ORIGINAL ARTICLE

Effects of Vietnamese Rice Bran Oil as Vegetable Shortening Substitution on the Physical and Sensory of Baked Cookies

Nguyen Van Toan[1], Ngo Thi Thanh Van[2]

[1]Department of Food Technology, School of Biotechnology, International University, Vietnam National University, Ho Chi Minh City, Block 6, Linh Trung Ward, Thu Duc District, Ho Chi Minh City, Vietnam, [2]181 Bui Huu Nghia street, Binh Thuy District, Can Tho City, Vietnam

ABSTRACT

Background: Rice bran oil (RBO) has been well known for its high free fatty acids, rich in polyunsaturated fatty acids, more micronutrients, longer shelf-life, more stable at high temperature, better taste as well as good flavor to food products. RBO also offers higher content of iodine compared to that of another bakery shortening. Then, as a consequence, a successful application of RBO into baked products such as cookies would be nutritionally advantageous. **Purpose:** The purpose of this study is to investigate the effect of RBO on the physiochemical and sensory quality of baked cookies and to develop new recipe to make good cookies from RBO with improved nutritional values. **Materials and Methods:** The Vietnamese RBO used in this study was commercially refined oil of simply brand. **Results:** During 45 days of storage, moisture content increased significantly, and the fat content decreased significantly. The storage duration also which had a negative effect on the sensorial quality of cookies of all attributes scored was reduced. Based on the results of proximate analysis and sensory evaluation, it is concluded that, by increasing the percentage of RBO, quality of cookies was improved.

Key words: Cookies, improved quality, physiochemical attributes, rice bran oil, sensory attributes, shortening, storage

INTRODUCTION

Rice bran oil (RBO) is produced using the outer layer of rice (*Oryzae sativa* L.), which is widely grown in over hundred countries and had been the staple food around the world.[1] When paddy is milled, there is a separation of the germ and the bran from the endosperm. Thus, RBO is a by-product of milling process, which is then commercialized in the form of refined oil. Currently, the most successful countries producing RBO are India and Thailand. In India, about 6.5 lakh tons of RBO are produced from 40 lakh tons of rice bran by solvent extraction process.[2]

Typically, the RBO comprises about 20% of saturated fatty acids, even balance of monounsaturated fatty acids and polyunsaturated fatty acids (40:40). The RBO also has relatively high amount of unsaponifiable components. The oil is well known for its high free fatty acid, rich in polyunsaturated fatty acid, more micronutrients, longer shelf-life, more stable at high temperature, and better taste and flavor to food products. It is also considered as the nutritionally superior.[3]

RBO has significant advantages not only on human health but also affect several attributes of food products as a substitution in some food product such as mayonnaise, salad dressing, etc.[4] The addition of RBO into food products had been studied. According to Kim *et al*. (2000),[5] the addition of RBO into beef roast will have higher oxidative stability during storage than beef roast without additive. This result

Address for correspondence:
Nguyen Van Toan, Department of Food Technology, School of Biotechnology, International University, Vietnam National University, Ho Chi Minh City, Block 6, Linh Trung Ward, Thu Duc District, Ho Chi Minh City, Vietnam.
E-mail: nvtoan@hcmiu.edu.vn

was also concluded by Kim *et al*. (2001)[6] that not only the oxidative stability of beef roast was increased but also the Vitamin E content is improved.

Vietnam has a bold agriculture history with the growing rice and has become the second exporter of rice over the world.[7] However, the potential of RBO is still underestimated as people are not used to using RBO as a cooking medium, as well as a food ingredient. Since Vietnam has the advantage of producing RBO, the need of fully maximizing the potential of RBO as food ingredient in Vietnam is in great demand.

Baking industry is well developed recent years which is growing in size. There are two trends in the baking industry which are first, to reduce the total amount of fat and oil and to replace plastic fat with the liquid vegetable oil, of which replacement of highest fat baked product by those lower in fat and replacement of some animal fat by polyunsaturated vegetable oil products have recently been paid special interest. Moreover, people are much aware of health and nutrition nowadays. The product with good taste, reasonable price, and have a good nutritional image is in great need.[8] Thus, the functional and nutritional properties of RBO appeared to be well suited with its usage as shortening in the baked product as cookies.

Conventionally, the fat component in baked product is the shortening. Vegetable shortening is a semisolid fat that is mostly solid at room temperature. Vegetable shortening is typically made from hydrogenated and partially hydrogenated vegetable oils, such as corn, cottonseed, or soybean. This changes the chemical structure of the oil from mostly unsaturated to mostly saturated as Marcus (2013) has evidently concluded. Moreover, it also creates artificial trans-fats, which have serious negative health effects. To be more specific, trans-fats raise the risk of heart disease, death from heart disease, heart attack, and stroke. They also raise "bad" cholesterol levels, lower "good" cholesterol, and cause inflammation and the hardening of arteries (Kummerow, 2009).[10]

The effect of RBO on bread making had also been studied as the effect of its usage as an alternate of shortening. According to Kaur *et al*. (2012),[11] RBO was found to have a higher content of essential fatty acid linoleic acid (34.98%) as compared to that of shortening (5.14%). It was concluded that shortening can be successfully replaced with refined RBO up to 50% level of replacement in the preparation of bread with improvement in baking quality of the product. At 50% level of replacement, RBO proved to be superior to normal bakery shortening in the preparation of bread as far as quality (baking and organoleptic) of the product was concerned.

Besides, research about the effect of RBO as alternate of shortening on baked cookies had been carried out in terms of testing stability of cookies during storage. As Sharif *et al*. (2003)[12] described, RBO was applied into baked products such as cookies at various levels, i.e., 0, 25, 50, 75, and 100% by gradually replacing normal shortening to improve the quality of cookies in terms of shelf life due to natural antioxidants present in RBO. The result was quite interesting since there was a significant difference of stability among various ratios of RBO. It was concluded that, by increasing the amount of RBO, it could increase higher stability during storage of the made food products. To be specific, the cookie with the highest amount of RBO addition shows a minimum increase in the rancidity. Moreover, the ash content and crude fiber showed no significant change while the others had significant changes such as moisture content and fat content.

Although there are studies carried out to evaluate the effect of RBO as shortening substitution on the stability of cookies as mentioned above, the suitable process of producing good quality of cookies has not been determined. Thus, it is scientifically and realistically to evaluate the process of using RBO for the production of high-quality cookies. In addition, the effects of different ratios of RBO are also needed determining to make good sensorial quality cookie. To sum up, this study is carried out to evaluate the effect of RBO on the physiochemical and sensory quality of cookies using the new developed cookies formulation from RBO.

MATERIALS AND METHODS

Research object and location

RBO used in this study was commercially refined oil of a simply brand [Figures 1 and 2].

Other major ingredients needed to prepare cookies such as wheat flour, sugar, baking powder, and butter were obtained from Vinmart supermarket, Ho Chi Minh City, Vietnam.

The experimental studies were carried out in laboratories

Figure 1: Cai Lan (Calofic) shortening

Figure 2: Rice bran oil simply brand

of Food Technology Department of International University - Vietnam National University in Ho Chi Minh City.

Preparation of cookies

The prepared cookies using the all needed materials are given in Table 1, and the ratio of RBO to shortening is shown in Table 2.

Analysis of RBO and shortening

The shortening and RBO analysis were carried out using the methods described by AOAC, 17th Edition.[13]

Acid value

The value measures the amount of fatty acids which have been liberated by hydrolysis from the glycerides due to the action of moisture, temperature, and/or lipolytic enzyme lipase.[14]

Saponification value

The saponification value is an index of mean molecular weight of the fatty acids of glycerides comprising a fat.[15]

Iodine value

The iodine value determines the amount of unsaturation (number of double bonds) in a fat.[16]

Physical property measurement of cookies

The physical property measurement of the cookies was determined by following the proposed methods of Adeola and Ohizua, 2018.[17]

Proximate analysis of cookies

The proximate analysis of the developed cookies including moisture content and fat content was carried out at specific intervals of time as 15 days, 30 days, and 45 days, followed by described methods by AOAC.[13]

Sensory evaluation

The sensory evaluation was carried out at specific interval of time to test the acceptance of consumer toward cookie products in terms of color, flavor, taste, texture, crispiness, and overall acceptability. It is worth noting that the consumer

Table 1: The material of cookie formulation

Material	Weight (g)
Flour	140
Shortening/rice bran oil	25
Egg	50
Sugar	60
Baking powder	2
Salt	1

Table 2 : The ratio between rice bran oil and shortening

Treatment	Vegetable shortening (%)	Rice bran oil (%)
T_1	100	0
T_2	75	25
T_3	50	50
T_4	25	75
T_5	0	100

acceptance of four different samples of cookies was evaluated using a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).[18]

Statistical analysis

Data were subjected to analysis of variance using the "Statistical Package for the Social Sciences" version 20.0. Results were presented as means ± standard deviations of triplicate experiments. A significant difference was established at $P \leq 0.05$.

RESULTS

Proximate analysis of RBO and shortening

The results of analysis proximate attributes of RBO and shortening are presented in Table 3.

Values as shown in Table 3 represent the means ± standard deviations ($n = 3$ replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$).

Physical properties of baked cookies

The results obtained from the physical measurements of made cookies are shown in Table 4.

Values in Table 4 represent the means ± standard deviations ($n = 3$ replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$).

Physiochemical properties of cookies

The physiochemical properties of the developed cookies are shown in Table 5.

Values in Table 5 represent the means ± standard deviations (n = 3 replicates). The values denoted by different letters in the same column are significantly different ($P \leq 0.05$).

Effect of storage days on variance of physiochemical properties of cookies

The results obtained from the investigation of effects of storage days on variance of physiochemical properties of the developed cookies are shown in Table 6.

Values in Table 6 represent the means ± standard deviations of five treatments. The values denoted by different letters in the same column are significantly different ($P \leq 0.05$).

Sensory evaluation of cookies

Sensory evaluation of the product was conducted based on 9-point hedonic scale for appearance, color, flavor, texture, and overall acceptability. A semi-trained panel of 50 members was randomly selected to evaluate the sensory properties of developed cookies. The mean scores of five samples in five sensory attributes are presented in Table 7.

Effect of storage days on means of sensory properties of cookies

The effect of the storage days on the means of sensory properties of the developed cookies is shapely shown in Table 8.

Values in Table 8 represent the means ± standard deviations of five treatments. The values denoted by different letters in the same column are significantly different ($P \leq 0.05$).

DISCUSSION

Proximate analysis of RBO and shortening

As shown in Table 3, the physiochemical properties of shortening are quite smaller compared to RBO in terms of the acid value and iodine value, but the saponification value of shortening appeared to be higher than that of the RBO. To be more specific, the acid value of shortening is 2.474 ± 0.04, the iodine value of shortening is 81.326 ± 0.356, and the saponification value is 354.675 ± 58.44.

Table 3: Physiochemical of rice bran oil and shortening

Properties	Rice bran oil	Shortening
Acid value	3.765±0.411	2.474±0.04
Iodine value	110.618±0.129	81.326±0.356
Saponification value	354.675±58.44	445.597±17.544

The obtained results are somehow similar to the study of Perzybylski and Mag (2002)[19] on composition, properties, and uses of vegetable oils used in food technology. The reason for this difference between the RBO and shortening is the different chemical structure of RBO and shortening. First of all, acid value measures free fatty acid content of oil and depicts deterioration in sensory properties of oil. In addition, the acid value measured the amount of fatty acids which have been liberated by hydrolysis from the glycerides due to the action of moisture, temperature, and/or lipolytic enzyme lipase. Since the RBO has higher acid value, it implies that the risk of rancidity of oil is much higher compared to shortening. Second, the iodine value determined the amount of unsaturation (number of double bonds) in a fat. RBO has relatively high amount of unsaturated fatty acid. Thus, the iodine value of RBO is much higher. Third, the saponification value indicated the mean molecular weight of the fatty acids of glycerides comprising a fat. In addition, the saponification value related to average molecular weights of fats depicts the actual molecular weight of fatty acids; the higher the saponification value, the higher the molecular weight.

Physical properties of baked cookies

From Table 4, it can be clearly seen that the tested properties of the developed cookies in terms of the physical properties can be affected by the amount of RBO and shortening. The width range of the cookies varies from 3.40 ± 0.1 to 3.561 ± 0.09 in the order of samples T_5, T_4, T_3, T_2, and T_1, respectively. The mean difference shown that there is no significant difference between samples. The thickness of the cookies was also measured which shown the difference among these samples as the range of thickness varies from 0.566 ± 0.06 to 1.172 ± 0.04. The highest thickness belongs to sample T_5 which is 1.172 ± 0.04, while the thinnest is sample T_1 which is 0.566 ± 0.06, followed by samples T_2 (0.572 ± 0.02), T_3 (0.655 ± 0.04), and T_4 0.772 ± 0.01. Means for the thickness imply that there is a significant difference among these treatments. The spread ratio of cookies was shown which varies from 2.903 ± 0.14 to 6.346 ± 0.8 of T_5, T_4, T_3, T_2, and T_1, respectively. Means

Table 4: Physical properties of cookies

Treatments	Width (cm)	Thickness (cm)	Weight (g)	Spread ratio	Volume (cm³)	Density (g/cm³)
T_1	3.561±0.09^a	0.566±0.06^c	3.796±0.06^b	6.346±0.8^a	5.625±0.3^b	0.675±0.02^a
T_2	3.524±0.08^a	0.572±0.02^c	3.343±0.17^b	6.162±0.12^a	5.591±0.5^b	0.599±0.02^a
T_3	3.513±0.10^a	0.655±0.04^c	3.442±0.15^b	5.380±0.49^{ab}	6.343±0.06^b	0.542±0.02^a
T_4	3.486±0.08^a	0.772±0.01^b	4.490±0.27^a	4.515±0.08^b	7.380±0.51^b	0.536±0.09^a
T_5	3.40±0.1^a	1.172±0.04^a	4.91±0.11^a	2.903±0.14^c	10.649±0.77^a	0.462±0.02^a

for spread ratio of cookies shown that there are significant differences among treatments, in which treatment T_1 showed highest spread ratio of cookies, while treatment T_5 showed the lowest spread ratio of cookies.

The density of cookies was also measured. The range of density varied from 0.462 ± 0.02 to 0.65 ± 0.02 of treatments T_5, T_4, T_3, T_2, and T_1, respectively. Although there is the difference in the density value, the means exhibit that the difference was not significant.

The width of cookies was affected by the amount of RBO substitution to shortening. The result of this study is similar with the results reported by Sharif *et al*. (2005)[20] that, with the increase in amount of RBO, there is a decrease in the width of cookies.

Table 5: Physiochemical properties of cookies

Treatments	Moisture	Fat content
T_1	8.363±0.2[a]	17.71±0.71[b]
T_2	8.02±0.1[ab]	17.97±0.91[ab]
T_3	8.08±0.1[ab]	18.00±0.89[ab]
T_4	6.67±0.2[c]	18.45±0.87[ab]
T_5	7.77±0.2[b]	20.57±0.72[a]

The thickness of cookies was also affected by different treatments as there is an increase in the thickness of cookies as an increased amount of RBO. As Sharif *et al*. (2005) reported that with the increase of RBO, there is progressive trend in the thickness of cookies.

The spread ratio of cookies was also noted to have a relatively decrease with the increase of RBO content. The difference in particle size index of flour, moistness, and type of fat used are major factors determining the spread factor of cookies in baking as Sharif *et al.* (2005)[20] concluded. The result of this study was in the similar trend with the study of Sharif *et al.* (2009)[21] reported.

Physiochemical properties of cookies

As can be easily seen in Table 5, the moisture and fat content of baked cookies, the average moisture contents were 8.363 ± 0.2, 8.02 ± 0.1, 8.08 ± 0.1, 6.67 ± 0.2, and 7.77 ± 0.2(%) for T_1, T_2, T_3, T_4, and T_5, respectively. The highest moisture content 8.363% was found in T_1 followed by 8.08% in T_3 and 8.02% in T_2, and the lowest 6.67% was found in T_4 followed by 7.77% in T_2. Means for moisture content of cookies explicit significant differences among the treatments. The flowchart for producing the developed cookies is clearly presented in Figure 3

Table 6: Effect of storage days on variance of physiochemical properties of cookies

Properties	0 days	15 days	30 days	45 days
Moisture content	7.154±0.71	8.717±0.78	8.953±0.62	9.336±0.35
Fat content	18.545±1.12	16.10±0.74	15.817±1.04	15.348±2.07

Table 7: Sensory properties of baked cookies

Treatments	Color	Taste	Flavor	Crispiness	Texture	Overall acceptability
T_1	6.93[ab]	7.06[a]	6.86[ab]	6.76[ab]	6.48[b]	6.76[ab]
T_2	6.56[bc]	6.9[ab]	6.57[ab]	6.9[ab]	6.6[b]	6.76[ab]
T_3	7.63[a]	7.7[a]	7.26[a]	7.32[a]	7.67[a]	7.5[a]
T_4	7.23[ab]	7[ab]	7.07[a]	6.67[ab]	7a[b]	7.03[ab]
T_5	6.1[c]	6.2[b]	6.17[b]	6.3[b]	6.43[b]	6.73[b]

*Average of 30 evaluations. The values denoted by different letters in the same column are significantly different ($P \leq 0.05$)

Table 8: Effect of storage days on means of sensory properties of cookies

Properties	0 days	15 days	30 days	45 days
Color	6.893±0.59	6.6±0.62	6.14±0.54	5.98±0.55
Flavor	6.78±0.43	6.21±0.3	6.02±0.35	5.83±0.43
Taste	6.97±0.53	6.73±0.49	6.28±0.49	6.02±0.46
Crispiness	6.78±0.35	6.62±0.35	5.94±0.27	5.88±0.27
Texture	6.77±0.51	6.60±0.45	6.16±0.4	5.86±0.34
Overall acceptability	6.96±0.32	6.63±0.37	6.17±0.3	5.94±0.29

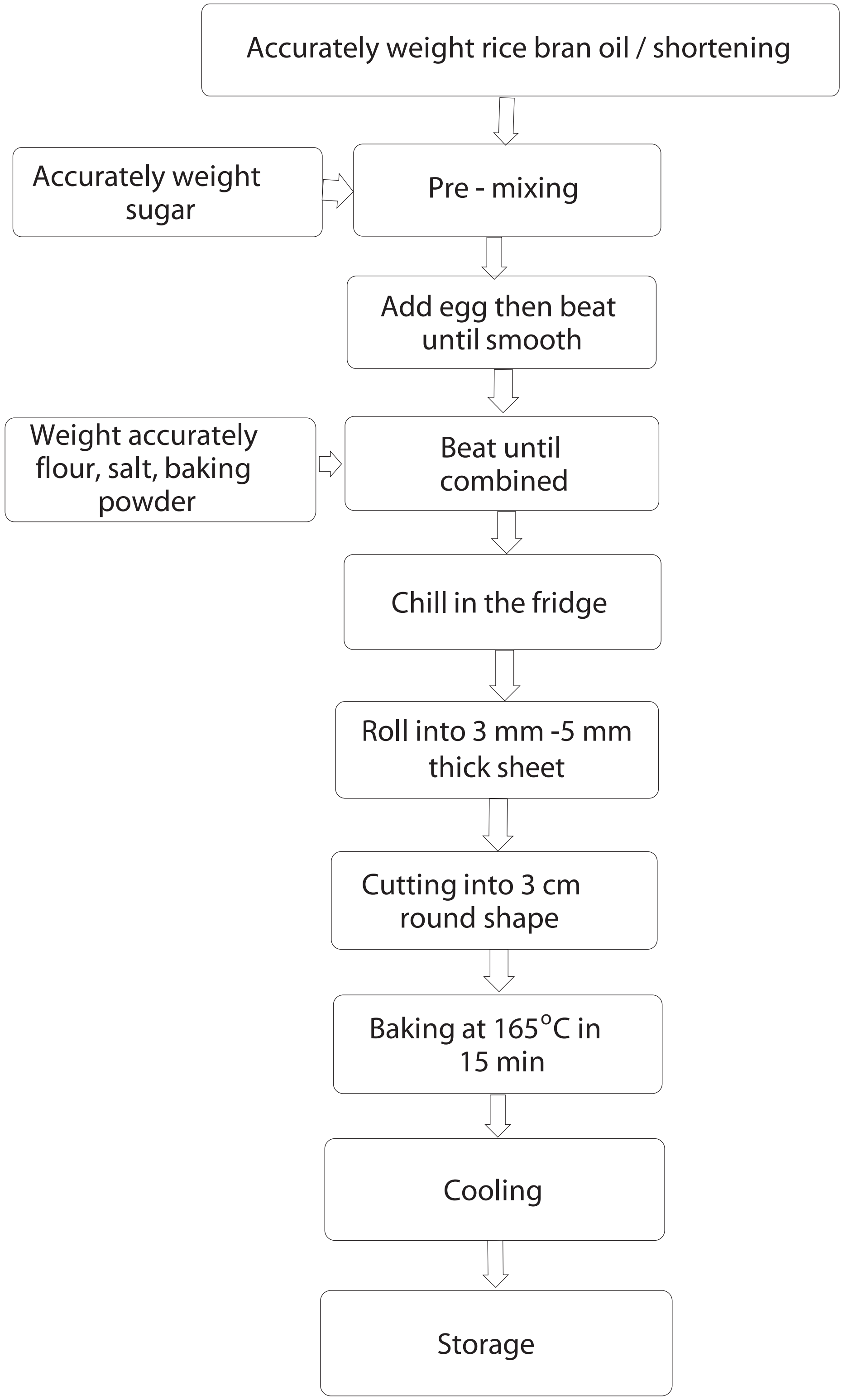

Figure 3: The flow chart of producing cookies

Average fat content of cookies was also measured. The range of fat content varies from 17.71% to 20.57% for T_1, T_2, T_3, T_4, and T_5, respectively. To be specific, the highest fat content belongs to treatment T_5 which is 20.57%, followed by 18.45% in T_4 and 18.06% in T_3. The lowest fat content is 17.71% in T_1 and 17.97% in T_2.

Effect of storage days on variance of physiochemical properties of cookies

As presented in Table 6, there was an increase in moisture content that was observed. The highest moisture content was noted at 45 days of storage which was 9.336%, and the lowest is at 0 day which was 7.14%. On the other hand, there is a decrease in fat content which decreases from 18.545% to 15.348% during 45 days of storage.

Both substitution levels of RBO and storage showed substantial influence on moisture content in all cookie samples. This increase was primarily due to packaging material (polythene bags). The packaging was not airtight, and lack of temperature control resulted in an increase in moisture contents of cookies. Moreover, cookies absorbed moisture from surrounding atmosphere due to hygroscopic behavior of wheat flour. A trend of increasing in moisture contents of cookie samples during storage has also been reported by Leelavathi and Rao (1993),[22] Rao *et al*. (1995),[23] Pasha *et al*. (2002),[24] Iqbal (2003), and Butt *et al*. (2004)[25] either due to atmosphere or packaging materials.

Different substitution levels of RBO and storage period revealed substantial effects on fat contents of cookies. The fat content value in this study is lower than the study carried out by Sharif *et al*. (2005).[20] The difference might be due to the difference in processing method, the storage condition, and also the difference in nature of shortening and oil used in project. However, the trend in decrease of fat content shares similarities. This decline in fat content during storage might be due to moisture uptake by cookies from the surrounding air and the breakdown of fats into different compounds as being concluded by Sharif *et al*. (2005),[20] Elahi (1997), Hussain *et al*. (2006),[26] and Mahmood (2008).[27]

Sensory evaluation of cookies

The sensory evaluation is one of the essential criteria in food industry. The cookies made in this project were prepared from commercial wheat flour with different amount of RBO as substitution of shortening was stored in polyethylene bags and placed in laboratory shelf at ambient temperature for 45 days. These were evaluated for various sensory attributes during 45 days of storage. Analysis of means explicits that cookies differed significantly regarding various sensory attributes such as color, taste, flavor, crispness, texture, and overall acceptability, due to treatments which are shown in Table 7. The results regarding each sensory attribute are discussed orderly.

The color of cookie samples was significantly affected by the level of RBO substitution, in which T_3 got the highest score which was 7.63, followed by 7.23 in T_4 and 6.93 in T_1. The lowest score in terms of color is 6.1 in T_5, followed by T_2. The panelist scored T_3 (7.26) at the first place and T5 (6.17) at the last position, followed by 6.57 in T_2, 6.86 in T_1, and 7.07 in T_4. Taste of cookies showed highly significant differences among the treatments. Judges ranked T_3 (7.70) at the first place and T_5 (6.20) at the last position, when taking averaged of all means. The sensory score in response to crispness of the cookies shown that T_3 got maximum score (7.32), while T_5 obtained the lowest score which is 6.3. The results indicated that the score for the texture of cookies released a highly significant difference among treatments. T_3 got the maximum score 7.0, while T_5 was at the bottom obtaining 6.43 in average. Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, taste, flavor, texture, and crispness of the cookies. T_3 got the maximum score 7.5, while T_5 was at the last position obtaining 6.73 score.

Treatments T_3 and T_4 got relatively high score in terms of sensory evaluation which showed that treatment T_3 (50% substitution of RBO) was preferred by the judges because it gave the desired sensorial properties to the cookies which distinguished it from others.

Effect of storage days on means of sensory properties of cookies

Storage has a significant effect on the color of cookies as shown in Table 8, and the maximum score 6.893 in average was obtained at 0 day by all the cookies which was significantly decreased as the storage time increased. The minimum score of 5.98 in average was obtained at 45 days of storage. The negative change in color of cookies might be due to the absorption of moisture from the atmosphere and oxidation of fats. These results are in close agreement with the findings of Pasha *et al*. (2002).[24]

Flavor of cookies revealed that maximum score was obtained by fresh cookies (0 days) which was gradually decreased with storage days. The range between 0 days and 45 days was 6.78–5.83. The loss in flavor might be attributed to absorption of water that resulted in fat oxidation. As regarding taste of cookies, the highest score was obtained by fresh cookies (0 days) which was gradually decreased with storage days. The range between 0 and 45 days was 6.62–7.36. Elahi (1997)[28] also found a decrease in mean score for taste from 6.62 to 5.81 after 90 days' storage in cookies prepared from composite flour. The quality score in response to crispiness of the cookies depicted that maximum score of 6.78 in average was obtained all the fresh cookies (0 days) which was decreased significantly as the storage time prolonged. The minimum score of 5.88 (average of 5 treatments) was obtained at 45 days. The range between 0 and 45 days was 5.88–6.78. Wade (1988)[29] stated that the cookies lost their crispiness during storage due to moisture absorption.

The results concerning with the score for the texture of cookies released maximum score were obtained by fresh cookies (0 day) which was gradually decreased with storage days. The range between 0 and 45 days was 5.86–6.77. Ahmad (1993)[30] stated that the texture of fresh cookies was better than the stored ones.

Overall acceptability was determined on the basis of quality scores obtained from the evaluation of color, taste, flavor, texture, and crispness of the cookies. As a whole, the maximum score was obtained by fresh cookies (0 days) which gradually decreased with prolonged storage time. The range between 0 and 45 days was 5.94–6.96. In earlier studies, a gradual decrease in overall acceptability of cookie during storage was reported by Elahi (1997)[28] who attributed it to moisture absorption, increase in peroxide value, and free fatty acid contents in cookie.

CONCLUSIONS

- In this study, the potential of substitution shortening of RBO in cookies to improve the physiochemical properties of cookies and the development of new recipes to make good quality cookies from the RBO were successfully and thoroughly investigated.
- The physiochemical analysis of the developed cookies revealed that the physical properties and chemical properties of RBO substitution cookies were much higher than the cookies made with shortening with the increase of RBO.
- Based on the sensory evaluation scores, the results of cookies produced from RBO substitution were significantly different than that of cookies made with 100% shortening in terms of all sensory attributes. The developed cookies exhibited the highest acceptable sensory characteristics among consumer panel members who were those containing 50–75% RBO substitution.
- The storage time had a significant effect on the physical and chemical properties of cookies due to the moisture uptake from environment, resulting in the higher chance of having fat rancidity. The moisture uptake can also affect the sensorial properties of cookies as the color of cookies, taste, and flavor of cookies and reduce crispiness.
- The obtained results of this study indicated that the developed cookies were successfully replaced shortening by RBO at the ratio of 50% (50% RBO-50% shortening). At 50% level of replacement, RBO proved to be superior than normal bakery shortening in the sensorial quality of products.

REFERENCES

1. Nagendra Prasad MN, Sanjay KR, Shravya Khatokar M, Vismaya MN, Nanjunda Swamy S. Health benefits of rice bran – A review. J Nutr Food Sci 2011;1:108.
2. Wasinee K, Ketmanee W, Artiwan S. Value added products from by-products of rice bran oil processing. Chiang Mai J Sci 2008;35:116-22.
3. Sharma AR. Edible Rice Bran Oil – Consumer Awareness Program. Rice Bran Oil Promotion Committee. Mumbai: Solvent Extractors Association of India; 2002.
4. Swern O. Bailey's Industrial Oil and Fat Products. 3rd ed. International Science Publication Technology; 1972. p. 196-225.
5. Kim JS, Godber JS, Prinaywiwatkul W. Restructured beef roasts containing rice bran oil and fiber influences cholesterol oxidation and nutritional profile. J Muscle Foods 2007;11:111-27.
6. Kim JS, Godber JS, King JM, Prinyawiwatkul W. Inhibition of cholesterol autoxidation by the nonsaponifiable fraction in rice bran in an aqueous model system. JAOCS 2001;78:685-9.
7. Demont M, Rutsaert P. Restructuring the Vietnamese Rice Sector: Towards Increasing Sustainability. Philippines: International Rice Research Institute; 2017.
8. Sharif MK, Butt MS, Anjum FM, Khan SH. Rice bran: A novel functional ingredient. Crit Rev Food Sci Nutr 2014;54:807-16.
9. Marcus JB. Culinary Nutrition. 1st ed. New York: Academic Press; 2013.
10. Kummerow FA. The negative effects of hydrogenated trans fats and what to do about them. Atherosclerosis 2009;205:458-65.
11. Kaur A, Jassal V, Thind SS, Aggarwal P. Rice bran oil an alternate bakery shortening. J Food Sci Technol 2012;49:110-4.
12. Sharif MK, Butt MS, Anjum FM, Qayyum MN. Extension of cookies shelf life by using rice bran oil. Int J Agric Biol 2003;5:455-7.
13. AOAC: Official Methods of Analysis. 17th ed. Arlington, Virginia: Association of Official Analytical Chemists; 2000.
14. Walter EF. Physical Refining of Vegetable Oils. AOCS Press; 2014.
15. Susan O, Victoria D, Leera S. Assessment of rancidity and other physicochemical properties of edible oils (mustard and corn oils) stored at room temperature. J Food Nutr Sci 2018;6:70-5.
16. Odoom W, Opoku VE. Evaluation of saponification value, iodine value and insoluble impurities in coconut oils from Jomoro district in the Western region of Ghana. Asian J Agric Food Sci 2015;3:223-6.
17. Adeola AA, Ohizua ER. Physical, chemical, and sensory properties of biscuits prepared from flour blends of unripe cooking banana, pigeon pea, and sweet potato. Food Sci Nutr 2018;6:532-40.
18. Meilgaard M, Civille V, Carr B. Sensory Evaluation Techniques. Boca Raton: CRC Press; 1991. p. 354.
19. Perzybylski R, Mag T. Canola/rapeseed oil. In: Gunstone DF, editor. Vegetable Oils in Food Technology: Composition, Properties and Uses. USA: Blackwell Publishing Ltd.; 2002. p. 12-98.
20. Sharif K, Butt MS, Anjum FM, Nasir M. Improved quality of baked products by rice bran oil. Internet J Food Saf 2005;5:1-8.
21. Sharif MK, Sharif Masood S, Butt FM, Nawaz AH. Preparation of fiber and mineral enriched defatted rice bran supplemented cookies. Pak J Nutr 2009;8:571-7.
22. Leelavathi KE, Rao PH. Development of high fiber biscuits using wheat bran. J Food Sci Technol 1993;30:187-90.
23. Rao TS, Rajmanuja MN, Ashok A, Vibhaker HS. Storage properties of whole egg powder incorporated biscuits. J Food Sci Technol 1995;32:470-6.
24. Pasha I, Butt MS, Anjum FM, Shehzadi N. Effect of dietetic

sweeteners on the quality of cookies. Int J Agric Biol 2002;4:245-8.
25. Butt MS. Storage studies of red palm oil fortified cookies. Nutr Food Sci 2004;34:272-6.
26. Hussain S, Anjum FM, Butt MS, Khan MI, Asghar S. Physical and sensoric attributes of flaxseed flour supplemented cookies. Turk J Biol 2006;30:87-92.
27. Mahmood SM. Baking and storage stability of retinyl acetate (Vitamin A) fortified cookies. Pak J Nutr 2008;7:586-9.
28. Elahi HH. Use of Emulsifies in the Production of Biscuits from Composite Flour. MSc. Thesis, Department of Food Technology, University of Agriculture, Faisalabad. Pakistan; 1997.
29. Wade P. Biscuits, Cookies and Crackers: The Principles of the Craft. Vol. 1. London and New York: Elsevier Applied Science; 1988.
30. Ahmad M. Effect of Supplementation of Treated Moth Beans on the Quality of Biscuits. MSc. Thesis. 1997. Department of Food Technology, University of Agriculture, Faisalabad. Pakistan; 1993.

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