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Effects of passion fruit peel powder concentration and baking temperature on the physicochemical, antioxidant, and sensory characteristics of the made biscuits

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Abstract
Passion fruit (Passiflora edulis) which belongs to the family Passifloraceae, is an attractive high-value crop. Among varieties of tropical fruit, purple passion fruit peel has been increasingly paid attention to the basis of the nutritional aspects as they are excellent sources of powerful natural antioxidants that provide various health-beneficial effects. Then consequently, a successful combination of Passion fruit peel flour with wheat flour for biscuits production would be nutritionally advantageous. In this study, purple passion fruit peel was incorporated with wheat flour in ratios of 0%, 5%, 10%, and 15%. The physicochemical analysis and sensory evaluation were conducted to know the acceptability of developed biscuits. Based on nutritional value, biscuits containing 15% passion fruit peel flour had significantly higher ash, fiber, amount of antioxidant, and total phenolic content than those in the control samples. As a result, baking always resulted in a general decrease in TPC, even at 160 °C, and the loss of antioxidant activity of Passion fruit peel flour during bread baking was avoided by heating at high temperatures. Besides, 5% and 10% passion fruit peel flour-biscuits also predominated the most in sensorial acceptability. The collected results of this study witnessed an improvement in terms of nutritional value, health benefits, and a high potential of being accepted by consumers of developed biscuits.

Keywords: Passion fruit peel powder, Biscuits, Temperature, Nutritional value, Antioxidant, Total phenolic content, Fiber content, Sensory evaluation.

Introduction

Passion fruit is widely grown in South America, Asia, Oceania, and Africa and comprises approximately 450-500 species (Dhawan et al., 2004; Ferreres et al., 2007) [1, 2]. The passion fruit vine belongs to the family Passifloraceae and the genus Passiflora. It is a native plant of tropical America and is cultivated in regions with tropical or subtropical climates (Kishore, Pathak, Shuklar, & Bhar, 2011) [3]. Passion fruit industrialization is generally aimed at juice and nectar production. In this process, 54,000 tons of by-products, such as seeds and peel, are generated per year in Brazil. Albedo (or pith), the main peel component, is rich in fiber and pectin and can be used as an ingredient in the preparation of functional foods. Furthermore, it can be added to products that require an increase in viscosity (Lopez-Vargas, MendezanLopezL Perez Perez- Alvarez, & ViudaMartos, 2013) [4].

In Vietnam, passion fruit is well grown in the central highland parts of the country.

It is worth noting that in the production process of passion fruit juice, a large amount of peel waste is produced, and the quantity this peel accounts for more than half of the total mass of the fruit (Silva et al., 2014) [5]. The main component of the peel is the pith, containing a large amount of fiber and pectin, which can be used in the production of functional foods (Coelho et al., 2017) [6].

Biscuits have been one of the oldest baked goods and consumed extensively all over the world by all age groups. The popularity of biscuits comes from their attributes such as high palatable, dense nutrients, quickly released energy and available in convenient sizes as well as in various forms. In addition, the biscuits formulation can be modified easily to meet the nutritional demands of the target consumers

(Ashaye, OA et al. 2015) [7]. Since biscuits are dried to low moisture content, and this can ensure their long shelf life storage, and especially free from microbial spoilage (Okaka 2005) [8].. Being faster in the growth of the biscuits manufacturing, there is a huge scope of research on diversification of this baked product in Vietnam (Agrofood Research Report, EU- Vietnam Business Network, STINFO 12- 2015) [9]..

Passion fruit is a good source of food containing high and healthy amount of potassium, vitamin A, vitamin C, niacin and fiber and it is low in sodium, cholesterol and saturated fats[10]. So, it is scientifically and economically important to know whether the made flour from passion fruit (planted in Vietnam) peel can be used for the production of high quality biscuits with improved nutritional values. Also, consequence of various proportion of passion fruit peel powder to wheat flour in biscuits formation needs to be determined in order to make high quality final biscuits products. In summary, this study has been conducted to determine the suitable process for preparation and possibly improved quality production of passion fruit peel powder and the made biscuits from the passion fruit peel.

Materials and Methods

20 fruits which is approximately 5 kilograms of passion fruit with good quality without any molds or insects were purchased from a local market in Tien Giang province, Vietnam for vital ingredients.

Figure 1. Passion fruit variety in this study

There are other necessary ingredients to prepare biscuits such as typical wheat flour (type no.8) of Baker's choice brand, sugar, butter, eggs were obtained from Nhat Huong company, Ho Chi Minh City, Vietnam. High density polyethylene bags were used for package and storage of samples.

Chemicals applied in samples analysis include Ethanol, Hexane, Sulfuric Acid, Acid Boric, Sodium Hydroxide 96%, Gallic acid, FolinCiocalteu's phenol reagent, 1,1-diphenyl-2-picrylhydrazyl (DPPH), Natri Carbonate and other tools that were purchased from local Chemical for laboratory agents in district 10, Vietnam.

The experimental studies were conducted in laboratories of the Department of Food technology, International University – Vietnam National University in Ho Chi Minh City.

Preparation of Passion fruit peel powder(PFPP)

The passion fruits were washed using distilled water within 20 minutes. After that, the cleaned fruits were cut in half and removed all of pulp and seeds inside. Subsequently, the peels were washed again with distilled water and dried at 60 °C in a hot air dryer for 24 hours. The dry peels were then processed in the blender in 1500 rpm for 10 minutes. In the following step, the powder were sieved with a particle size of 300-500 µm. Finally, the dried flour samples were packed in zip-lock bags and stored inside a desiccator for further chemical analysis.

All remaining ingredients used to make cookies, including wheat flour (Bakers' Choice 8, Inter flour Vietnam Limited), refined sugar (Bien Hoa, Vietnam), butter, and the baking powder were purchased from Coop-mart supermarket and Nhat Huong Company, Ho Chi Minh City, Vietnam.

Besides that, chemicals and equipment used in powder testing and further sampler analysis of cookies (namely hexane, natri hydroxide, potassium sulfate, methanol, and so on) will be obtained from local agents in Ho Chi Minh City, Viet Nam and in laboratories of Food technology department of International University – Vietnam National University in Ho Chi Minh City.

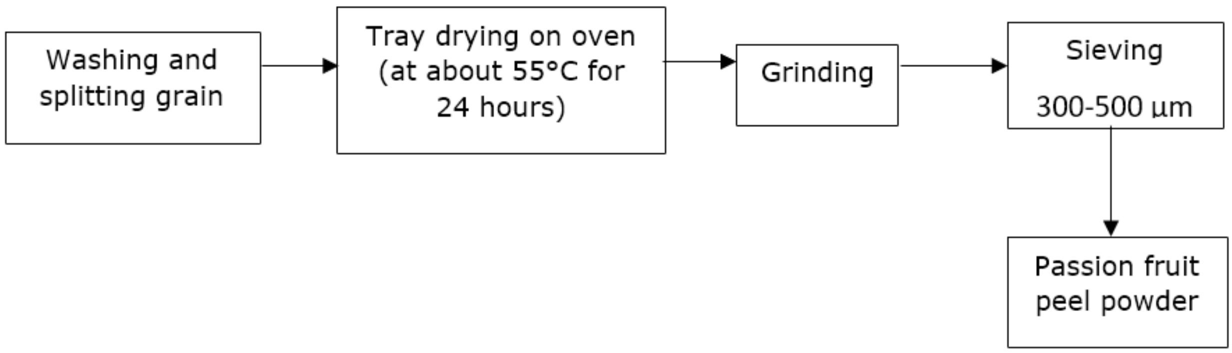

Figure 2. Passion fruit peel powder preparation flow chart

Production of Wheat-Passion fruit peel powder biscuits

The mixture of wheat flour and PFPP was well prepareed by replacing 5%, 10%, and 15% of wheat flour with other ingredients were weighed accurately as the formulation (Weng et al. 2020) [11]. For each sample, every 120g of mixture flour (respectively rate), 55g of sugar, 40g of butter, 1g of salt, 1g of baking powder and 1 egg was added. Firstly, with an electric hand mixer, the mixture will be blended with first butter and sugar, at low speed for 3 minutes and then eggs added before stopping the mixer every minute in order to reincorporate cream that adhered to the blending bowl. After that, the remaining ingredients were added and blended again for 3 minutes at level 2 and make sure to reincorporate. The dough will be sheeted with a thickness of around 3.5 mm and freeze in 30 minutes until firm in order to easily cut the dough sheet with the round die.

A = 100 : 0 ratio of wheat – Passion fruit peel powder in biscuits
B = 95 : 5 ratio of wheat – Passion fruit peel powder in biscuits
C = 90 : 10 ratio of wheat – Passion fruit peel powder in biscuits
D = 85 : 15 ratio of wheat – Passion fruit peel powder in biscuits

Table 1. The mix formulation for biscuit preparation

Ingredients	**Control** **100:0**	**Sample 1** **95:5**	**Sample 2** **90:10**	**Sample 3** **85:15**
Wheat flour (g)	120	114	108	102
Passion fruit peel powder (g)	0	6	12	18
Refined sugar (g)	55	55	55	55
Butter (g)	40	40	40	40
Egg	1	1	1	1
Salt (g)	1	1	1	1
Baking powder (g)	1	1	1	1

Figure 3. Flow chart for the production of biscuits

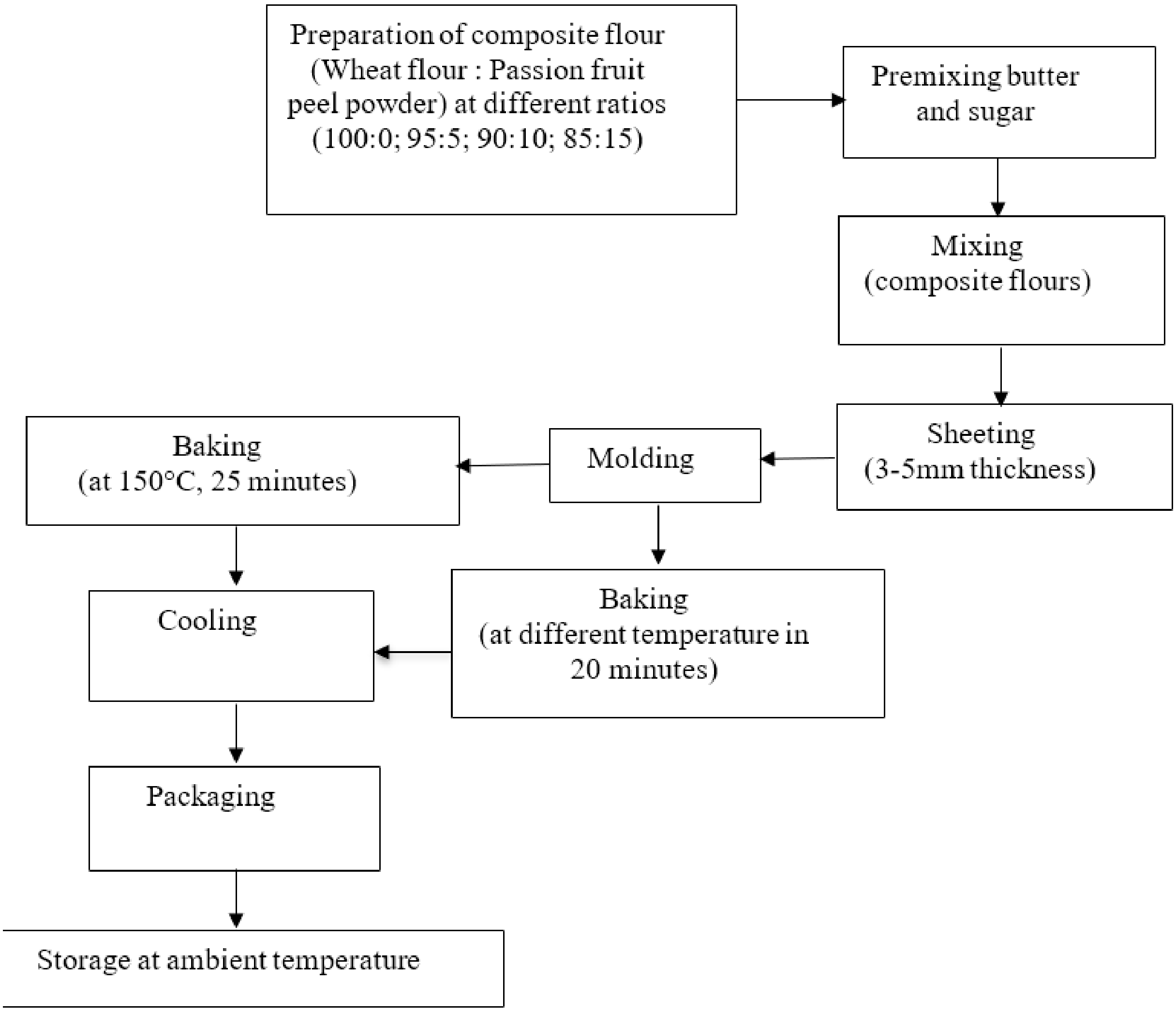

Figure 3. Flow chart for the production of biscuits

Proximate composition analysis of Passion fruit peel powder and wheat flour

Passion fruit peel powder and different ratio composite flours were determined; the chemical compositions such as moisture content, protein, ash, crude fiber, fat content and antioxidant capacity; total phenolic content are determined by the methods described by (AOAC, 2012) [12]. water absorption capacity, oil absorption capacity and bulk density. Total carbohydrate is calculated as the difference method (AOAC, 1990)[13].

Moisture content

The porcelain crucible contained 2g of PFPP that would be placed in a forced draft oven and dried at around 130°C for 3 hours. The crucible was weighed with samples after every 30 mins until no change in weight was observed. The sample should be stored in a desiccator until they are weighed. The result will be determined based on the loss of weight of samples before and after drying (AOAC, 2012) [12]. The moisture content can be determined as the following formula:

$$Moisture\ content\ (\%MC) = \left(\frac{m_1 - m_2}{m}\right) \times 100$$

Where,

m: initial sample weight

m_1: weight of wet sample and crucible

m_2: weight of dried sample and crucible

Ash content

The porcelain crucible contained 5g of PFPP that partially dried samples. The content was then burned by flame in a fume hood until there is no white smoke to evaporate and black color appears. Then, all crucibles will be placed in a muffle furnace at 550°C for 3 hours until only white matters could be seen. After that, the crucible with ash content was then cooled in a desiccator and weighed accurately to a constant weight (AOAC, 2012) [12]. The ash content can be determined as following formula:

$$Total\ ash\ (\%) = \frac{(w1 - w2)}{(w1\ - w\ )} \times 100$$

Where,
$w_{1:}$ weight of crucible and ash sample after removing from the muffle furnace
$w_{2:}$ weight of crucible and ash sample
w: weight of crucible

Protein content

The protein content of flour was determined by the Kjeldahl method (AOAC, 2012) [12]. Firstly, 1g of flour was placed in a digestion tube and added with 0.2 g CuSO4, 1 g K2SO4, and 20 ml concentrated H2SO4 to each tube. Then, the sample islet was digested on the digestion block until white fumes could be seen and continued being heated for about 60 –90 minutes until cleared with no charred material remaining. The samples were be taken off the digestion block and they were allowed to cool before being diluted with 50 ml of distilled water. To be specific, the distillation system and the measurement were conducted following program 1 of manual instruction. The protein content can be determined as following formulas:

$$\%N = Normality\ H_2SO_4 \times \frac{Corrected\ acid\ vol.L}{g\ of\ sample} \times \frac{14gN}{mol} \times 100$$

$$\%\ Crude\ protein =\ \%N \times\ Protein\ Factor$$

Fat content

Fat content was determined by extracting 3g of sample with hexane using Soxhlet apparatus for 6 hours. The residual hexane was removed from the extracted sample by evaporation. The extracted fat was then dried and weighed (AOAC, 2012) [12].

Crude fiber

Crude fiber was determined following the approved AOAC method 962.09[13].. Crude fiber is loss on ignition of dried residue remaining after digestion of sample with 1.25% H2SO4 and 1.25% NaOH solutions under specific conditions.

2g of each sample was extracted with ether or petroleum ether and transferred to beakers of ceramic fiber mixture. Two beakers of ceramic fiber mixture for each sample were prepared as follows: 1.5 g dry weight of sample was added to each 100 ml beaker, then 60-75 ml 0.255N H2SO4 was added to each beaker and allowed to soak. Beakers were placed on digestion apparatus with pre-adjusted hot plate and boiled exactly 30 minutes. Contents of beaker were filtered through Buchner funnel (pre-coated with ceramic fiber if extremely fine materials are being analyzed). Beaker was rinsed with 50-75 ml boiling H2O and washed through Buchner funnel. Residue was removed before 200 ml 1.25% NaOH was added and boiled exactly 30 minutes. Contents was filtered and then washed with 25 ml boiling 1.25% H2SO4, 50 ml H2O and 25 ml alcohol. Residue was transfer to ashing dish, dried for 2 hours at 130 ± 2 ^{o}C . Then, it was cooled in desiccator and weighed. Residue was ignited 30 minutes at 600 ± 15 ^{o}C and cooled in desiccator before being reweighed.

% Crude fiber in ground sample = C = (Loss in weight on ignition loss in weight of ceramic fiber blank) x 100- weight sample

Total carbohydrate content

Total carbohydrate was determined by the difference[13].

% Carbohydrate = 100 – % (protein+ fat + ash+ fiber + moisture)

Functional properties analysis of the composite flour samples

Bulk density

Bulk density was determined following the method described by Eleazu and Ironua (2013) [14] and Onabanjo and Dickson (2014) [15]. A (10ml) graduated cylinder, previously tarred, was gently filled with 5g of sample. The bottom of the cylinder was gently tapped on a laboratory bench several times until there was to a constant. The bulk density of the sample (g/ml) was calculated as weight of the sample per unit volume of sample.

Water Absorption Capacity (WAC)

Water absorption capacity was determined by Eleazu and Ironua (2013) [14] and Onabanjo and Dickson (2014) [15]. A measured quantity (1g) of the sample was mixed in 10 ml of distilled water in a conical graduated centrifuge tube. The sample was thoroughly mixed for 30 seconds and kept at ambient temperature for 30 minutes before being centrifuged at 2000 rpm for another 10 minutes. The volume of the supernatant was measured directly from the graduated centrifuge tube. The amount of water absorption was multiplied by the density of water (1 g/ml) and results were expressed as percent water per gram of sample.

Oil Absorption Capacity (OAC)

Oil absorption capacity was determined by (Adepeju, Gbadamosi et al, 2011) [16] and (Eleazu and Ironua, 2013) [14]. A measured quantity (1g) of the sample was mixed in 10 ml of distilled water in a conical graduated centrifuge tube. The sample was thoroughly mixed for 30 seconds and kept at ambient temperature for 30 minutes before being centrifuged at 2000 rpm for another 10 minutes. The volume of the supernatant was measured directly from the centrifuge tube and the tubes were allowed to drain at an angle of 45° for 10 minutes and then weighed. The amount of water absorption was expressed as the increasing weight of the sample.

Proximate composition analysis of developed biscuits on concentration and different temperature

Moisture, protein, crude fiber, ash, fat, total carbohydrate content and of prepared biscuits were determined by the same methods used for Passion fruit peel powder analysis.

Antioxidant activity and Total phenolic content

Extraction preparation of developed biscuits

Blending the developed biscuits into powder. The procedure had been modified to reach the suitable condition in the lab. Briefly, 1g of samples were extracted with 10ml Ethanol 80%. The extract was centrifuged at 5000 rpm for 15 minutes at room temperature. The volume after extracting has been recorded for further calculation. The residue was then re-extract 3 times with the same procedure as above and stored at 4ºC for further use. Successive dilutions were made from the stock solution and submitted to evaluate the antioxidant activity and total phenolic content of the samples (Nguyen, Le, Inoue, Morita, & Pham, 2018) [17]

Measurement of Antioxidant Activity (DPPH Free Radical Scavenge)

DDPPH (1, 1-diphenyl-2-picryl hydrazine) assay was used to estimate antioxidant activity by *Blois, M S, 1958*[18]. 1ml of each extract was mixed with 3.9ml of 0.1mM DPPH in Ethanol concentration. It has to incubate exactly 30 minutes in dark at room temperature before measuring in a spectrophotometer with the absorbance at 517 nm. The remaining DPPH free radical was determined by absorbance measurement against Ethanol blanks. The percentage scavenging effect was calculated from the reduction of absorbance against control (DPPH radical solution in Ethanol without sample) using the following equation:

$$\text{Scavenging activity (\%)} \quad \frac{AbsControl - AbsSample}{AbsControl} x100 \quad =$$

Determination of Total Phenolic Content

Total phenolics in all samples were determined using Folin-Ciocalteu reagent by spectrophotometer at 750nm according to the method of *Singleton and Rossi (1965)* [19] using Gallic acid as a standard. Standard curve was determined by using the Ethanolic Gallic acid standard solution at concentrations 0;20;40;60;80;100 mg/ml. Briefly, 0.3ml of the extraction (diluted 10 times) or Gallic acid standard was mixed with 1.5ml Folin-Ciocalteu reagent (diluted 10 times) and 1.2ml of Sodium carbonate (Na_2CO_3) (7.5g/100ml) in test tube. The contents of the tubes were mixed thoroughly and stored in the dark for 30 minutes before measuring in a spectrophotometer.

Physical properties measurements of biscuit Thickness

The width was measured by placing 6 biscuits edge-to-edge to get the average value in millimeters. The thickness was measured by stacking 6 biscuits on top of each other to get the average value in millimeters. Width divided by the thickness gave the spread factor. Digital weighing scale was used to determine the weight (in grams) of biscuits. Volume of biscuits was defined as the area multiplied by thickness. After calculating volume, density was obtained by ratio of weight of volume[20,21].

Sensory evaluation

The sensory evaluation was conducted by adapting the proposed method of Morten C. Meilgaard, B. Thomas Carr, Gail Vance Civille (2006) [22], providing that the consumer acceptance of different samples of biscuits was evaluated by over 0 judges comprising undergraduate students and staffs of the International University without training. The sensory evaluation test was conducted in the air-conditioned laboratory, which provided a quiet and comfortable environment in the laboratory at International University. The biscuits were served on white disposable plastic trays and tap water was provided for rinsing. Samples were coded with different symbols and the sample order was randomized. Consumers were asked to evaluate the color, taste, aroma, crispness and overall impression of the biscuits using a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).

Statistical analysis

Data was subjected to analysis of variance using the "Statistical Package for Social Sciences" (SPSS) version 19.0. Results were presented as means ± standard deviations of triplicate experiments. Significant difference was established at $p \leq 0.05$.

Results And Discussion

Proximate analysis of Passion fruit peel powder

The results of the analysis proximate attributes of Passion fruit peel powder are shown in Table 2. Also, the same analyzed attributes of wheat flour for a possible comparison is included.

Table 2: Proximate values of wheat flour and Passion fruit peel powder

Parameter (%)	Wheat flour	Passion fruit peel powder
Moisture	13.81±0.204^{a}	0.69±0.01^{b}
Ash	0.69±0.01^{b}	7.87±0.16^{a}
Protein	10.47±0.12^{a}	7.07±0.06^{b}
Fat	5.09±0.12^{a}	1.07±0.05^{b}
Crude fiber	ND	23.33±0.25
Total carbohydrate	71.14±0.14^{a}	52.92±0.89^{b}

**Values in the table represent the means ± standard deviations (n = 3 replicates)*
DWB = dry weight basis. ND: Not detected.

a, b, c, d, e: Means with the same column with different letters are significantly different (P<0.05)

As shown in the table 2, the purple passion fruit *(Passiflora edulis)* peel powder has a moisture content with a dry basis weight was 8.06±0.16% which was lower than wheat flour of 13.81±0.204%. Reportedly, the moisture content influences the taste, texture, weight, appearance, and shelf life of foodstuffs *(*Yvonne Appoldt and Gina Raihani, 2017*)* [23], the lower moisture, the better its storage stability as well as reducing the deterioration of baking quality. Also, flour with lower than 14% can resist microbial growth and with lower than 9% more restricts the infestation (Butt, Masood & Nasir, Muhammad & Akhtar, Saeed & Sharif, Mian. (2004) [24]. Therefore, either wheat flour or passion fruit peel powder fall between 0-14% of moisture content which is acceptable for effective flour storage for further processing without the risk of microorganism contamination.

In addition, from the table 2, passion fruit peel powder has a much higher ash content constituting about 7.87±0.16% compared to wheat flour, which is steady at 9±0.01%. Ash contents indicate the level of minerals present in samples *(*Ape, Nwogu, Uwakwe, & Ikedinobi, 2016*)* [25]. As compared to recent research about other common maize, which is yellow and purple passion fruit peel, the ash content of passion fruit peel powder is steadily higher than rice and wheat flour. Besides moisture and ash content, protein and fat content are also considered as one of the most essential elements. The considerable difference in those two values were clearly shown in table 2. Wheat flour type Dia Cau has been chosen to make biscuits which leads to higher protein contents than passion fruit peel powder. It could be easily seen that the pretty low protein content of passion fruit peel powder, comprising 7.07±0.06%, is significantly different from the protein with wheat flour, 10.47±0.12%. This could be advantageous in the formulation of biscuits supplemented with passion fruit peel powder. Also, the fat content of passion fruit peel powder is nearly much lower than wheat flour which is 1.07±0.05% compared to 5.09±0.12%. In fact, wheat flour is a low level of free fatty acids, it is therefore not subject to rancidity which is important for biscuits formulation (NDSU Dept. 7670, Sanay Simsek, 2018) [26]. Passion fruit peel powder is low in fat which means it has been connected to a decline in the risk of chronic diseases such as obesity and type 2 diabetes (Milena V, et al. (2020) [27]

As illustrated by Marlett JA. et al., (2002) [28] and Castro IS. et al., (2005) [29], fiber is considered as an efficient protective agent for a wide variety of illnesses, including cardiovascular disease, colon cancer, and constipation. In order to increase the consumption of fiber, the American Dietetic Association (ADA) recommended that mushrooms are one of four types of food (a variety of grains, vegetables, and fruits) included to add in daily diets for active and healthy life (Johnson, R. and Kennedy E. 2000) [30]. As shown in Table 2, wheat flour owns nothing of crude fiber value that data showed not detected result. In contrast, the obtained result from the analysis of passion fruit peel powder accounted for 23.33±0.25% on a dry weight basis. Due to its high fiber content, passion fruit peel powder could be included in foods to help satisfy the dietary requirement of this valuable nutrient, according to the Brazilian government dietary guidelines These fibers are beneficial in treating or preventing constipation, diverticulosis, hemorrhoids, coronary heart diseases, and some type of cancer (Madhu, Krishna, Reddy, Lakshmi, & Kelari, 2017) [31]. Also from the Table 2, it can be seen that the data on the total carbohydrate content of both flours displayed the highest value in all proximate compositions. Wheat flour’s total carbohydrate value is significantly higher than the passion fruit peel powder one which is allocated at around 71.14±0.14 % and 52.92±0.89 %, respectively.

Functional properties of composite flours

The results of the functional properties of Passion fruit peel powder sample and flour blends including wheat and Passion fruit peel powder are presented in Table 3 consisting of bulk density, water absorption capacity, and oil absorption capacity. Functional property is defined as any property of a food or food ingredients, besides its nutritional value that affects its utilization. These functional properties: are bulk density, water absorption capacity (WAC), and oil absorption capacity (OAC) which may become one of the effects of the behavior of food systems during storage (Shobha et al., 2012) [32].

Table 3: Effect of incorporating Passion fruit peel powder on the functional properties of the composite flours

Samples	Bulk density (g/cm^3)	Water Absorption Capacity (g/g)	Oil absorption capacity (g/g)
WA	1.53 ± 0.24^a	0.13 ± 0.006^c	2.27 ± 0.006^a
WB	1.13 ± 0.04^b	0.17 ± 0.008^b	2.23 ± 0.006^{ab}
WC	1.16 ± 0.08^b	0.2 ± 0.01^b	2.17 ± 0.006^{ab}
WD	1.25±0.01ab	0.26 ± 0.02^a	2.16 ± 0.006^b

**Values in the table represent the means ± standard deviations (n = 3 replicates).*

a, b, c, d: Means with the same column with different letters are significantly different (P<0.05)

WA (control) = 100:0, 100% wheat flour

WB = 95:5, 95% of wheat flour incorporated with 5% of Passion fruit peel powder

WC = 90:10,90% of wheat flour incorporated with 10% of Passion fruit peel powder
WD = 85:5, 85% of wheat flour incorporated with 5% of Passion fruit peel powder

Table 4: Functional properties of Passion fruit peel powder

Physical property	Value
Bulk density (g/cm^3)	1.31±0.103
Water Absorption Capacity (g/g)	0.85±0.14
Oil absorption capacity (g/g)	2.15±0.006

**Values in the table represent the means ± standard deviations (n = 3 replicates).*

Bulk Density

The bulk density of flour is the density measured without the influence of any compression. As shown in the table 4, the value of passion fruit peel powder is 1.31 g/cm^3 compared to 1.52 g/cm^3 of wheat flour they are not significantly different which means passion fruit peel powder has a similar bulk density to wheat flour. consequently, it was clear that the incorporation of passion fruit peel powder with wheat flour in 5%, 10%, and 15 % illustrate a stable trend of 1.13 g/cm^3, and 1.16 g/cm^3, 1.25 g/cm^3, respectively. The particle size and the density of the food affect the bulk density of food materials. Bulk density is an important factor in food packaging *(Adelakun Oluyemisi Elizabeth, 2017).* According to Oladele and Aina(2009) [33], the lower bulk density of the discussed flours has been reported to be useful for food formulation when used for complementary foods (Akapata and Akubor, 1999) [34]. Moreover, low bulk density is desirable in infant feeding (Iwe and Onadipe, 2001)[35] and low bulk density food is desirable where packaging is a serious problem (Ikujenlola, 2008). [36]

Water Absorption Capacity (WAC)

The rate of water absorption determined in a food product is related to the availability of the hydrophilic group to bind to water molecules, forming into a gel with the starch molecules. Only the gelatinized starch granules will absorb water and swell at room temperature. The water absorption capacities affect the quality of baked goods and depend partly on the damaged starch contained in the flour, the protein content, and particle size (Kulkarni KD, 1991). [37]
As can be seen from Table 3, the WAC of composite flour samples increases according to a higher level of passion fruit peel powder substitution. The composite flour sample that has the highest and second highest WAC is sample D which had been incorporated with 15% (w/w) of passion fruit peel powder. The flour sample, sample A, is the one that has the lowest WAC. Also, the WAC values from wheat flour and passion fruit peel powder varied from 0.13 to 0.85 g/g. Good WAC demonstrates higher polysaccharide content of composite flour. According to Chandra et al. (2015) [38], the high WAC of composite flour suggests that the flour can be used in the formulation of some food such as sausage, dough, processed cheese, and bakery products. However, this characteristic may be undesirable in producing biscuits due to the high capacity of moisture absorption from the surrounding environment, which can quickly cause sogginess in the biscuits. The amount of water absorbed depends primarily on the availability of two types of hydrophilic groups which are capable of binding water through the bond formation. The water absorption capacity of flour is an indication of the amount of water available for gelatinization and a useful indication of whether the protein can be incorporated with aqueous food formulations, especially those involving dough handling such as processed cheese, sausages, and bread (Edema et al., 2005[39],Osungbaro et al., 2010[40]).

Oil Absorption Capacity (OAC)

Data shown in Table 3 indicated that the flour derived from the passion fruit peel variety had considerable oil absorption capacity- OAC (215%). Among all flour samples, the OAC with 227% in the highest recorded value was sample A and the lowest one was sample D. The OAC of flour composites slightly decreased as more and more passion fruit peel powder was incorporated, which indicated diluting effect of passion fruit peel powder on OAC of wheat flour (Adeleke and Odedeji 2010) [41]. The values of OAC were reported significantly different between samples A and D.

It can be considered as the more passion fruit peel powder incorporated into the flour, the higher the OAC. Good OAC among corporate flours suggested that there were improvements in the protein and polysaccharide compositions. According *to (*Elmanan, Al-Assaf, Phillips, and Williams (2008) [42]), the mechanism of oil retention is due to the non-polar amino acid side chains that can form hydrophobic interactions with hydrocarbon chains of lipid and strongly adsorb onto the surface of oil droplets.

The mechanism of fat absorption is attributed mainly to the physical entrapment of oil and the binding of fat to a polar chain of the protein. Non-polar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids (Adeleke and Odedeji 2010)[41], Chandra, Singh et al. 2015)[38]). Therefore, the low protein content in passion fruit peel powder is the possible reason for the decrease in the OAC of composite flours when increasing the level of substitution.

Antioxidant assay and Total Phenolic Content in Passion fruit peel powder and wheat flour

Table 5: DPPH scavenging activity and total phenolic content (TPC) of flour

Sample	Scavenging activity (%)	Total phenolic content (mg GAE/ g)
Passion fruit peel powder	55.05 ±3.01[a]	70.95 ± 0.46[a]
Wheat flour	27.02 ± 0.247[b]	4.37 ± 4.53[b]

**Values in the table represent the means ± standard deviations (n = 3 replicates).*

a, b: Means with the same column with different letters are significantly different (P<0.05)

Passion fruit peel powder (PFPP) extract presented antioxidant activity in the higher concentrations in the performed assays. Antioxidants have already been found in plant materials and supplements. Due to their natural origin, the antioxidants obtained from plants are of greater benefit in comparison to synthetic ones (Rohman et al., 2010[43]; Zheng and Wang, 2001[44]). The absorption antioxidant from PFPF decreased the body weight gain, and fat deposition, predominantly in the liver, and improved glucose tolerance and insulin sensitivity to metabolic changes caused by the cafeteria diet (Nasreddine et al., 2018) [45]

As shown in the table 5, the Passion fruit peel powder has a higher antioxidant potential towards the DPPH free radical (55.05 ±3.01 %) compared to the Wheat flour (27.02 ± 0.247 %). The TPC of extractable methanol compounds was reported to be 70.95 ± 0.46 mg GAE/ g for PFPP while white wheat flours contained 4.37 ± 4.53 mg GAE/ g. The lower values presented could be attributed to the defatting step of the thermal process of peel drying at 55°C for 24 h which removed some phenolic compounds.

- **Developed functional biscuits with different ratios of the wheat flour**

Physical properties of developed biscuits

Diameter, thickness, spread ratio, and density of biscuits are five physical parameters recorded in table 6 to study the effect of replacing 5%, 10%, and 15% of wheat flour with Passion fruit peel powder.

Table 6: Effect of Passion fruit peel powder on the physical parameter of biscuits

Physical properties	A	B	C	D
Diameter (cm)	5.86 ± 0.18[a]	6.01 ± 0.15[a]	5.95 ± 0.07[a]	6.04 ± 0.13[a]
Thickness (cm)	3.6 ± 0.2[a]	3.83 ± 0.27[a]	3.82 ± 0.14[a]	3.7 ± 0.3[a]
Spread ratio	1.63 ± 0.05[b]	1.57 ± 0.04[a]	1.56 ± 0.02[a]	1.65 ± 0.04[b]
Weight (g)	5.82 ± 0.13[b]	6.01 ± 0.07[ab]	6.10 ± 0.07[ab]	6.22 ± 0.12[a]
Volume (cm^3)	18.12 ± 0.14[c]	20.34 ± 0.20[b]	20.86 ± 0.07[b]	21.13 ± 0.06[ab]
Density (g/cm^3)	0.13 ± 0.01[a]	0.12 ± 0.01[a]	0.13 ± 0.01[a]	0.12 ± 0.01[a]

**Values in the table represent the means ± standard deviations (n = 3 replicates).*
The values denoted by different letters in the same column are significantly different (p ≤0.05)

A (control)= 100:0, 100% wheat flour biscuits
B= 95:5, 95% of wheat flour incorporated with 5% of Passion fruit peel powder biscuits
C= 90:10, 90% of wheat flour incorporated with 10% of Passion fruit peel powder biscuits

D= 85:5, 85% of wheat flour incorporated with 5% of Passion fruit peel powder biscuits.

The results obtained from the physical measurements of biscuits made from wheat flour and composite flour with varying levels of passion fruit powder are shown in Table 6. The biscuit B and C got a similar result of spread ratio, control one and sample D are nearly the same and have the highest value in the same parameter. The spread ratio of biscuits is considered as one of the most important quality parameters of biscuits because it correlates with the texture, grain finesse, bite, and overall mouth feel of the biscuits (Jothi, Hashem et al. 2014) [46]. The higher the spread ratio of biscuit the more desirable it is (Chauhan, Saxena, & Singh, 2016) [47]. Hence, biscuits A prepared from 100% wheat flour and biscuit D prepared from 15% of passion fruit peel powder may be demonstrated as the most preferred based on the spread ratio that allocated approximately 1.65 cm and was significantly different from biscuits B and C. Besides, the spread ratio was calculated by dividing diameter to thickness meaning thicker biscuit will lead to lower spread ratio.

As can see that the more passion fruit peel powder content, the higher significantly increased the spread ratio of the biscuits, which was directly related to their thickness, whereas the diameter was generally affected. In other reported studies, the lower spread ratios of biscuits can be attributed to the samples containing more water-absorbing constituents like protein and fiber. Several reports (Patel et al., 1996; Hooda et al., 2005) [48] revealed that a reduced spread ratio was observed when wheat flour was replaced by either high protein or high fiber ingredients. These constituents form aggregates with available hydrophilic sites thus reducing free water in biscuit dough (McWatters, 1978) [49]. Rapid partitioning of free water of these hydrophilic sites occurs during dough mixing and increases dough viscosity relating to the limitation of biscuit spread. Therefore, the lower spread ratio characteristic of biscuits B and C are useful to increase their suitability for rotary mold *preparation* in which a lower spread is desirable to keep the embossing complete (Hooda et al., 2005) [48].

The weight of sample D was the highest value, and the lowest ones were found in sample A between 6.22g and 5.82g with the highest value of sample D and the lowest found in sample A. The results differed significantly among samples ($p<0.05$). As can be seen, the higher the level of passion fruit peel powder incorporated, the more the weight of the biscuits. The passion fruit peel powder had a higher water absorption capacity than the wheat flour. Therefore, this resulted in higher initial moisture content of the dough and a higher loss of water during the baking of the biscuits (Dogan 2006) [50].

The volume of biscuits increased from 18.12 as the lowest value in sample A to 21.13 cm^3, with the highest value in sample D. This is possibly due to the fibers present in the passion fruit peel powder, which might interfere with the structure of the matrix, diminishing the gas retention capacity in the dough (Ostermann-Porcel, Quiroga-Panelo et al. 2017) [51]. The volume of passion fruit peel powder biscuits increased linearly whereas, density is no significantly differences in a similar manner with densities of biscuits A and D with ranged from 0.12-0.13 g/cm^3. Besides, the differences between the two attributes among samples were insignificant ($p<0.05$).

Proximate values of developed biscuits with different ratios of the wheat flour

Table 7 presents the nutritional composition of biscuits prepared from the composite flour of wheat flour substituted with Passion fruit powder at different ratios 5%, 10%, 15% compared to the control sample (biscuit A).

Table 7: Proximate composition values of developed biscuits

Parameters (%)	A	B	C	D
Moisture	5.26 ± 0.13^a	4.88 ± 0.04^b	4.72 ± 0.05^{bC}	4.56 ± 0.15^c
Ash	0.54 ± 0.02^d	1.13 ± 0.02^c	1.5 ± 0.03^b	1.92 ± 0.015^a
Protein	8.73 ± 0.1^b	8.26 ± 0.13^b	7.9 ± 0.02^c	7.63 ± 0.03^d

Fat	19.12±0.15^{a}	17.02±0.36^{b}	16.27±0.006^{c}	15.46±0.005^{d}
Crude fiber	0.75±0.015^{d}	1.23±0.02^{c}	1.99±0.015^{b}	2.63±0.04^{a}
Total carbohydrate	65.63±0.22^{b}	67.43±0.4^{a}	67.62±0.07^{a}	67.86±0.2^{a}

**Values in the table represent the means ± standard deviations (n = 3 replicates). The values denoted by different letters in the same column are significantly different (p ≤0.05); ND: Not detected.*

A (control) = 100:0, 100% wheat flour biscuits

B = 95:5, 95% of wheat flour incorporated with 5% of Passion fruit peel powder biscuits

C = 90:10, 90% of wheat flour incorporated with 10% of Passion fruit peel powder biscuits

D = 85:5, 85% of wheat flour incorporated with 15% of Passion fruit peel powder biscuits.

The results indicated that adding the Passion fruit peel powder to prepared biscuits caused a significant (P ≤ 0.05) decrease in their moisture contents ranging from 4.88% to 4.56% compared to the control biscuit which gave 5.26%. The difference between them is mostly due to different baking conditions, environmental issues, and moisture absorption ability of the ingredients in different conditions. According to a study, the lower the moisture of the biscuit, the longer the shelf life (Bertagnolli.et al., 2014) [52]. Therefore, the addition of an appropriate amount of PFPF in biscuits will help to reduce the moisture content of the products, resulting in a longer shelf life

From the table 7, the fat content of the biscuit with 100% wheat flour has the highest fat content (19.12%) and biscuit with a ratio of passion fruit peel powder 15% has the lowest with 15.56%. The fat content of the developed biscuits met the standard value (15%-20%) for soft dough biscuits *(Manley, 2001).* Also, according to table 7, the fat content is higher than the protein content which could be explained by the original passion fruit peel powder used in biscuits formulation containing 8.73% (Table 7). In terms of flavor and texture, the high calorific value could also serve as a lubricating agent that improves the product's quality which stems from the presence of high-fat content in samples. As a result, although these samples are high in fat content compared to protein, biscuits incorporated with Passion fruit peel powder are desirable for production. Moreover, from the table, 7 biscuits B, C, and D owning fat results do not exceed 25% which leads to preventing rancidity in food or unpleasant and odorous compounds (Ihekoronye & Ngoddy, 1985) [53].

Especially, as can be seen, the passion fruit peel contains a very high fiber as compared to other vegetables, it is considered higher than wheat flour. Due to this result, biscuits B, C, and D significantly contained a certain proportion of fiber compared to the control one. There was an upward trend in the fiber value of biscuits following the rise in the percentage substituted for passion fruit peel powder. Therefore, sample D is recorded with the highest ones. In this research, the dietary fiber content of the samples was determined. Due to its high fiber content, passion fruit peel powder could be included in foods to help satisfy the dietary requirement of this valuable nutrient, according to the Brazilian government dietary guidelines. Crude fiber consists largely of cellulose (60–80%) and lignin (4–6%) plus some mineral matter. These fibers are beneficial in treating or preventing constipation, diverticulosis, hemorrhoids, coronary, heart diseases, and some types of cancer (Madhu, Krishna, Reddy, Lakshmi, & Kelari, 2017) [54]. This high content of fiber in the passion fruit peel powder makes it a potentially suitable food ingredient that could be used to fiber-enrich conventional and ready-to-eat foods.

As displayed in Table 7, it is generally high in carbohydrate contents which range from 65.63% to 67.86%. There is no significant difference between 5% (B) and 10% (C) Passion fruit peel-based biscuits that share 67.43% and 67.62%which is also the highest value of carbohydrate contents. Besides that, biscuits, D, was recorded with 67.86% which is higher than the control one about 65.63% and shares a similarity with the other 2 samples. Therefore, biscuits and D are rich in carbohydrate content that are an ideal supplement for marasmus patients (Helen Obioma Agu, 2014) [55]. The presence of the passion fruit peel powder in the diet reduced the digestion and absorption of carbohydrates and increased the sensitivity of muscle and adipose tissue to insulin remaining allowing greater gluconeogenesis (production of liver glycogen), thereby contributing to the reduction of hyperglycemia of these animals (SACHS, 2002)) [56].

Antioxidant assay and Total Phenolic Content in developed biscuits

Table 8: DPPH scavenging activity and total phenolic content (TPC) of developed biscuits

Sample	Scavenging activity (%)	Total phenolic content (mg GAE/ g)
A	7.83 ± 1.25[d]	4.05 ± 2.5[c]
B	22.835 ± 0.83[c]	6.99 ± 5.29[b]
C	40.5 ± 0.14[b]	7.76 ± 5.63[ab]
D	47.34 ± 0.2[a]	8.5 ± 1.57[a]

**Values in the table represent the means ± standard deviations (n = 3 replicates)*

a, b, c: Means with the same column with different letters are significantly different (P<0.05)

A (control)= 100:0, 100% wheat flour
B= 95:5, 95% of wheat flour incorporated with 5% of Passion fruit peel powder
C= 90:10, 90% of wheat flour incorporated with 10% of Passion fruit peel powder
D= 85:5, 85% of wheat flour incorporated with 15% of Passion fruit peel powder

DPPH radical scavenging activities

Antioxidant compounds are known to prevent, delay or retard rancidity development or other flavor deterioration in foods or can protect the oxidative damage in the human body. Moreover, the purple variety has been reviewed by Zas and John (2016)) [57] that Passiflora edulis plant contains anti-inflammatory, anticonvulsant, antimicrobial, anticancer, antidiabetic, antihypertensive, anti-sedative, antioxidant properties, and various remedial measures for treating conditions like osteoarthritis, asthma, and act as a colon cleanser.

As shown in table 8, the Passion fruit peel powder added biscuits formulation showed a significant increase in the antioxidant potential towards the DPPH free radical. The antioxidant activity of raw passion fruit peel powder was the highest result following biscuits D, C, and B and the last one is A allocated 47.34%, 40.5%, 22.835%, and 7.83%, respectively. Therefore, the passion fruit peel four supplemented cookies exhibited higher antioxidant activities compared to whole wheat flour cookies ($p<0.05$) By their free radical scavenging capacities, all the levels of passion fruit peel powder incorporated in biscuits showed a good ability in radical scavenging activity around 40% at sample C and D, while it was only 7.83% in the case of the control. There was a gradual upward trend in the higher incorporation of Passion fruit peel powder into biscuits had significantly elevated the antioxidant activity for a few folds compared to the original control. Thus, these results reveal the importance of supplementation of biscuits with Passion fruit peel powder that biscuit products can be considered as a functional food ingredient because of their antioxidant properties.

Total Phenolic Content

The content of phenolic compounds of passion fruit peel powder and ground developed biscuits extraction was determined by the Folin-Ciocalteu procedure with some modification (Nguyen, Le, Inoue, Morita, & Pham, 2018) [17], using Gallic acid as a standard. Absorbance was measured at 765 nm. The content of total phenolic compounds has been expressed as mg of gallic acid equivalent (GAE) per g of the extraction (mg GAE/g).

In this study, the phenolic content of passion fruit peel powder sample and developed biscuit with different ratios of Passion fruit peel powder addition was investigated and given in table 7. The TPC of extractable methanol compounds was reported to be 70.95 ± 0.46 mg GAE/ g for PFPP while white wheat flours contained 4.37 ± 4.53 mg GAE/ g. The lower values presented could be attributed to the defatting step of the thermal process of peel drying at 55°C for 24 h which removed some phenolic compounds. According to Zuofa zhang (2009) [58], different drying treatments affected the TPC result that oven heating at 50°C was shown to rapidly inactive polyphenol oxidase present in plant materials, however, some of their initial activities may have occurred earlier and caused some polyphenols to be degraded (Zhang S, 2023) [59]. Furthermore, freeze-drying is known to have high extraction efficiency because ice crystals formed within the sample matrix can rupture cell structure, which allows the exit of cellular components and access to solvent, and consequently better extraction (Asami et al. 2003) [60].

As pointed out in the Table 7, data on TPC increased gradually following the rising addition of Passion fruit peel powder levels. To be specific, biscuit D was the highest value which shared 8.5 mg GAE/g. All three biscuit samples incorporated with Passion fruit peel powder exhibited a significant level of TPC of the products compared to the control samples. The TPC (μg GAE/g) in the different varieties of the sample extracts were calculated using the standard curve for Folin with the equation y= 0.0094x +0 0.0216, R^2= 0.9942. In the supplemented Passion fruit peel powder biscuits, TPC ranged between 8 mg GAE/g, while the result of the control sample was 4.05 mg GAE/g. These concentrations were statistically different ($p < 0.05$) among the studied samples. Therefore, passion fruit peel could be considered a source of natural antioxidants and alpha-glucosidase inhibitors Therefore, passion fruit peel could be considered a source of natural antioxidants (Cao et al., 2021) [61].

Sensory evaluation

Consumer acceptance, preference or hedonic (degree of liking) tests were used to determine the degree of consumer acceptance for a made product. Examples of acceptance tests are: the 9-Point Hedonic Scale, Labeled Affective Magnitude Scale (LAM), Line Scales, Just-About-Right scales (JAR) and Food Action Rating Scale (FACT) [62]. Among these tests, the hedonic scale is probably the most commonly used[63]. This scale is a category-type scale with an odd number (five to nine) categories ranging from “dislike extremely” to “like extremely.” A neutral midpoint (neither like nor dislike) is included[64]. The panelists included in the test should be users of the product and there is no need for panel training. Optimally, a panel should consist of at least thirty people and much larger numbers are preferable[64]. This is necessary for the development and marketing of a new product, as no laboratory test can tell whether the public will accept a new product or not[65]. The result of acceptance of a food product usually indicates actual use of the product (purchase and eating). Moreover, preferences of individual consumers can be projected as vectors to suggest directions for product optimization

Table 9: Sensory evaluation scores of developed biscuits in terms of color, aroma, crispiness, taste and overall impression in 9 - point scale.

Attributes	A	B	C	D
Color	8.67 ± 0.837^a	7.38 ± 1.197^{ab}	6.01 ± 1.284^d	6.02 ± 1.217^d
Aroma	8.1 ± 1.28^a	7.85 ± 1.123^a	6.32 ± 1.32^c	6.19 ± 1.29^d
Crispness	8.27 ± 0.95^a	7.92 ± 0.80^a	6.73 ± 1.07^b	6.5 ± 1.23^d
Taste	8.2 ± 1.176^a	7.43 ± 1.125^{ab}	7.29 ± 1.062^a	6.52 ± 1.035^d
Overall acceptance	8.32 ± 0.97^a	7.1 ± 0.95^b	6.77 ± 1.01^b	6.25 ± 1.05^d

*Average of 40 evaluations. The values denoted by different letters in the same column are significantly different ($p \leq 0.05$)

Color is an important factor affecting the food choices of consumers, especially those of baked goods such as biscuits(Calvo et al., 2001) [66]. Obviously, the surface of the biscuit samples with incorporated PFPF was significantly darker than that of the control ($P < 0.05$). The results for sensorial color acceptance from the Table 9 showed that the formulation of the original biscuits made from 100% wheat flour had the highest score which was more than 8 points. However, the biscuits D displayed the significantly lowest score, 6.02, which evaluated the following to prefer lighter color for biscuits’ appearance. However, the increase in darkness reflected in biscuit D may decrease appetite because people may suppose bitter taste, over temperature. Color attribute is a major criterion that affects the quality of baked products. Also is essential to the manufacture of
biscuits of good quality. During baking, complex chemical reactions take place in the biscuits,
such as the Maillard reaction and caramelization.(Stamatovska et al. 2017) [67]

From the Table 9, it can be seen that wheat flour incorporated with PFPF did affect the perception of most panelists about the taste. The B and C biscuits samples (wheat flour incorporated with 5% and 10%PFPF) show nearly scores as the control samples. Conversely, the other biscuit samples (wheat flour incorporated 15% PFPF) show lower scores than those of the control samples. The taste of biscuits B and C was insignificantly different from the control ones which are 7.43 and 7.29, respectively which gave us the highest score as the most preferred by the panelists. Thanks to 5% and 10 % of Passion fruit peel powder, they create a nutty and cereal feeling while chewing biscuits. For the original biscuits and the other biscuits, we usually can not recognize this taste. Next, as biscuit D with 6.52 which is also the lowest score compared to the rest, this could result from a bit bitter of taste and the cereal taste covers all the butter and sweet taste that make some people feel strange and could not adapt to this taste. As a consequence, sample D got the lowest score on the aroma from the panelists and shared a significant difference from each other. Samples B and C had the acceptable point which was an indifferent score from the 100% wheat flour biscuit. However, all developed biscuits ensured the crispness of the normal biscuits which showed insignificantly different scores.

The general acceptance for biscuits control, B and C were not significantly different sharing in the range between 7.1 and 6.77 within the rate of like slightly and moderately like that compared to the control one (8.32). As shown in Table 9, biscuit D was sharply lowest one allocating 6.25 for the impression but it rated slightly like this 15% passion fruit peel powder biscuits because there is a minority of people like its strange taste and aroma. Therefore, the 5%, 10%, and 15% addition of Passion fruit peel powder may get consumers' perception, especially, in sample B (wheat flour incorporated with 5% PFPP).

- **Developed biscuits at different temperature**

Physical properties of developed biscuits

Diameter, thickness, spread ratio, and density of biscuits are five physical parameters which were collected and are shown in the table 10 to study the effect of different temperatures of 60°C, 170°C, 180°C) with replacement of 15% wheat flour and passion fruit peel powder biscuit.

Table 10: Effect of temperature on the physical parameter of biscuits

Physical properties	E	F	G
Diameter (cm)	5.86 ± 0.18^{a}	6.01 ± 0.15^{a}	5.95 ± 0.07^{a}
Thickness (cm)	3.6 ± 0.2^{a}	3.83 ± 0.27^{a}	3.82 ± 0.14^{a}
Spread ratio	1.63 ± 0.05^{b}	1.57 ± 0.04^{a}	1.56 ± 0.02^{a}
Weight (g)	6.66 ± 0.05^{c}	6.81 ± 0.13^{bc}	6.89 ± 0.20^{ab}
Volume (cm^3)	18.23 ± 0.14^{b}	20.99 ± 0.04^{a}	20.35 ± 0.20^{a}
Density (g/cm^3)	0.13 ± 0.01^{a}	0.12 ± 0.01^{a}	0.013 ± 0.01^{a}

**Values in the table represent the means ± standard deviations (n = 3 replicates).*
The values denoted by different letters in the same column are significantly different (p ≤0.05)

E = 160°C baking temperature biscuits
F = 170°C baking temperature biscuits
G = 180°C baking temperature biscuits

Baking is a complex process inducing physical, chemical and biochemical changes in the cereal matrix such as crust formation and colour changes (Zanoni et al., 1995) [68]. Colour is one of the most important visual changes occurring during food processing and the correlation between colour formation (browning) and acrylamide formation has been pointed out (Surdyk et al., 2004) [69].

As can be seen from these results, there are no significant differences at diameter, thickness, or weight loss of biscuit at different temperature. While the volume of biscuits increased according to higher level of baking temperature, especially among biscuits with 180°C, the density of biscuits decreased respectively. The biscuits with the highest density was the biscuit E and the lowest density belongs to biscuit F. From the Table 10, the biscuits made with higher baking temperature somehow have lower density compared to the wheat flour biscuit and biscuits with lower baking temperature. The reason of decreasing in the density, according to Ostermann-Porcel, Quiroga-Panelo, Rinaldoni, and Campderrós (2017) [70], possibly due to high fiber content. Incorporation of highest passion fruit peel powder at 15% also increase the fiber content of biscuits, therefore, resulted in lower density.

Proximate values of developed biscuits

Table 11 presents the nutritional composition of biscuits prepared from the composite flour of wheat flour substituted with Passion fruit peel powder at different temperature (160°C, 170°C, 180°C) with replacing 15% wheat flour and passion fruit peel powder biscuit.

Table 11: Proximate composition values of developed biscuits

Parameter (%)	E	F	G
Moisture	3.85±0.18^{a}	3.31±0.18^{b}	2.78±0.06^{c}
Ash	1.82±0.3^{a}	1.83±0.3^{a}	1.83±0.3^{a}
Protein	8.81±0.66^{a}	8.72±0.16^{a}	8.97±0.09^{a}
Fat	15.55±0.45^{a}	15.84±0.52^{a}	15.46±0.46^{a}
Crude fiber	1.89±0.08^{c}	2.27±0.06^{b}	3.69±0.006^{a}
Total carbohydrate	68.55±0.67^{a}	68.42±0.34^{ab}	67.64±0.33^{b}

**Values in the table represent the means ± standard deviations (n = 3 replicates). The values denoted by different letters in the same column are significantly different (p ≤0.05)*

E = 160°C baking temperature biscuits
F = 170°C baking temperature biscuits
G = 180°C baking temperature biscuits

The values for moisture content at different baking temperatures are shown in table 11, the moisture content of biscuits decreased according to the higher level of baking temperature. At 160°C baking temperature biscuits, the moisture content of biscuit E was 3.85% and compared to the highest temperature at sample F was 2.78%, and the rest one at 170°C with 3.31%. The final moisture content is important in determining the quality of the cake. If too much water evaporates during the baking process, the cake will become dry and is not preferable. A typical cake has a moisture content between 15-30%, compared to bread 35-45% and the moisture content of biscuits is the lowest around 1-5% (Lostie, M. Peczalski, R. Andrie, J. and Laurent, M. (2002) [71]. Additionally, the biscuit baked at different temperatures had no significant dissimilarity in ash content. Through the Table 11, it can be seen that the lowest ash content belongs to biscuit e and the highest ash content belong to F and G with around 1.82 and 1.83, respectively. A decreased ash content is also affected by the addition of water in humidity in biscuits that will increase the weight of the samples, hence when ash content was analyzed, its levels are reduced because of the increased sample weight which is used to indicate the mineral content in food, is one of the most important parameters in daily nutritional requirement. Overall, the biscuit baked at high temperature had no significantly difference in ash content, at around 1.8%, which is used to indicate the mineral content in food, is one of the most important parameters in daily nutritional requirements.

From the Table 6, the fat content of biscuits ranging around 15%. Overall, there has no clearly changes in fat content at different baking temperature. As a result, the absorption of water limited the retention capacity of oil, which resulted in lower fat content. The value of biscuits protein content ranging from 8.81% to 8.97%. As can be seen from the table, the biscuit sample G, which was baked at 180°C, had the highest percentage of value, 8.97± 0.09%. From this data, it proposed that replacing baking temperature does not help improve the protein content of pastries. One of the reasonable explanations for this phenomenon is depending on the protein content of the wheat flour and the passion fruit peel powders. The protein content of the wheat flour, according to the manufacturer of the wheat flour used for this experiment, ranges from 9.5 to 11%, not much higher than the passion fruit peel powder (about 8%).

Also, from Table 11, overall, the fiber content of biscuits increased according to a higher level of baking temperature. Biscuit sample E had the lowest fiber content, only about 1.89 ± 0.08% whereas biscuit sample G had the highest fiber content, about 3.69 ± 0.006%. As can be seen from Table 11, the crude fiber content of 180°C baking temperature biscuits is significantly higher than the 160°C baking temperature biscuits.

According to Kohli et al., 2019, Effect of Baking Temperature on The Quality of Prepared Amla Pomace Biscuits[72] and Suresh Lokhande and K. Raja Reddy, 2014[73], Quantifying Temperature Effects on Cotton Reproductive Efficiency and Fiber Quality, high temperature stress during this stage affects the elongation processes which, in turn, shortens the fiber length and lowers fiber uniformity. Optimum growing temperature conditions produced longer fibers as compared to high temperature which supports previous findings by Reddy et al. (1999) [74]. Fiber strength increased linearly with temperature. Besides that, the tendency of change could not be considered only from the total dietary fiber, but also the proportion of insoluble dietary fiber and soluble dietary fiber increased sharply with the increasing of temperature during baking. Fiber has been seen as one of the most important nutrients required in daily food consumption. Moreover, the fiber of passion fruit peel powder has been found to be health benefits such as losing weight, reducing energy intake, reducing waist circumference, controlling blood glucose, controlling body weight, and reducing the risk of obesity (Chaitokkia & Nitchatorn, 2018)[75]. This study might be useful in applying passion fruit peel products to developing various food products and increasing the fiber intake in daily meals. During the thermal processing of foods, several reactions are taking place which has a direct impact on the sensory and nutritional properties of food. Maillard's reaction is involved in the generating of characteristics of flavor and color which dramatically influence the consumer's perception of food quality. However, the Maillard reaction is also responsible for the formation of acrylamide during food processing at elevated temperatures (Tareke et al., 2002[76]).

Antioxidant assay and Total Phenolic Content in developed biscuits at different temperature

Table 12: DPPH scavenging activity and total phenolic content (TPC) of developed biscuits

Sample	Scavenging activity (%)	Total phenolic content ($_m$g GAE/ g)
E	19.93 ± 4.31^a	7.76 ± 0.22^a
F	7.59 ± 0.981^b	6.99 ± 0.12^b
G	0.678 ± 0.386^c	4.05 ± 0.996^c

**Values in the table represent the means ± standard deviations (n = 3 replicates)*
a, b, c: Means with the same column with different letters are significantly different (P<0.05)

E = 160^{o}C baking temperature biscuits
F = 170^{o}C baking temperature biscuits
G = 180^{o}C baking temperature biscuits

DPPH radical scavenging activities

As shown in table 12, the different baking temperature biscuits showed a significant decrease in the antioxidant potential of the DPPH free radical. The antioxidant activity was the highest result following biscuit E and the higher temperature having the higher content that allocated 19.93%, 7.59%, and 0.678%, respectively.

There exist several bibliographic reports describing the direct relationship between the content of colored compounds, such as anthocyanins and carotenoids, and the antioxidant activity of a food. Since the content of the major anthocyanin, namely, cyanidin-3-O-glucoside, decreased significantly with heating, the increase of the DPPH activity was most likely due to Maillard reaction products being produced because of the high temperatures. In fact, the effect of Maillard reactions on the increase of antioxidant activity has already been reported in cookies. Accordingly, some non-enzymatic browning compounds are capable of stabilizing anthocyanins via interaction with the resulting aglycone during the thermal degradation process. However, it is important to bear in mind that Maillard products are regarded as undesirable compounds since their formation involves the destruction of essential amino acids and the production of anti-nutritive compounds. Therefore, baking temperatures higher than 150 C are not recommendable. On the other hand, it is also worth pointing out that non-anthocyanin antioxidants, such as carotenoids and certain non-colored compounds (e.g., ferulic acid), can also contribute to antioxidant activity. The use of extremely high temperatures might easily degrade these beneficial compounds. Overall, 160°C was the selected temperature for the cake making process

Total Phenolic Content

As can be seen in Table 7, the total phenolic content values decreased gradually following the rising baking temperature levels. In particular, TPC dropped from 7.76 ± 0.22 mg GAE/g in 160°C baking sample to 6.99 ± 0.12 mg GAE/g and 4.05 ± 0.996 mg GAE/g at 170°C and 180 °C, respectively. To be specific, biscuits E was the highest value which shared 7.76 mg GAE/g. The TPC (mg GAE/g) in the different varieties of the sample extracts was calculated using the standard curve for Folin with the equation y= 0.0094x + 0.0216, R^2= 0.9942. Most phenolic compounds are heat-sensitive and easily oxidized, hence an upper limit temperature must be observed to preserve its useful components (Che Sulaiman, I.S., Basri, M., Fard Masoumi, H.R. et al. 2017) [77]. Alpha-glucosidase inhibition decreased with decreased phenolic content.

Sensory evaluation of developed biscuits at different temperature

The mean scores of tested samples in the five sensory attributes are presented in Table 13

Table 13: Sensory evaluation scores of developed biscuits in terms of color, aroma, crispiness, taste, and overall impression in 9 - a point scale.

Attributes	E	F	G
Color	7.72 ± 0.826^a	6.58 ± 1.186^b	6.11 ± 1.484^b
Aroma	7.23 ± 1.18^a	6.85 ± 1.13^{bc}	6.32 ± 1.33^{ab}
Crispness	7.42 ± 0.916^a	6.82 ± 0.71^{ab}	6.73 ± 1.16^b
Taste	7.8 ± 1.186^a	7.23 ± 1.136^b	7.28 ± 1.152^b
Overall acceptance	7.53 ± 0.96^a	7.15 ± 0.96^{bc}	6.41 ± 1.04^b

**Average of 40 evaluations. The values denoted by different letters in the same column are significantly different (p ≤0.05)*

As shown in the table 13, the mean scores of three samples in five sensory attributes revealed that the color of biscuits made from 160°C baking temperature biscuits was preferable to the rest one. The highest score was for sample E (7.53) baking at 160°C, followed by sample F (7.15) with 170°C while the score of biscuit at 180°C baking temperature was the lowest (6.41). The results of the evaluation also showed that biscuits baked at 160°C baking temperature were more desirable than the rest ones in terms of all sensory attributes.

Conclusions

- In this study, the incorporation potential of wheat flour with Passion fruit peel powder in biscuits production to improve nutritional values and the development of new recipes to make good quality were successfully and thoroughly investigated.
- The total phenolic content and antioxidants of all three ratios of Passion fruit peel powder added biscuits were significantly higher than the control ones.
- The chemical analysis of the wheat-passion fruit peel powder biscuits with different temperatures were significantly different in nutritional values and physical properties as well as the amounts of antioxidants and total phenolic content of developed biscuits.
- According to sensory evaluation, the consumer acceptance for wheat-passion fruit peel biscuit was preferable to compared to the wheat biscuits, especially substitution of up to 5% and 10% of wheat flour with Passion fruit peel powder
- There are nearly no sensorial differences detected among biscuits made with different temperatures the same level of substitution

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