INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 19, No. 6, p. 11-19, 2021
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Development of functional biscuits prepared from wheat-dragon fruit composite flours

Shella B. Cacatian* **and Lyndon John V. Guittap**

Cagayan State University Sanchez Mira, Cagayan Valley, Philippines

Article published on December 06, 2021

Key words: Functional ingredients, Biscuits, Dragon fruit, Wheat composite flours

Abstract

Utilizing the flour from Dragon Fruit peel could enhance the value of Dragon Fruit in the production of biscuits. This study evaluated the consumer acceptability, physical quality, and preliminary product cost of biscuits prepared from composite flours of wheat and Dragon fruit peel. The wheat flour (WF) was partially substituted with Dragon fruit peel flour (DFPF) at 15, 30, and 45 percent. Data were analyzed using analysis of variance (ANOVA) and least significant difference (LSD) to compare further any significant differences between the means of the treatment groups. Evaluation of the consumer acceptability of the biscuits shows that those formulated from composite flours of wheat and Dragon fruit peel favorably compared with those of wheat flour alone in the sensory attributes tested. The samples in all the treatments obtained a Hedonic mean score of 6.0 and above. DFPF had contributed to the production of smaller diameter, lesser thickness, reduced spread ratio, and lower percent spread than the control treatment containing 100 percent wheat flour. Supplementing the preparation of biscuits with DFPF decreases the expenditure of production. WF-DFPF blends could be used as raw materials for the production of biscuits.

***Corresponding Author:** Shella B. Cacatian ✉ allehsbc2013@gmail.com

Introduction

The consumers demand for food with functional ingredients is expected to drive the global food market owing to the rising concern about health and increase in life expectancy (Ali & Rahut, 2019). Fruits and vegetables are major sources of functional ingredients, like dietary fiber, vitamins, and minerals, together with phytochemicals that serve as antioxidants, phytoestrogens, and anti-inflammatory agents (Slavin & Lloyd, 2012). Consuming fruit and vegetable varieties could help ensure an adequate intake of these essential nutrients (WHO, 2019). Despite these benefits, teenagers typically eat more foods with high-fat and high-sugar content and fewer fruits, vegetables, and dairy products than their body needs (Gonzales *et al.*, 2016). The major concern today is to develop inexpensive foods that are nutritionally superior yet highly acceptable to intended consumers (Tikle & Mishra, 2019).

Dragon fruit (*Hylocereus spp.*) or Pitaya has received global recognition for a rich source of nutrients and minerals. It is also a potential source of phytoalbumins which are rich in antioxidant properties (Jaafar *et al.*, 2009). Notably, the fruit has lots of dietary fiber particularly the peel which was found to be 21.34% (Cacatian & Guittap, 2018). One way to get dietary fiber, vitamins, and minerals from Dragon Fruit is to eat the peel itself as long as it is fit for the intended purpose, without any spoilage or molds. But the problem is that Dragon Fruit peel does not taste as good as the pulp. Yet, the peel can enhance any dish, and even tastes good if it is prepared into baked products. A technologically yet economically and feasible alternative is to make a flour from peels either to produce new products, such as biscuits, or partially substitute wheat flour to enhance the nutritional quality of the product (Bertagnolli *et al.*, 2014).

The use of composite flours for the production of biscuits to increase and improve their nutritional quality has been carried out and is drawing cognizance from researchers (Noorfarahzilah *et al.*, 2014). Klunklin (2018) exploited the use of purple rice flour, defatted green-lipped mussel powder, and spices in formulating biscuits to improve their protein and dietary fiber contents. Grant (2017) improved the nutrient content of the biscuits by replacing cassava starch up to 50 percent with an orange-fleshed variety of sweet potato puree and cowpea flour. Chandra *et al.* (2015) used composite flours from wheat, rice, green gram, and potato to increase the functional properties of their developed biscuits. Similarly, Srivastava *et al.* (2012) combined the flours of sweet potato and wheat for the preparation of biscuits with improved functional properties.

Due to the nutritional value, affordability, availability, and benefits of Dragon Fruit peel flour, possibilities of utilizing them in preparing biscuits have therefore been offered through this pioneering work. Particularly, the study investigated the sensory attributes, physical quality, and simple cost analysis of the products without any complex process to undergo and without compromising the quality.

Materials and methods

Experimental Design

The experimental design used in this study is a complete randomized design (CRD) wherein the control and three other treatments were manipulated. Following were the treatments: T1 - 100 percent WF (control); T2 - 15 percent DFPF; T3 - 30 percent DFPF; and T4 - 45 percent DFPF.

Sampling Procedure

The present investigation employed purposive sampling in selecting the individuals as evaluators according to the purposes of the researchers. This sampling method is a type of nonprobability sample where a researcher selects the participants due to good evidence that he/she is a representative of the total population.

Materials of the Study

The materials that were used in the study are oven, baking sheets, biscuit molder, wire cooling rack, measuring cups, mixing bowls, silicone spatula, electric mixer, spoon, pan, gas stove, vernier caliper and weighing scale

Procurement of Raw Materials

Dragon fruit peel was obtained from discarded byproducts of the small-scale wine processing industry at Magacan, Sanchez Mira, Cagayan. Other major ingredients like wheat flour, sugar baking powder, cream butter, salt butter, vanilla extract, egg, were purchased from the local market in Sanchez Mira.

Preparation of the Dragon Fruit Peel Flour

The peels of the Dragon Fruit were sun-dried until all the moisture content was gone. The Dragon fruit peel was chopped into 1 cm² piece using a stainless-steel knife before sun-drying. Then, the dry peels were ground into fine powder in a laboratory dry blender for three minutes. The powdered fruit peels were stored in dark containers to retain the color.

Development of the Biscuit

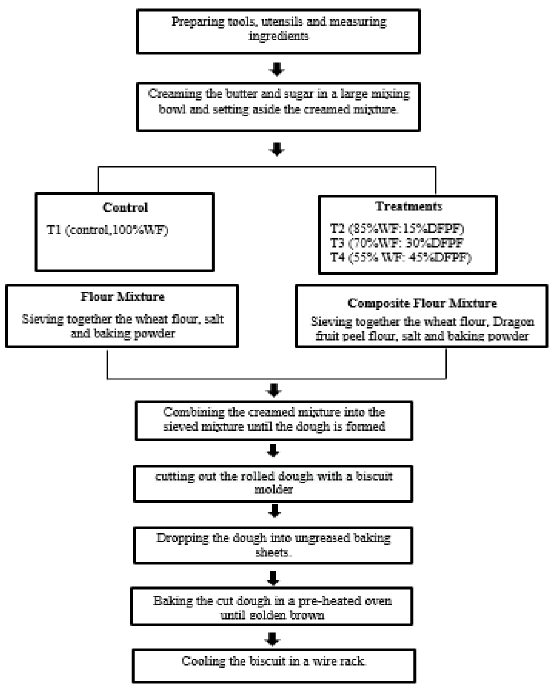

Fig. 1. Process of Biscuit Making.

Sensory Evaluation of the Biscuits

The main sources of data on the sensory parameters of the biscuits were the responses of the panel of evaluators. They evaluated the attributes of the samples as to aroma, taste, color, texture, and overall acceptance of the products at weekly intervals for four weeks. The scale used is a nine-point hedonic scale, with nine representing the highest score (like extremely) and one, the least score (dislike extremely).

Evaluation on the Physical Quality of the Biscuits

The physical attributes of the biscuits identified were the diameter, thickness, spread factor, and percent spread of the biscuits. The diameter of the biscuits was determined by laying six biscuit samples edge-to-edge and getting the mean diameter. Biscuit thickness was measured as average values of six individual biscuits stacked on top of each other using a vernier caliper.

The mean value for diameter and thickness was reported in millimeters. The spread factor was calculated by diving the mean value of the diameter of the biscuits by the mean value of their thickness. Percent spread was computed by dividing the spread ratio of biscuits containing DFPF with the spread ratio of control biscuits and multiplying by 100. Physical analysis was conducted on four groups of biscuit samples, and three measurements were done for each sample.

Product Costing

Product cost was determined by computing all the expenditures in buying the materials. The specific measurements of the materials used in the conduct of the study were the basis for the computation of the price of the biscuits.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) to ascertain which mean yield among the treatments used were highly significant. Least significant difference (LSD) was likewise performed to determine whether there are any statistically significant differences within and between the means of the treatment groups.

Results and discussion

Acceptability on the Physical Characteristics of Biscuit

Table 1 discloses that no significant differences exist in the aroma acceptability of the biscuit containing 15 percent DFPF, in comparison with the control.

Together, the two treatments have higher discernment than the treatments with DFPF higher than 15 percent. The incorporation of more than 15 percent DFPF is moderately preferred because they seemed to lack the extremely good quality of a fresh biscuit. These results corroborate the findings of Bertagnolli *et al.* (2014) that substituting the WF with 30 percent or more of Guava peel flour negatively affected the aroma parameter of their cookie formulation.

Moreover, the highest mean score for taste was observed for T_2 (15% DFPF). Historically, the association between the color red and food comes from the experience of tasting sweetness in fruits, which tend to turn red when they are fully ripe. It would seem reasonable to assume that more intensely colored foods are expected to be more deeply flavored, while pale foods are anticipated to be bland. What also seems likely is that the respondents will tend to think that the more deeply colored a biscuit is, the sweeter they expect its taste to be. The lighter the color, the more boring the taste. Such is the basis of the respondents for rating the taste of the biscuit formulation with 15 percent DFPF to be the best. The biscuit is neither pale nor dark, hence it is perceived to be highly acceptable. The other three treatments are evaluated as moderately acceptable.

The present study likewise suggests that WF up to 100 percent level as well as the addition of 15-30 percent DFPF to WF gave a higher score for color acceptability than the other treatment. The respondents expect the biscuit to have a light and fresh color and may dislike a biscuit that is dark (45% DFPF). The strong color produced by the fourth formulation is due to betacyanin, a natural pigment found in Dragon fruit peel. This pigment is responsible for the characteristic color of red-violet (Priatni & Pradita,2015). Research has found that eating a red food item is commonly associated with sweetness (Spence *et al.*, 2015).

Moreover, the study determined the parameters for texture such as crispiness and fracturability. As a sensory attribute of texture, crispiness or hardness is typically described as the force required to compress food between teeth (Tunick, 2013). The addition of DFPF has influenced the textural quality of the biscuit. Crispiness decreased upon the addition of DFPF to WF. Correspondingly, the level of acceptability by the respondents decreased with the inclusion of more DFPF. The result of the study highlights that respondents like biscuits that make noise when they bite. Indeed, it turns out that crispness and pleasantness are related concerning the rating of foods (Vickers, 2006). Similarly, Romm (2016) reported that the sound generated while biting into or chewing food affects how one experiences what he/she eats. Our brains, which are responsible for making food seem attractive to us far beyond its taste, have established an automatic relationship between crunchiness and pleasantness (Spence, 2015). Fracturability, or the breaking strength, significantly ($p < .05$) reduced as the level of DFPF increased.

A similar trend was noticed in biscuits with increased addition of pigeon pea flour (Silky & Tiwari, 2014; Adeola & Ohizua, 2018). The textural characteristics of the sample biscuits can be attributed to the manufacturing and baking processes, the ingredients used during the preparation, and the variation in the proximal composition of the biscuits (González *et al.*, 2018). The greater fat content in WF than the biscuits with composite flours have enhanced the aeration process responsible for the increased volume and leavening of the dough and made the biscuit more easily breakable (Pareyt *et al.*, 2009).

The trend of the score for general acceptability was remarkably comparable to that of aroma acceptability such that the control treatment is as good as the treatment with 15 percent DFPF. The present results achieved are consistent with the report of Ubbor and Akobundu (2009), who stated that amending WF flour with cassava flour up to 15 percent did not change the overall acceptability of the composite cookies. However, in this study, enriching the biscuit with DFPF beyond 15 percent would tend to decrease the level of acceptability of the biscuit.

Generally, 100 percent of the sample biscuits fall under the Hedonic scale of 7 and above. The mean liking score of 7 or higher on a nine-point scale is usually indicative of highly acceptable sensory quality; hence, a product attaining this score could be used confidently as a good illustration of target quality. On this basis, the formulated product can be selected to provide physical references to illustrate the sensory quality that realistically represents the consumers' acceptance limits (Everitt, 2009).

Additionally, results of the acceptability test of biscuits using composite flours reveal that the raters are willing to change over to healthier variants of biscuits (Trivedi & Soni, 2016). The raters give credence to the benefits attached to the consumption of biscuits supplemented with DFPF.

Table 1. Acceptability on the physical characteristics of biscuit.

Treatment	Aroma	Taste	Color	Texture	General Acceptability
T_1 (control, 100% WF)	7.60^a	7.20^b	7.76^a	8.02^a	8.00^a
T_2 (80%WF:20%DFPF)	7.66^a	7.68^a	7.88^a	7.72^{ab}	7.90^a
T_3 (60%WF:40%DFPF)	6.76^b	6.82^b	7.84^a	7.56^b	7.38^b
T_4 (40%WF:60%DFPF)	6.90^b	6.86^b	7.18^b	7.16^c	7.04^b

Values with a different superscript letter on the same rows are significantly different (p<.05). All values are mean with different superscripts in the same row such as a, b, c indicate significant differences among the groups at p<.05 based on ANOVA with LSD test.
KEY: T_1-100% WF; T_2 -85%WF:15%DFPF; T_3-70%WF:30%DFPF; T_4-55%WF:45%DFPF

Physical Quality of the Biscuits

Table 2 describes the influence of the different proportions of DFPF on the physical attributes of the biscuits. Results depict that the DFPF affected both the thickness and the diameter of the biscuits. Increasing the level of DFPF resulted in a linear decrease in the thickness and diameter of the biscuits. Hence, as a higher amount of DFPF was replaced with WF, a decreasing trend in the spread ratios of biscuits was observed. Consequently, the highest value for spread ratio was noted in the control treatment. The spread ratio decreased from 7.30, 7.09, 7.06, 7.01 at the level of DFPF substitution from 0, 15, 30, 45 percent, respectively.

The results agree with the earlier findings of Panghal *et al.* (2018) and Demirkesen (2016) that the rate of dough flow in the oven decreased with a decrease in thickness. Consideration is due to the interaction of the ingredients used in biscuit formulation which affected the rate of spread. Cacatian and Guittap (2018) reported that DFPF is very rich in fiber (21.34%). It must be noted that increasing the level of DFPF also increased the fiber contents in the biscuits. Fiber changes the viscosity of dough or batters; therefore, it significantly affects the quality of the baked products (Demirkesen *et al.* 2010).

The reduced spread ratios of biscuits with the replacement of DFPF may be related to the fact that the fiber content formed aggregates with an increased number of hydrophilic sites available to compete for the limited free water in the dough resulting in a rise in dough viscosity (Demirkesen, 2016). Dough with higher viscosity causes the biscuits to spread at a slower rate (Hoseney & Rogers,1994). Several researchers have reported a decrease in spread ratio when flours used in preparing biscuits are rich in fiber (Klunklin & Savage, 2018; Demirkesen, 2016; Sharma & Gujral, 2014; Rajiv *et al.*, 2012; Nassar *et al.* 2008; Dachana *et al.* 2010; Sudha *et al.*, 2007; Rababah *et al.* 2006).

The spread ratio of biscuits may also be related to the fat content, which in turn affects the viscosity and strength of the flour. With low-fat content, the dough has high gel viscosity and strength. WF has a higher amount of fat (Ocheme *et al*, 2018; Saeed, 2012) than DFPF (Cacatian & Guittap, 2018). So, it can be construed that the fat content of the flour decreases with increasing levels of DFPF and hence the spread ratio. If there is a small amount of fat in the dough, it will not spread as much in the oven. Conversely, if there is too much fat in the dough, it will overspread because the viscosity and strength decrease, and the fat melts in the oven. Moreover, van der Sman & Renzetti (2019) clarified that increasing fat levels enhance the number of aerated bubbles in the dough, which results in larger porosity and final size in the baked product. Results likewise reveal that the percent spread of the biscuits exhibited an increasing trend along with the increasing substitution level of DFPF.

Table 2. Physical quality of the biscuit.

Treatments	Diameter (D) in mm	Thickness (T) in mm	Spread ratio (D/T)	% spread
T1(control,100%WF)	44.88±0.15	6.15±0.10	7.30±0.12	100
T2(85%WF:15%DFPF)	43.23±0.33	6.10±0.06	7.09±0.11	97.12
T3(70%WF: 30%DFPF)	42.92±0.32	6.08±0.08	7.06±0.12	96.71
T4 (55% WF: 45%DFPF	42.05±0.26	6.00±0.09	7.01±0.10	96.03

KEY: T_1-100% WF; T_2 -85%WF:15%DFPF; T_3-70%WF:30%DFPF; T_4-55%WF:45%DFPF

Simple Cost Analysis of the Baked Products

The price that must be paid for the baked products per treatment was computed to find out the reduction in cost per treatment when compared with the control. The amount of expenditure incurred in preparing the baked products includes the ingredients, water, labor, electricity, and fuel. One preparation of biscuit without composite flours is priced at Php 218.12. The preparation could yield 48 pieces with an average weight of 7.15 g per piece. T1 (with 100% WF) worked out to be Php 4.54 ($0.0908) per piece. Treatment 2 (with 15% DFPF) was computed to be Php 4.46 ($0.0892) per piece. The inclusion of 30 percent DFPF (T3) decreased the expense to Php 4.37 ($0.0874). Amending the preparation to 45 percent DFPF reduced the cost to Php 4.29 ($0.0858). Conversion is based on the USD/PHP exchange rate of 1 USD = 50 PHP. The cost difference is about 1.76, 3.74, and 5.51 percent, respectively from the cost estimate of the control treatment. Successively modifying the preparation to 15 percent or more DFPF to each treatment would correspondingly decrease the price of the baked products. Based on the cost analysis, the cost difference between the control and the treatments with composite flours is quite big. The success therefore in producing a low-cost biscuit is achieved with the addition of DFPF.

Table 3. Simple cost analysis of the baked products (in peso).

Items	T_1	T_2	T_3	T_4
All-Purpose Flour	22.05	17.64	13.23	8.82
Dragon Fruit Peel Powder		0.28	0.56	0.84
Salt	0.07	0.07	0.07	0.07
Baking Powder	4.46	4.46	4.46	4.46
Butter	50.00	50.00	50.00	50.00
White Sugar	6.61	6.61	6.61	6.61
Dragon Fruit Flesh	13.23	13.23	13.23	13.23
Electricity	22.20	22.20	22.20	22.20
Fuel (LPG)	7.00	7.00	7.00	7.00
Water	5.00	5.00	5.00	5.00
Labor	87.50	87.50	87.50	87.50
TOTAL COST	218.12	213.93	209.86	205.73
No. of Yield	48	48	48	48
Cost Per Piece	4.54	4.46	4.37	4.29

KEY: T_1-100% WF; T_2 -85%WF:15%DFPF; T_3-70%WF:30%DFPF; T_4-55%WF:45%DFPF

Conclusion

The Dragon fruit peel flour-formulated product up to 15 percent is most preferred by its sensory characteristics. However, all the formulations showed good acceptance in terms of sensory characteristics, exceeding the mean liking score of 6.0 on the hedonic scale used. The products, achieving such a score, could be used confidently as an essential reference for sensory quality. Hence, the use of DFPF has opened up potential use in biscuit applications.

The diameter, thickness, spread ratio, and percent spread of the biscuits decrease with increasing levels of DFPF in the formulation. There is a positive rate of return in producing biscuits from composite flours of wheat and Dragon fruit peel.

Recommendation

The sample products from this study may be used to provide physical references to illustrate the sensory quality that credibly represents the consumers' acceptance limits. Future researchers may consider evaluating other fruit peels as sources of flour which may have significant commercial implications.

Acknowledgment

The authors are grateful to the Cagayan State University, for funding the research study.

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