations in UK bread-making wheat grain. *Journal of the Science of Food and Agriculture, 82*(10), 1160-1165.Available at: https://doi.org/10.1002/jsfa.1167.

Adebowale, Y., Adeyemi, I., & Oshodi, A. (2005). Functional and physicochemical properties of flours of six Mucuna species. *African Journal of Biotechnology, 4*(12), 1461-1468.

Ajala, L. (2009). The effect of boiling on the nutrients and anti-nutrients in two non-conventional vegetables. *Pakistan Journal of Nutrition, 8*(9), 1430-1433.Available at: https://doi.org/10.3923/pjn.2009.1430.1433.

Amando, C., Maythe, S., & Beatriz, N. P. (1997). Antioxidant activity of grapefruit seed extract on vegetable oils. *Journal of the Science of Food and Agriculture, 77*(4), 463-467.

Anderson, J. W., Baird, P., Davis, R. H., Ferreri, S., Knudtson, M., Koraym, A., & Williams, C. L. (2009). Health benefits of dietary fiber. *Nutrition Reviews, 67*(4), 188-205.

AOAC. (2000). *Official methods of analysis* (17th ed. Vol. 2). Gaithersburg, MD, USA: Association of Official Analytical Chemists.

AOAC. (2005). *Official methods of analysis* (18th ed.). Gaithersburg MD: Association of Official Analytical Chemists.

AOAC. (2010). *Official methods of analysis* (18th ed.). Washington, D.C, USA: Association of Official Analytical Chemists.

Cerda, J., Robbins, F., Burgin, C., Baumgartner, T., & Rice, R. (1988). The effects of grapefruit pectin on patients at risk for coronary heart disease without altering diet or lifestyle. *Clinical Cardiology, 11*(9), 589-594.Available at: https://doi.org/10.1002/clc.4960110902.

Emojorho, E. E., & Akubor, P. I. (2016). Effect of debittering methods on the proximate composition, sensory and functional properties of orange (Citrus sinensis) seed flour. *IOSR Journal of Environmental Science, Toxicology and Food Technology, 10*(9), 9-16.Available at: https://doi.org/10.9790/2402-1009010916.

Fellers, P., Nikdel, S., & Lee, H. (1990). Nutrient content and nutrition labeling of several processed Florida citrus juice products. *Journal of the American Dietetic Association, 90*(8), 1079-1084.

Frazier, W. C., & Westhoff, D. C. (1995). Food microbiology (4th ed., pp. 10). New Delhi, India: Tata McGraw-Hill Publishing Company Ltd.

Ihekoronye, A., & Ngoddy, P. O. (1985). Integrated food science and technology for the tropics (pp. 285). United Kingdom: Macmillan Publishers.

Ikegwu, O., Okechukwu, P., & Ekumankana, E. (2010). Physico-chemical and pasting characteristics of flour and starch from achi Brachystegia eurycoma seed. *Journal of Food Technology, 8*(2), 58-66.Available at: https://doi.org/10.3923/jftech.2010.58.66.

Ishiwu, C., Nkwo, V., Iwouno, J., Obiegbuna, J., & Uchegbu, N. (2014). Optimization of taste and texture of biscuit produced from blend of plantain, sweet potato and malted sorghum flour. *African Journal of Food Science, 8*(5), 233-238.Available at: https://doi.org/10.5897/ajfs2013.1112.

Iwe, M. O. (2001). Handbook of sensory methods and analysis (pp. 32-78). Enugu, Nigeria: Rojoint Communication Services Ltd.

Lee, H. S. (2000). Objective measurement of red grapefruit juice color. *Journal of Agricultural and Food Chemistry, 48*(5), 1507-1511.Available at: https://doi.org/10.1021/jf9907236.

Marangoni, F., & Poli, A. (2008). The glycemic index of bread and biscuits is markedly reduced by the addition of a proprietary fiber mixture to the ingredients. *Nutrition, Metabolism and Cardiovascular Diseases, 18*(9), 602-605.Available at: https://doi.org/10.1016/j.numecd.2007.11.003.

Matz, S. A. (1996). *Chemistry and technology of cereals as food and feed*. New York: Van Nostrand Reinhold.

Newport Scientific. (1988). Applications manual for the rapid viscotmanalyzer using thermocline for windows (pp. 2-26). Austrialia: Newport Scientific Pty Ltd.

Onimawo, A. I., & Egbekun, K. M. (1998). Comprehensive science and nutrition (pp. 103-208). Benin City, Nigeria: Ambik Press Ltd.

Platt, R. (2000). Current concepts in optimum nutrition for cardiovascular disease. *Preventive Cardiology, 3*(2), 83-87.Available at: https://doi.org/10.1111/j.1520-037x.2000.80364.x.

Shewry, P. R., Powers, S., Field, J. M., Fido, R. J., Jones, H. D., Arnold, G. M., & Barro, F. (2006). Comparative field performance over 3 years and two sites of transgenic wheat lines expressing HMW subunit transgenes. *Theoretical and Applied Genetics, 113*(1), 128-136.Available at: https://doi.org/10.1007/s00122-006-0279-1.

Shimelis, A. E., Meaza, M., & Rakshit, S. (2006). Physico-chemical properties, pasting behavior and functional of flours and starches from improved bean (Phaseolus vulgaris L.) varieties grown in East Africa. *Agricultural Engineering International. The International Council on Large Electric Systems Journal, 8*, 18 –36.

Spiller, G. A. (2001). CRC handbook of dietary fiber in human nutrition (3rd ed., pp. 363 - 365). Raton. Florida: CRC Press Boca.

Stone, P. J., & Savin, R. (1999). Grain quality and its physical determinants. determination ecology and physiology of wheat yield. (Eds.), Satorre. E. H. and Slafer, G. A (pp. 85-120). New York: Food Products Press.

Ubbor, S. C., & Akobundu, E. N. T. (2009). Quality characteristics of cookies from composite flour of water melon seed, cassava and wheat. *Pakistan Journal of Nutrition, 8*(7), 1095-1102.Available at: https://doi.org/10.3923/pjn.2009.1097.1102.

Van Soest, P. J. (1982). *Nutritional ecology of ruminant*. Ithaca, NY, USA: Cornell University Press.

Van Soest, P. J., Robertson, J. D., & Lewis, B. A. (1991). Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74*(10), 3583-3597.Available at: https://doi.org/10.3168/jds.s0022-0302(91)78551-2.

Wardlaw, G. M. (1999). Perspectives of nutrition (4th ed., pp. 23-40). Boston: WCB/ McGraw-Hill.