Effect of Riceberry Rice Flour and Glutinous Rice Flour on Some Qualities of Gluten-Free Cookies

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Abstract

This research aimed to study the optimal ratio of riceberry rice flour to glutinous rice flour for quality characteristics of gluten-free cookies. The various ratios of wheat flour to riceberry rice flour to glutinous rice flour as the following: 0:25:75 (formula 1); 0:50:50 (formula 2); 0:75:25 (formula 3); 0:100:0 (formula 4) were mixed into gluten-free flour mixture for gluten-free cookies production, except the control (original cookies) produced using a ratio of 100:0:0 (wheat flour to riceberry flour to glutinous rice flour). The appropriate ratio of wheat flour to riceberry flour to glutinous rice flour was 0:75:25 (formula 3). The results showed that the sensorial scores of the all parameters obtained from formula 3 of the gluten-free cookies were > 3. Moreover, the moisture content and a_w value of this formula of gluten-free cookies were lower than those of the control but the values of hardness and spread ratio were slightly higher than the control.

Keywords: Riceberry rice flour, Glutinous rice flour, Gluten-free cookies

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1. Introduction

Cookies are the convenient food product consumed nearly by all levels of society. Some of the reasons for such wide popularity are varied taste, easy availability, longer shelf life and low cost among other processed foods (Miller and Hoseney, 1997). Main ingredient of cookies production is wheat (*Triticum aestivum* L.) flour impact on dough rheology of cookies. Furthermore, wheat flour can be ascribed to the viscoelastic properties of gluten proteins. Gluten proteins represent about 80 to 85% of total wheat proteins and consist of monomeric gluten units (gliadin) which cause viscous behavior while polymeric gluten units (glutenin) are elastic. Kneading and/or mixing wheat flour with water could facilitate the formation of cohesive viscoelastic dough to retain gas produced during fermentation resulting in typical foam structure of bread. However, the disadvantage of wheat flour is gluten allergy to general population which they are led to be celiac disease. Celiac disease is common among general population of the world. Cereals containing gluten are traditionally everyday food (Rewers, 2005).

The replacement of wheat flour by other flours, such as riceberry rice flour and glutinous rice flour, can avoid celiac disease. Riceberry rice is enriched with both water soluble antioxidants, mainly anthocyanin, and lipid soluble antioxidants, such as carotenoid, gamma oryzanol, and vitamin E. Moreover, the potential anti-cancer activity of compounds extracted from riceberry rice bran was evaluated in human cancer cell lines (Leardkamolkarn et al., 2011). Besides its advantages of antioxidant activity and important substances of riceberry rice, the disadvantages of riceberry rice are the higher amylose content in rice grain producing a harder texture and less gloss in the cooked rice due to retrogradation phenomenon (Keeratipibul et al., 2008). Thus, the addition of glutinous rice starch led to improve the quality of products since it contains higher amylopectin content (Lu et al., 2006). These flours could improve the nutritional values of the protein and bioactive compounds in the cookies through the incorporation of less expensive non-wheat flours. Many researchers have used alternative, locally-grown crops in place of wheat flour in pastry products in order to decrease the costs associated with using imported wheat (Agu and Okoli, 2014).

Hence, an objective of the present work was to study an optimal ratio of riceberry rice flour to glutinous rice flour on texture and some quality characteristics of the gluten-free cookies.

2. Materials and Methods

2.1 Cookie preparation

The various formulae for making cookies were presented in Table 1. The cream shortening, sugar, egg, baking powder, baking soda and vanilla flavor were mixed on low speed (Hobart mixer N50, Germany) for 3 min by scraping down after each minute. After scraping, all flours were added and mixed 2 min at low speed and scraped down after each ½ min. Dough was gently scraped from the bowl and placed six portions on lightly greased cookie sheet. Dough was sheeted to 5 mm by rolling pin and cut into circular shapes with a circular scone cutter of 60 mm inner diameter. Baking was performed in a convection oven (Fimak FSET4, Turkey) at 205°C±2°C for 10 min. After baking, they were cooled and put in high-density polyethylene (HDPE) bags with hermetic cover until further analysis.

Table 1. Formulation of cookies with various ratios of wheat flour : riceberry rice flour : glutinious rice flour

Ingredient (g)	Formulation (weight (g))[1]				
	Ratio (%) (wheat flour : riceberry rice flour : glutinious rice flour)				
	Control (100:0:0)	1:(0:25:75)	2: (0:50:50)	3: (0:75:25)	4: (0:100:0)
Wheat flour (14% moisture basis)	210.00	-	-	-	-
Riceberry rice flour	-	52.50	105.00	157.50	210.00
Glutinious rice flour	-	157.50	105.00	52.50	-
Hydrogenated vegetable oil (cream shortening)	70.00	70.00	70.00	70.00	70.00
Sugar (fine granulated)	100	100	100	100	100
Egg (fine granulated)	50.00	50.00	50.00	50.00	50.00
Baking powder	1.00	1.00	1.00	1.00	1.00
Baking soda	4.00	4.00	4.00	4.00	4.00
Vanilla flavor	2.50	2.50	2.50	2.50	2.50
Total	437.50	437.50	437.50	437.50	437.50

[1] For control sample, only wheat flour was used. For gluten-free cookie samples, gluten-free flour mixtures prepared with the mixture of riceberry rice flour and glutinous rice flour as the following formulations in Table 1 were used

2.2 Moisture content and a_w of cookies

Moisture content of gluten-free cookies were determined according to AACC Method 44-01.01 (AACC, 2001). The results were expressed as percent moisture (dry basis). For the measurement of water activity (Woody, 2003), the cookies were ground with a grinder. Two grams of the ground cookies were placed in plastic dishes and determining by water activity meter (Novasina, LabTouch-aw, Lachen, Switzerland).

2.3 Spread ratio of cookies

The physical parameters of the cookies were evaluated i.e. width (W), thickness (T), and spread ratio (W/T) values by a digital caliper. Spread ratio was calculated by the proportion of width to thickness (W/T). Six cookies were randomly sampled from each experiment. The results were expressed as millimeter (Sudha et al., 2007).

2.4 Color analysis of cookies

The color of cookies was measured determined using colorimeter (Minolta CR-300, Minolta Co Ltd., Tokyo, Japan). The colorimeter was calibrated using standard white plate. Minolta L indicates brightness, (0 = black, 100 = white), a redness (+value = red, -value = green), and b yellowness (+value = yellow, -value = blue). Five readings were taken from the surface of cookies for color measurement. The average of five measurements for L, a and b values was recorded (Sahan et al., 2013).

2.5 Hardness of cookies

Texture analysis was determined 6 hours after baking according to Sahan et al. (2013) with some modifications. Texture analyzer (TA-XT PLUS, Stable Micro Systems, Surrey, UK) equipped with a 3-Point Bending Rig (HDP/3PB) using 50 kg load cell was used for calculation of hardness value. Once the trigger force was attained, the force was seen to increase until the biscuit/cookie fractures and falls into two pieces. This was observed as the maximum force and was referred to as the 'hardness' of the sample. The texture analyzer was set to 'return to start' cycle, a pre-test speed of 1.0 mm/s, the test speed of 3.0 mm/s, the post-test speed of 10 mm/s, and a distance of 5.0 mm and data acquisition rate, 500 pps.

2.6 Sensory evaluation of cookies

Sensory evaluation of cookies was done according to Gül et al. (2013). The sensory test was carried out 4 hours after cookies were made. Fifteen untrained judges evaluated cookies for color, texture, flavor and overall acceptance. Five-point hedonic scale was used. This scale was from 1 to 5 point referring 'dislike extremely' to 'like extremely' was used for sensorial evaluation.

2.7 Statistical analysis

Experiments conducted to measure moisture content, water activity, width, thickness, spread ratio, color, hardness and sensory attributes of cookies were undertaken in accordance to completely randomized experimental design (CRD) with three replications. All data obtained from individual treatments were subjected to Analysis of variance (ANOVA) and differences among treatments subsequently were analyzed using Duncan Multiple range test ($P \leq 0.05$) using SPSS for window version 16.0.

3. Results and Discussion

3.1 Hardness, a_w and spread ratio of cookies

Table 2 shows the moisture contents, hardness and a_w values of the original cookies (control) and gluten-free cookies. Increasing the ratios of riceberry rice flour and decreasing the ratios of glutinious rice flour trended to enhance the hardness of gluten-free cookies and the highest hardness (33.49 N) was obtained from the gluten-free cookies (formula 4) produced from 100 % of riceberry rice flour. Juliano (1971) indicated that high contents of amylose contributed to an ability to form a firm gel during the gelatinization process and prone to retrogradation during storage; whereas, high contents of amylopectin showed low syneresis and high resistance to starch retrogradation. According to Seyhun et al. (2003), the increased hardness of the cookies could be attributed to the amylose and amylopectin re-crystallization, to the formation of complexes between starch and proteins, and to redistribution of water between the components of the product, as well as other events which may occur in this baked product during storage.

Table 2. Hardness, moisture content and a_w of cookies with various ratios of wheat flour : riceberry rice flour : glutinious rice flour

Formulation / % ratio (wheat : riceberry rice : glutinious rice)	Hardness (N)[1]	Moisture content (% d.b)[1]	a_w[1]
Control (100:0:0)	25.52 ± 3.15[c]	7.37 ± 0.13[b]	0.63 ± 0.06[b]
Formula 1 (0:25:75)	20.06 ± 1.30[d]	9.35 ± 0.07[a]	0.66 ± 0.01[a]
Formula 2 (0:50:50)	20.79 ± 3.31[d]	6.00 ± 0.13[c]	0.60 ± 0.20[c]
Formula 3 (0:75:25)	29.29 ± 3.11[b]	6.06 ± 0.26[c]	0.60 ± 0.002[c]
Formula 4 (0:100:0)	33.49 ± 0.98[a]	5.73 ± 0.13[d]	0.58 ± 0.02[d]

[1] Data were expressed mean ± S.D. of triplicate
a-d values within a column with different letter are significantly different ($P \leq 0.05$)

Increasing the ratios of riceberry rice flour and decreasing the ratios of glutinious rice flour led to significantly decrease in the moisture contents and a_w values of gluten-free cookies. These a_w values and moisture contents of the cookies seemed to be negative correlation with the hardness values because of syneresis phenomenon, this term describing liquid oozing out of a large number of foods water binding capacity (Inglett et al., 2015).

The spread ratios of the cookies are given in Table 3. The increased width values and decreased thickness values were obtained from the gluten-free cookies produced from increasing the ratios of riceberry rice flour ($p \leq 0.05$). The spread ratios of gluten-free cookies were higher than that of original cookies (control). The increased ratios of glutinious rice flour affected the increased spread ratios of gluten-free cookies. This may be attributed to the presence of amylopectin that helps in the retention of a higher quantity of water through hydrogen bonding affecting swelling of cookies (Devisetti et al., 2015).

Table 3. Width, thickness and spread ratio of cookies with various ratios of wheat flour : riceberry rice flour : glutinious rice flour

Formulation / % ratio (wheat : riceberry rice : glutinious rice)	Width (W, mm)[1]	Thickness (T, mm)[1]	Spread ratio[1]
Control (100:0:0)	58.32±0.17[e]	8.20 ± 0.25[c]	7.11 ± 0.02[d]
Formula 1 (0:25:75)	94.21±0.65[a]	7.48 ± 1.65[d]	12.59 ± 0.01[a]
Formula 2 (0:50:50)	85.01±1.5[b]	8.10 ± 0.98[c]	10.49 ± 0.02[b]
Formula 3 (0:75:25)	73.61±0.61[c]	8.73 ± 045[b]	8.43 ± 0.01[c]
Formula 4 (0:100:0)	60.81±0.88[d]	9.50 ± 0.74[a]	6.40 ± 0.01[d]

[1]Data were expressed mean ± S.D. of triplicate

a-d values within a column with different letter are significantly different ($P \leq 0.05$)

3.2 Colors of cookies

The colors of cookies after baking can be seen in Table 4. Increasing the ratios of riceberry rice flour tended to be lower values of both brightness (L) and yellowness (b) and higher value of redness (a) observed in the gluten-free cookies. The highest ratio of riceberry rice flour (100 %) led to the highest a value and the lowest L and b values of formula 4 of gluten-free cookies. This is due to riceberry rice enriched with both water soluble are mainly anthocyanin and lipid soluble antioxidants including carotenoid (Prangthip et al., 2013). However, many factors have been reported to affect the development of colors on the product surface, including temperature, air velocity, moisture and heat transfer into the sample (Shibukawa et al., 1989). Nevertheless, the main causes of changed color of cookies are the result of Maillard reaction, which depend on the content of reducing sugars and amino acids or proteins on the surface, the temperature and cooking time (Cauvain and Young, 2006).

Table 4. Color properties of cookies with various ratios of wheat flour : riceberry rice flour : glutinious rice flour

Formulation / % ratio (wheat : riceberry rice : glutinious rice)	L[1]	A[1]	b[1]
Control (100:0:0)	71.88 ± 0.82[a]	2.79 ± 0.19[d]	35.72 ± 0.38[a]
Formula 1 (0:25:75)	34.58 ± 4.76[b]	3.94 ± 0.03[d]	9.82 ± 0.03[b]
Formula 2 (0:50:50)	31.30 ± 0.59[c]	5.27 ± 0.21[c]	6.17 ± 0.54[c]
Formula 3 (0:75:25)	22.73 ± 0.27[d]	8.08 ± 0.11[b]	3.86 ± 0.04[d]
Formula 4 (0:100:0)	20.50 ± 0.21[d]	10.42 ± 0.04[a]	2.82 ± 0.04[d]

[1]Data were expressed mean ± S.D. of triplicate

a-d values within a column with different letter are significantly different ($P \leq 0.05$)

3.3 Sensory Evaluation

The sensory analysis (Figure 1) revealed that the highest values of cookies color, texture, flavor and overall acceptance were obtained from the original cookies (control), while the gluten-free cookies of all formulae were lower for all these parameters. The increased ratios of riceberry rice flour affected all sensorial parameters significantly ($p \leq 0.05$). The highest ratio of riceberry rice flour (100 % of riceberry rice flour) led to the lowest sensorial scores of all parameters of gluten-free cookies. Obviously, this indicated that the increased ratios of riceberry rice flour showed the darkened color due to higher anthocyanin content (Dizlek and Özer, 2016) and the enhanced hardness of the gluten-free cookies which affected sensory analysis such as color, texture, flavor and overall acceptance of gluten-free cookies.

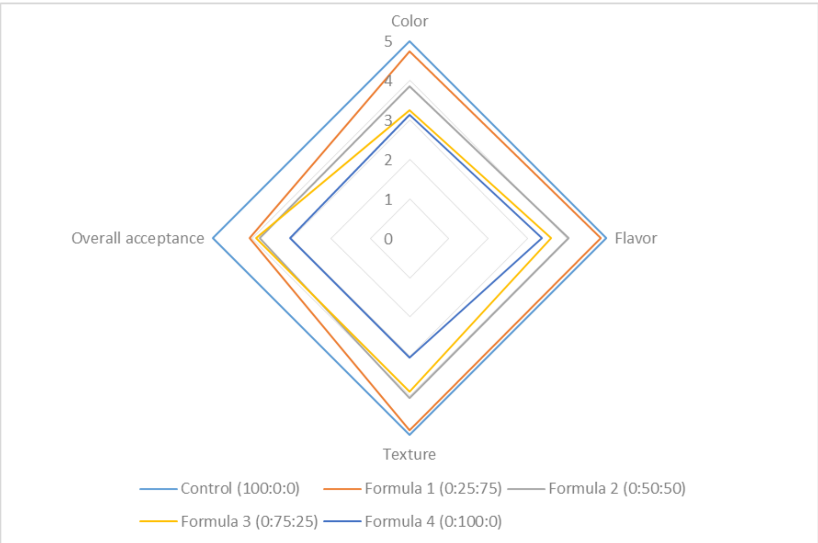

Figure 1. Sensory attributes of cookies with various ratios of wheat flour : riceberry rice flour : glutinious rice flour

4. Conclusion

The use of riceberry rice flour in recipes for gluten-free cookies had significant effects on chemical, physical, textural and sensorial characteristics of them. According to results of present study, the moisture contents and a_w of gluten-free cookies decreased significantly ($p \leq 0.05$) when the increased ratios of riceberry rice flour. Furthermore, the spread ratios of gluten-free cookies of all formulations were higher than that of original cookies (control). Increasing the ratios of riceberry rice flour led to lower values of both brightness (L) and yellowness (b) and higher value of redness (a) observed in gluten-free cookies. As well, the sensorial scores of all parameters of gluten-free cookies were lower when increasing the ratios of riceberry rice flour.

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