PHYSIOCHEMICAL AND SENSORIAL CHARACTERISTICS OF BISCUITS FROM FLOUR BLENDS OF GERMINATED WHEAT AND PIGEON PEA

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ABSTRACT

The physiochemical and sensory characteristics of biscuits made from flour blends of germinated wheat and germinated pigeon pea were studied. The wheat and pigeon pea grains were germinated and processed into flours. Six blends were obtained with different proportions of germinated wheat and germinated pigeon pea flours designated as GWGP1 (90% germinated wheat flour and 10% germinated pigeon pea flour), GWGP2 (80% germinated wheat flour and 20% germinated pigeon pea flour), GWGP3 (70% germinated wheat flour and 30% germinated pigeon pea flour), GWGP4 (60% germinated wheat flour and 40% germinated pigeon pea flour), GWGP4 (50% germinated wheat flour and 50% germinated pigeon pea flour) and GWGP0 (100% germinated wheat flour which served as control). Functional properties of the processed flour samples were analyzed. The biscuits produced were analyzed for proximate, physical and sensory properties. The functional properties of the flour blends showed significant (p<0.05) differences. The proximate composition mean values portrayed increased moisture, fat, ash, fibre, protein and decrease in carbohydrate contents as the supplementation of the flours of wheat with pigeon pea increased. The physical attributes mean values showed significant differences (p<0.05) in weight, thickness, diameter, spread ratio and breaking strength. The sensory evaluation mean score ranged from 5.45 to 6.75 appearance, 5.15 to 7.15 taste, 5.00 to 6.30 texture, 5.35 to 6.85 aroma and 5.16 to 7.30 general acceptability. Acceptable biscuits with improved nutritive values can be produced from flour blends of germinated wheat and germinated pigeon pea, hence should be encouraged in the food industry.

Key words: Physiochemical, sensory, germinated wheat, germinated pigeon pea, composite flours
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INTRODUCTION

Biscuits are ready-to-eat baked snacks consumed by all age groups in several nations (Adebo, 2020). Biscuit is common compared to other processed foods due to the fact that it is inexpensive, has decent nutritious traits, accessible in assorted shapes, diverse taste and extended storage life (Petrović *et al*., 2016). Biscuit is an unleavened crispy, sweet pastry produced from wheat flour, shortening (hydrogenated fat) and sugar, with the addition of baking powder (Adebo, 2020) and other ingredients like egg, fat, sugar and water (Uchenna and Omolayo, 2017). The basic ingredient for production of biscuit is wheat flour due to its gluten proteins, which are absent in flour of other cereals (Žilić, 2013). During baking, gluten protein forms soft dough and gives high organoleptic properties to the finished product (Žilić, 2013).

The concept of using composite flour in production of biscuits is not new and has been subject to numerous studies (Arukwe, 2020; Arukwe *et al*., 2021). Utilization of composite flour lessens the need to import wheat flour, supports use of indigenous harvests (Hasmadi *et al.*, 2014) and heighten the nutrient quality of biscuits (Arukwe *et al*., 2021).

Pigeon pea (*Cajanus cajan*) is an underutilized pulse plant frequently referred to as "fiofio"in some south eastern parts of Nigeria (Arukwe *et al*., 2017). Pigeon pea is rich in carbohydrates, proteins, vitamins, minerals and essential amino acids (Rabia and Ying, 2018). Its protein is rich in lysine (Arukwe *et al*., 2017). Pigeon pea is commonly consumed as cooked beans with stew (Kabuo *et al*., 2015). It can also be processed into flour for production of value added products like biscuits.

Processing of food crops is generally a prerequisite for improving their digestibility and palatability (Otemuyiwa *et al*., 2018). Germination is a simple processing technique by which the nutrient configuration and certain functional characteristics of seeds can be improved. Specifically, in pigeon pea seed, germination improves its nutritional composition, eliminates anti-nutrients (Arukwe *et al*., 2017) and can contribute in controlling hyperglycemia and lipid peroxidation (Uchegbu and Ishiwu, 2016a).

There has been report of wide extension of lack of adequate nourishment in protein in majority of the poorer countries in Africa due to insufficient consumption of protein rich foods especially among children. The main wellspring of protein which is from animals is costly and unaffordable by the poor. It has therefore become necessary to harness plant protein in the production of various baked food products such as biscuits to meet the protein needs of the people. Pigeon pea seed that can contribute in mitigating protein deficiency is hard-to-cook, thus deterring consumers from obtaining its protein. Economically, the use of wheat flour in biscuit production is affecting Nigeria's gross GDP as well as the development of locally grown crops, while nutritionally; biscuit from only wheat flour does not possess adequate essential nutrients like protein. More so, pigeon pea has not been well utilized, developed and positioned as an industrial raw material, hence, resulting to its underutilization. It is therefore important to advance the advocacy for improved utilization of home-grown crops via preparation of biscuit from composite flours of germinated pigeon pea and germinated wheat blends. Upon completion of this study, it is expected that the biscuit manufactured from composite flours of germinated wheat and germinated pigeon pea would contribute in curbing protein malnutrition in most developing countries. This study will also provide valuable information on the development of a novel variety of biscuit thereby enhancing the utilization and increase in cultivation of pigeon pea. The main objectives of this research were to produce and evaluate the proximate composition, functional, physical and sensory characteristics of biscuits from composite flours of germinated wheat and germinated pigeon pea.

MATERIALS AND METHODS

SOURCES OF RAW MATERIALS

The wheat grains used were bought from *Ubani* main market, Umuahia, while pigeon pea seeds were procured from *Orie-Ugba* market, Abia State. Other ingredients like margarine, sugar, baking powder, amongst others were also purchased from the same markets. Reagents used for analyses were obtained from the Biochemistry Laboratory of the National Root Crops Research Institute, Umudike.

Sample Preparation

Production of germinated pigeon pea and wheat flours

For the production of germinated pigeon pea and wheat flours, the method described by Arukwe *et al*. (2017) was used. The grains were sorted and washed with tap water, then soaked in water for 3 hours and the water drained. After that, two (2) kg of the soaked seeds were spread on a moistened jute bag in single layer and left to germinate for 3 days at room temperature. The seeds were sprinkled with water at intervals of 12 hours until the last day of germination after which the seeds were dehulled and rootlets removed. Drying of the germinated seeds were carried out in an oven at 60°C and for 7 hours. The dried grains were milled into flour with a disc attrition mill and sieved with 1.0 mm mesh size. The sieved flours were packaged in polyethylene bag for further use.

Formulation of Composite Flours

Table 1 depicts the composite flours formulated with flours of germinated wheat and germinated pigeon pea. Sample produced with 100 % germinated wheat flour served as the control.

Production of Biscuits

The recipe (Table 2) and the method described by Adeola and Ohizua (2018) were employed in the manufacture of the biscuits. Kenwood mixer was utilized to mix up the fat and sugar until the blend was fluffy followed by addition of eggs and milk while mixing continuously. Other ingredients such as baking powder, ground nutmeg, composite flour, water and salt were included in the blend to form soft dough. The dough was then brought out from the mixing bowl unto a flat surface where it was kneaded to procure a homogenous blend, rolled out into sheets with the aid of a rolling pin and cut into the desired shape with a cutter. The cut mass was transferred to a greased baking tray. Baking was carried out at 180°C for 17 min. The biscuits were then left to cool before packaging in airtight polyethylene for further use.

Functional Properties Analysis of the Composite Flours

Water absorption capacity (WAC), oil absorption capacity (OAC), wettability, emulsion capacity, foam capacity and stability, gelatinization temperature and time were analyzed using the methods of Onwuka (2018).

Proximate Composition Analysis of the Biscuits

Moisture, ash, fat, crude fibre, crude protein and carbohydrate contents of the samples of biscuits were analyzed with the method of Onwuka (2018).

Physical Properties Analysis of the Biscuits

Weight, thickness, break strength, diameter and spread ratio of the biscuit samples were assessed using the method described by Bala *et al*. (2015).

Sensory Characteristics Evaluation of the Biscuits

Sensory characteristics of the biscuit samples were evaluated by employing a test panel of 20 judges from College of Applied Food Science and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State. A 9-point Hedonic scale which denotes that: 1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely was used to evaluate the appearance, taste, texture, aroma, and general acceptability of the biscuit as described by Iwe (2014). The panelists were instructed to rinse their mouths with water after tasting every sample and not to make comments during evaluation to prevent influencing other panelists. They were also asked to comment freely on samples on the questionnaires given to them.

Experimental Design

For this research, the completely randomized design was employed.

Statistical Analysis

All analysis was carried out in triplicates and the results expressed as mean. One-way analysis of variance (ANOVA) was done with SPSS version 22.0 and means separated using Duncan's Multiple Range Tests.

RESULTS and DISCUSSION

Results of Functional Properties

The functional properties result is presented in Table 3. All the samples showed significant differences ($p<0.05$) on the functional properties. The bulk density of the flour samples was observed to increase with increase in pigeon pea flour substitution suggesting that germinated pigeon flour is denser than germinated wheat flour. This result is not in agreement with the report of Arukwe et al. (2022) who reported a decrease in bulk density as the level of inclusion of pigeon pea flour to sorghum flour increased during the production of gruels. Bulk density is the ratio of the mass per unit volume of a substance. It is an indication of the porosity of a product which influences package design. The bulk density of processed products dictates the characteristics of its container or package and also indicates the relative amount of load the sample can carry, if allowed to rest directly on one another (Obadina *et al*., 2013). The high bulk density observed on the composite flour sample suggests low moisture retention rate and hence implies increased shelf life of the product. In contrast, low bulk density would be an advantage in the formulation of complementary foods (Ugwu and Ukpabi, 2002). The bulk density mean range (0.76 to 0.83 g/cm^3) observed in this study was found to be higher than 0.67 to 0.73 g/cm^3 earlier reported by Adeola *et al*. (2019) on orange-fleshed sweet potato/pigeon pea flour blends.

Water absorption capacity (WAC) of the flour samples was observed to increase with increase in pigeon pea flour substitution. The WAC mean values (1.20 and 2.00 g/ml) observed in the present study were found to be in consonant with 0.57 to 2.00 % reported by Bello *et al*. (2020) on flour blends from wheat, unripe plantain and germinated fluted pumpkin seeds. The high WAC observed in the present study suggests that the flours could be used in the preparation of bakery products (Chandra *et al*., 2015). The increase in water absorption capacity as a result of germination is in agreement with the report of Gernah *et al*. (2011) who observed an increase in the water absorption capacity of maize as a result of malting. Flours with good water absorption capacities are useful in baking.

The oil absorption capacity (OAC) of the flour samples was also found to progressively increased with wheat flour substitution with mean values range of 1.00 to 1.85 g/g. Deepali *et al*. (2013) stated that germination-induced increased oil absorption capacity may be due to solubilization and dissociation of proteins leading to exposure of non-polar constituents from within the protein molecule. Oil binding enhances flavour and mouth feel. Furthermore, foods with good oil binding abilities can be used as meat replacers and extenders.

The swelling index of the flour samples increased with an increase in wheat flour substitution as a result, the 100 % wheat flour had the lowest swelling index value of 1.20 % while sample GWGP5 (50 % Germinated Wheat flour and 50 % Germinated Pigeon pea flour) had the highest swelling index value (1.43 %). High swelling capacity has been reported as part of the criteria for good quality products (Apotiola and Fashakin, 2013). The emulsion capacity was observed to increase with wheat flour substitution. The 100 % wheat flour had the lowest emulsion capacity (28.78 %) while sample GWGP5 (50 % Germinated Wheat flour and 50 % Germinated Pigeon pea flour) had the highest emulsion capacity value of 32.72 %. The mean range (28.78-32.72 %) of the emulsion capacity was found to be higher than 10.67 to 16.7 g/100g earlier reported by Apotiola and Fashakin (2013) on wheat, yam and soybean flour. The increase in emulsion capacity could be due to an increase in the area of stabilized oil droplet at interface which is a function of the food components (Imtiaz *et al*., 2011). Foam capacity of the flour samples was found to progressively increase with an increase in pigeon pea flour inclusion. The 100 % wheat flour had the lowest foam capacity of 16.48 % while sample GWGP5 (50 % Germinated Wheat flour and 50 % Germinated Pigeon pea flour) had the highest (19.44 %). Gelation temperature mean values ranged from 65.00 to 80.00 ^{o}C. The gelation temperature of the flour samples was observed to increase with an increase in wheat flour substitution. This indicates that pigeon pea flour have higher gelation temperature than wheat flour. The higher gelation temperature observed on the composite flour samples is an indication that higher temperature and more time would be required during processing. This is not an advantage in developing countries especially in Nigeria where the cost of power supply is high and not regular.

Proximate Composition of the Biscuits

Table 4 presents the result of the proximate composition of the biscuit samples. It can be observed that the moisture content of the biscuit samples increased with increase in wheat flour substitution. The 100 % wheat flour biscuit had the lowest moisture value (6.05 %) while sample GWGP5 had the highest moisture value (6.85 %). The moisture values (6.05-6.85 %) reported in the present study were found to conform to the value range of 4.59 to 8.81 % reported by Ojinnaka *et al*. (2013) for cookies from African breadfruit starch and wheat flour. The moisture contents of the biscuits were below 10 % which implies reduced chances of spoilage by microorganisms and consequently increased shelf life (Akubor, 2017).

Fat content of the biscuit samples was also found to increase with an increase in pigeon pea flour inclusion. The 100 % wheat flour biscuit had the lowest fat value (14.70 %) while sample GWGP5 had the highest fat value (16.00 %). This simply suggests that pigeon pea could be a better fat source than wheat. The 100 % wheat biscuit with low fat content could therefore be recommended as part of weight reducing diets since low fat foods are said to reduce the level of cholesterol and obesity. Hence, the 100 % wheat biscuit could be more suitable for consumption by people with obesity while the composite biscuit samples with high fat content could be recommended to those seeking weight gain (Udousoro and Ekanem, 2013).

The addition of germinated pigeon pea flour to wheat flour in biscuit production was observed to increase the ash content of the biscuit produced. Sample GWGP5 recorded the highest ash value (2.70 %) though it was not significantly different ($p>0.05$) from sample GWGP4 (2.65 %). The

100 % wheat biscuit had the lowest ash value (1.60 %) which was not significantly different (p>0.05) from sample GWGP1 (1.80 %). This observation suggests that pigeon pea could be a good source of ash. The high ash content of the composite biscuits is an indication that they are good source of minerals.

The addition of pigeon pea flour to wheat flour in biscuit production was observed to increase the fibre content. The 100 % wheat biscuit had the lowest fiber content (1.50 %) while sample GWGP1 had the highest fibre content (2.55 %). The fibre values obtained in this study were within the recommended FAO/WHO (1994) level of not more than 5% for both children and adults as reported by Okoye and Obi (2016). The result suggests that the consumption of the composite biscuits could aid digestion, absorption of water from the body, bulk stool, prevent constipation, control body weight, among others (Idris *et al*., 2011; Igile *et al*., 2013).

Protein content was also observed to increase with an increase in pigeon pea flour inclusion. The protein result suggests that pigeon pea could be a better protein source when compared to wheat (Torres *et al*., 2007). The protein mean range (11.75 to 19.28 %) observed in the present study was higher than 7.59 to 8.11 % reported by Ojinnaka *et al*. (2013) for cookies from African breadfruit-wheat flours. The high protein content of the composite biscuits can help reduce the problem of protein-energy malnutrition among the vulnerable groups.

Carbohydrate on the other hand decreased with an increase in wheat flour substitution. This suggests that pigeon pea could be a poor source of carbohydrate. Such decrease in carbohydrate content with increasing substitution of African bread fruit flour for cake production has been reported (Ihediohanma *et al*., 2009). Sample GWGP5 had the lowest (52.63 %) carbohydrate while the 100 % wheat biscuit had the highest (64.40 %).

Physical Characteristics of the Biscuits

Table 5 depicts the result of the physical properties of the biscuit samples which indicated significant differences (p<0.05). The weight mean values showed that sample GWGP5 had the highest weight value of 19.34 g which was not significantly different (p>0.05) from sample GWGP (19.20 g), while the 100 % wheat biscuit recorded the lowest weight (18.58 g) which was not significantly different from sample GWGP1 (18.70 g). It was observed that the biscuit weight increased with an increase in pigeon pea flour inclusion, and this agrees with the work of

Apotiola and Fashakin (2013) who reported higher weight with increase in soybean and yam flour inclusion. This result also suggests that pigeon pea flour is denser than wheat flour.

The biscuit thickness was observed to increase with increase in pigeon pea flour inclusion. Sample GWGP5 had the highest thickness (1.37 mm) while 100 % wheat biscuit had the lowest thickness (1.11 mm). This result suggests that the substitution of wheat flour with pigeon pea increased the thickness of the biscuit product. The biscuit thickness (1.11 to 1.37 mm) reported in the present study was lower than 4.20 to 5.70 mm reported by Okoye and Obi (2016) for wheat-pigeon pea composite flour biscuit.

Biscuit diameter was also observed to progressively increase with increase in wheat flour substitution. Sample GWGP5 recorded the highest (5.50 cm) diameter value while the 100 % wheat biscuit had the lowest (4.51 cm). Diameter is used to determine the quality of flour used in preparing biscuits and the ability of the biscuit to rise (Bala *et al*., 2015). The diameter mean values (4.51 to 5.50 cm) were found to be lower than 37.27 to 39.95 mm reported by Bello *et al*. (2020) for biscuit from yellow yam, unripe plantain and pumpkin seed flour blends. The higher diameter of sample GWGP5 suggests a better flour quality used during production.

There was no significant difference ($p>0.05$) on the spread ratio of the biscuit samples. This observation implies that substitution of wheat flour with pigeon pea flour had no significant effect ($p>0.05$) on the spread ratio of the biscuits. Spread ratio is the factor that depends on the values of the thickness and diameter of the biscuits (Ade *et al.*, 2012). When a dough or batter becomes less viscous, it tends to spread more thereby increasing in diameter and consequently the spread ratio (Ade *et al.*, 2012). There was no significant difference ($p>0.05$) on the spread ratio of the biscuit samples. This observation implies that substitution of wheat flour with pigeon pea flour had no significant effect ($p>0.05$) on the spread ratio of the biscuit product. The breaking strength of the biscuit samples was observed to increase with an increase in wheat flour substitution. This observation implies that addition of pigeon pea flour in biscuit production increases the strength of the resultant biscuit.

Sensory Characteristics of the Biscuit Samples

The sensory properties result of the biscuit samples is given in Table 6. Significant differences ($p<0.05$) exist on the sensory characteristics of the biscuit samples. The sensory evaluation mean scores ranged from 5.45 to 6.75 for appearances, 5.15 to 7.15 for tastes, 5.00 to 6.30 for textures, 5.35 to 6.85 for aromas and 5.16 to 7.30 for general acceptability. The sensory evaluation result revealed that the 100 % wheat biscuit was generally more preferred in terms of general acceptability with a mean score of 7.30, but it was not significantly different (p>0.05) from sample GWGP1 (7.25). Sample GWGP3 had the lowest general acceptability score (5.16) though it was not significantly different (p>0.05) from 5.30 score reported for sample GWGP5.

The 100 % wheat biscuit had the highest appearance and taste scores of 6.75 and 7.15 respectively though it was not significantly different from sample GWGP1, while sample GWGP5 had the lowest appearance and taste score values of 5.45 and 5.15 respectively.

Addition of pigeon pea flour to wheat (up to 50 % substitution) was observed to significantly decrease the texture of the biscuit samples. This suggests that the pigeon pea flour should be added with caution and should not go beyond 40% substitution to prevent a significant decline in biscuit texture.

Although the 100 % wheat biscuit had the highest aroma score (6.85) it was not significantly different (p>0.05) from samples GWGP1, GWGP2 and GWGP4. This suggests that the addition of pigeon pea flour up to 40 % into wheat had no significant effect on the aroma of the biscuit samples.

CONCLUSION

The result of this research has shown that the addition of germinated pigeon pea flour to germinated wheat flour enhanced the nutritive value of the biscuit without a significant effect on the sensory characteristics. The increased protein content observed in the blended samples could help alleviate the problem of protein malnutrition among the vulnerable groups.

The substitution of wheat flour with pigeon pea flour in biscuit production will help reduce wheat importation and diversify the utilization of pigeon pea. It can be recommended that substitution of wheat flour with pigeon pea flour should not exceed 40 % in order to avoid a decline in the sensory attributes. Also, more research should be carried out on the shelf stability of biscuits from flour blends of germinated wheat and germinated pigeon pea.

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APPENDICES

Table 1: Flour Blends Formulation (%)

Samples	Germinated wheat Flour	Germinated pigeon pea Flour
GWGP0	100	0
GWGP1	90	10
GWGP2	80	20
GWGP3	70	30
GWGP4	60	40
GWGP5	50	50

Table 2: Recipe for Biscuit Production

Ingredient	Quantity
Composite flour	500 g
Margarine	126 g
Sugar	126 g
Whole egg	40 ml
Water	100 ml
Salt	2 g
Baking powder	2 g
Ground nutmeg	3 g
Powdered milk	10 g

Table 3: Functional Characteristics of the Flours

Samples	BD (g/cm^3)	WAC (g/ml)	OAC (g/g)	SI (%)	EC (%)	FC (%)	GT (^oC)
GWGP0	0.76^{f}±0.00	1.20^{f}±0.00	1.00^{f}±0.00	1.20^{f}±0.01	28.78^{f}±0.18	16.48^{f}±0.46	65.00^{f}±0.00
GWGP1	0.77^{e}±0.00	1.35^{e}±0.07	1.20^{e}±0.00	1.25^{e}±0.00	29.30^{e}±0.00	16.90^{e}±0.00	70.00^{e}±0.00
GWGP2	0.79^{d}±0.00	1.50^{d}±0.00	1.35^{d}±0.07	1.29^{d}±0.01	29.94^{d}±0.12	17.25^{d}±0.00	73.00^{d}±1.41
GWGP3	0.80^{c}±0.00	1.65^{c}±0.07	1.55^{c}±0.07	1.34^{c}±0.00	30.76^{c}±0.00	17.80^{c}±0.00	76.00^{c}±0.00
GWGP4	0.82^{b}±0.01	1.80^{b}±0.00	1.70^{b}±0.00	1.39^{b}±0.02	31.34^{b}±0.16	18.42^{b}±0.00	77.50^{b}±0.71
GWGP5	0.83^{a}±0.00	2.00^{a}±0.00	1.85^{a}±0.07	1.43^{a}±0.00	32.72^{a}±0.11	19.44^{a}±0.23	80.00^{a}±0.00

Means with different superscripts within the same column are significantly different ($p<0.05$), GWGP0 = 100 % Wheat flour, GWGP1= 90 % Germinated Wheat flour and 10 % Germinated Pigeon pea flour, GWGP2 = 80 % Germinated Wheat flour and 20 % Germinated Pigeon pea flour, GWGP3 = 70 % Germinated Wheat flour and 30 % Germinated Pigeon pea flour, GWGP4 = 60 % Germinated Wheat flour and 40 % Germinated Pigeon pea flour, GWGP5 = 50 % Germinated Wheat flour and 50 % Germinated Pigeon pea flour, BD = Bulk density, WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, SI = Swelling Index, EC = Emulsion capacity, FC = Foam capacity, GT = Gelation Temperature.

Table 4: Proximate Composition of the Biscuits

Samples	Moisture (%)	Fat (%)	Ash (%)	Crude Fiber (%)	Protein (%)	CHO (%)
GWGP0	6.05^{f}±0.07	14.70^{f}±0.14	1.60^{d}±0.00	1.50^{f}±0.14	11.75^{f}±0.00	64.40^{a}±0.07
GWGP1	6.20^{e}±0.00	14.90^{e}±0.00	1.80^{d}±0.00	1.70^{e}±0.00	12.50^{e}±0.00	62.90^{b}±0.00
GWGP2	6.35^{d}±0.07	15.25^{d}±0.07	2.05^{c}±0.07	1.90^{d}±0.00	14.28^{d}±0.18	60.18^{c}±0.11
GWGP3	6.50^{c}±0.00	15.50^{c}±0.00	2.30^{b}±0.00	2.15^{c}±0.07	16.25^{c}±0.00	57.30^{d}±0.07
GWGP4	6.65^{b}±0.07	15.75^{b}±0.07	2.65^{a}±0.21	2.35^{b}±0.07	18.05^{b}±0.00	54.55^{e}±0.28
GWGP5	6.85^{a}±0.07	16.00^{a}±0.00	2.70^{a}±0.00	2.55^{a}±0.07	19.28^{a}±0.18	52.63^{f}±0.04

Table 5: Physical Characteristics of the Biscuits

Samples	Weight (g)	Thickness (mm)	Diameter (cm)	Spread ratio	Breaking Strength (g)
GWGP0	$18.58^{c}\pm0.08$	$1.11^{e}\pm0.03$	$4.51^{e}\pm0.01$	$4.06^{a}\pm0.08$	$735.00^{f}\pm1.21$
GWGP1	$18.70^{c}\pm0.01$	$1.18^{d}\pm0.04$	$4.83^{e}\pm0.04$	$4.11^{a}\pm0.16$	$760.00^{e}\pm1.14$
GWGP2	$18.85^{b}\pm0.10$	$1.22^{cd}\pm0.00$	$5.00^{d}\pm0.03$	$4.10^{a}\pm0.02$	$795.00^{d}\pm1.07$
GWGP3	$18.99^{b}\pm0.04$	$1.26^{bc}\pm0.00$	$5.19^{c}\pm0.02$	$4.12^{a}\pm0.02$	$820.00^{c}\pm0.00$
GWGP4	$19.20^{a}\pm0.04$	$1.31^{b}\pm0.01$	$5.37^{b}\pm0.02$	$4.11^{a}\pm0.01$	$850.00^{b}\pm1.14$
GWGP5	$19.34^{a}\pm0.04$	$1.37^{a}\pm0.02$	$5.50^{a}\pm0.00$	$4.04^{a}\pm0.00$	$880.00^{a}\pm0.00$

Table 6: Sensory Characteristics of the Biscuits

Samples	Appearance	Taste	Texture	Aroma	General acceptability
GWGP0	$6.75^{a}\pm1.83$	$7.15^{a}\pm1.04$	$6.10^{a}\pm1.17$	$6.85^{a}\pm1.31$	$7.30^{a}\pm1.03$
GWGP1	$6.70^{a}\pm0.86$	$6.90^{a}\pm0.79$	$6.30^{a}\pm1.49$	$6.55^{a}\pm1.15$	$7.25^{a}\pm1.02$
GWGP2	$6.00^{abc}\pm1.26$	$5.86^{bc}\pm1.42$	$5.90^{ab}\pm1.37$	$5.86^{ab}\pm1.46$	$6.33^{b}\pm1.15$
GWGP3	$5.63^{bc}\pm1.46$	$4.42^{d}\pm1.43$	$5.32^{ab}\pm1.57$	$5.16^{b}\pm1.54$	$5.16^{c}\pm1.34$
GWGP4	$6.45^{ab}\pm1.10$	$6.25^{ab}\pm1.65$	$6.00^{a}\pm1.34$	$6.10^{ab}\pm1.71$	$6.30^{b}\pm1.49$
GWGP5	$5.45^{c}\pm1.50$	$5.15^{cd}\pm1.93$	$5.00^{b}\pm1.59$	$5.35^{b}\pm1.63$	$5.30^{c}\pm1.59$