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EVALUATION OF NUTRITIONAL, PHYSICAL, TEXTURAL AND SENSORIAL PROPERTIES OF GLUTEN FREE COOKIES SUPPLEMENTED WITH DRIED *Rosa damascena* Mill. PETALS

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Abstract

In the present study, the effects of dried and ground Rosa damascena Mill. petals (Rosa flour-RF) for improving the nutritional and some characteristics of gluten-free cookies (GFC) were investigated. The RF was used to replace 0-2.5-5-7.5-10% of gluten free flour (GFF) formulations. RF supplementation increased lightness and yellowness but decreased redness whereas a slight increase was observed at both moistures and spread ratio. RF addition lead to a significant reduction in the hardness of GFC while different levels of RF did not shown such an effect. RF provided darker samples and cookies became more brittle. RF addition led to an increase in total dietary fibre, total phenolics, and antioxidant activity of GFC. GFC containing RF were more appreciated than GFC with no added RF regarding taste and aroma. At the same time, a higher purchasing decision was found for cookies with added RF. Results showed that acceptable GFC couldbe produced by using RF up to 7.5% level to enhance the nutritional value of GFC that could be important for the gluten-free industry.

Key words: *antioxidant activity, celiac disease, dietary fibre, gluten-free, Rosa damascene.*

INTRODUCTION

Rosa damascena, regarding the economic and therapeutic point of view, has an essential place among medicinal and aromatic plants. There are about 15,000 tons of rose flower production per year in the world. It is commonly grown mainly in Turkey and Bulgaria (Anonymous, 2017).
Rosa genus consists of more than 200 species and 18,000 cultivars, among them *Rosa damascena* Mill.*, Rosa gallica* L. *and Rosa centifolia* L., have found industrial scale application for their flavouring and fragrance properties (Mahboubi, 2016). The Isparta Rose, *Rosa damascena* Mill.*,* stands in *Rosaceae* family, *Rosa* genus (Gül et al., 2015). *Rosa damascena* Mill. is usually grown in Isparta, Burdur and Denizli provinces of Turkey and mainly used for the production of rose oil (Gül, 2000).
Rosa damascena is a valuable raw material for cosmetic perfume, and drug industry (Şentürk and Doğan, 2017). Today, it is also used for the production of various food products such as: dessert (Gül et al., 2010), bread, delight, jam, syrup and vinegar.
Rosaceae family contains various components such as terpenes, glycosides, flavonoids and anthocyanins. Thus it possesses a wide range of pharmacological activities including antioxidant, antimicrobial, analgesic, anticancer, anti-inflammatory, antimutagenic, antidiabetic and antidepressant properties (Boskabady et al., 2011; Mahboubi, 2016). Memory enhancing effects of *Rosa damascena* due to the antioxidant effects were also reported by Mohammadpour et al. (2015).
Rosa damascena Mill. petals and leavens show significant antimicrobial and antioxidant effects (Şengül et al., 2017). Among flavonoid skaempferol and quercetin, in petals of *Rosa damascena* Mill. were found by Jaimand et al. (2010). Antimicrobial, anti-inflammatory, antioxidant, anticancer, protective neuronal, cardiac, gastrointestinal and hepatic effects of *Rosa damascena* Mill. in 21 *in vivo* and 30 *in vitro* animal studies were reviewed by Nayebia et al. (2017).
Dried flowers, petals, of *Rosaceae* family can solve problems with the digestive system (Boskabady et al., 2011). The dried buds and petals of the rose are used as laxative agent and flavouringin foods (Mahboubi, 2016).

Celiac disease which can be defined as an autoimmune disorder that is seen genetically predisposed individuals after eating foods including gluten and/or other environmental factors (Green et al., 2015).

Syndromes of this disease such as diarrhea, malabsorption, growth issues etc. can be prevented only by being tightly bound to gluten-free diet during lifelong.

There has been an increase in the number of patients suffering from the celiac.

Therefore the demand for gluten-free products increases day by day. Unfortunately, both the low quality and the nutritional deficiencies are significant problems due to the starch-based composition of these products (Hayıt and Gül, 2017a).

There are extensive research to produce gluten-free products at least partially resembles the gluten-containing counterparts regarding nutritive, sensory and technological quality (Pellegrini and Agostoni, 2015).

All age groups have extensively consumed cookies since for a long time for their convenience of ready to eat, long shelf life and rich nutrient composition (Acun and Gül, 2014; Gül et al., 2016; Gül et al., 2017). At the same time cookies are also preferred and consumed in large quantities by celiac patients.

Valitutti et al. (2017) were investigated the pattern of cereal-based products consumption among people with celiac disease. Celiac disease patients' median three-day intake of biscuits and crackers was found higher compared with a control population (65.8 g vs. 22.7 g and 44.7 g vs. 10.6 g, respectively), by these researchers.

There ismore researches regarding the improving of nutritional content and technological quality of gluten-free cookies (Hadnađev et al., 2013; Giuberti et al., 2018; Molinari et al., 2018; Porcel et al., 2017), and other gluten-free bakery products (Özer and Dizlek, 2016; Hayıt and Gül, 2017b; Hayıt and Gül, 2017c).

To the best of our knowledge, we found no study to use dried and ground *Rosa damascena* Mill. petals (RF) in the formulations of gluten-free cookies. In this context, the effect of increasing levels (0-2.5-5-7.5-10%) of RF on chemical, physical, textural, nutritional and sensorial properties of GFC were investigated.

MATERIALS AND METHODS

Materials

Rosa flour, as dried and ground form of *Rosa damascena* Mill. petals, was obtained from Kurucum Gıda (Isparta Turkey). Potato and corn starch from Tat Construction Industry and Trade Incorporation (İzmir, Turkey), corn and rice flour from Hüsnü Özmen Food Industry Incorporation (İzmir, Turkey), sodium bicarbonate from Şişecam Chemicals Group Soda Industry (Mersin, Turkey) were purchased. Corn syrup (42%) was kindly supplied from Sunar Corn Integrated Plant Inc. (Adana, Turkey). Hydrogenated vegetable oil, fine granulated sugar and salt were purchased from local markets.

Chemical analysis

Moisture, ash, protein, total lipid, total dietary fibre content of RF, corn starch, potato starch, corn flour, rice flour and cookie samples were determined by using AACC Method 44-01.01, AACC Method 08-01.01, AACC Method 46-12.01, AACC Method 30-25.01 and AACC Method 32-05.01 (AACC, 2001), respectively. pH was determined according to Sertakan, 2006. For the measurement of water activity (Woody, 2003), the cookies were crushed into small granules, and approximately 2 g of sample were placed in plastic dishes designed for use with an a W-meter (Novasina, LabTouch-aw, Lachen, Switzerland). Total phenolic content (TPC) and antiradical activity of RF and cookies were detected by using methods of Singleton and Rossi, (1965) and α-diphenyl-β-picrylhydrazyl DPPH method of Dorman et al. (2003).

Experimental design

RF was used to replace 0-2.5-5-7.5-10% of gluten free flour (GFF) formulations. GFF included 7% corn starch, 8% corn flour, 40% rice flour and 45% potato starch. Response Surface Methodology analysed this mixture and range of ingredients in our previous study (not pressed yet).

GFC preparation

Cookies were prepared according to AACC method 10-50.05 (AACC, 2000) with slight modifications. 225 g GFF mixture (14%

moisture basis), 64 g hydrogenated vegetable oil (cream shortening), 130.0 g fine granulated sugar, 2.1 g salt, 2.5 g sodium bicarbonate ($NaHCO_3$), 33 g high fructose corn syrup (42%), and 16.0 g distilled water was used for preparation of cookies. No added RF (0%) GFC sample was taken as control. Preparation of dough was made in a mixer (Hobart, N-50) according to the procedure given in the method 10-50.05 (AACC, 2000). The dough was then gently scraped from the bowl and sheeted by rolling pin to 5 mm thickness. Then it was shaped circular with a diameter of 60 mm with a circular scone cutter. Baking was performed in a convection oven (Fimak FSET4, Turkey) at $205^0C \pm 2^0C$ for 10 min. Cookies were cooled at room temperature and packed in high-density polyethene bags with hermetic cover until further analysis.

Geometrical analysis

The physical characteristics of cookies were analysed for width (W), thickness (T), and spread ratio (W/T) values by digital calliper in mm. The cookies were laid edge to edge and were measured for diameter and measured after rotating them through 90^0. The spread ratio was obtained by finding the ratio between the average width and thickness of the cookies. Six cookie samples were taken in each experiment.

Color analysis

Color parameters of RF and GFC were determined using colourimeter (Minolta CR-310, Minolta Co Ltd., Tokyo, Japan). Average L (lightness), a (redness) and b (yellowness) values were recorded after five readings for each measurement.

Texture analysis

The maximum force „hardness" and the distance at the point of break „fracturability" values of GFC were measured by using a texture analyser (TA-XT PLUS, Stable Micro Systems, Surrey, UK) equipped with a 3-Point Bending Rig (HDP/3PB). 5 kg load cell was used for calculation of these texture parameters. The pre-test speed of 1.0 mm/s, the test speed of 3.0 mm/s, the post-test speed of 10 mm/s, a distance of 5.0 mm and data acquisition rate, 500 pps. All textural tests were performed in triplicate.

Sensory analysis

Cookies were evaluated by ten untrained judges from food engineering department according to Gül et al. (2013) after 4 hours of baking. Hedonic scale from 1 to 5 point; 'dislike extremely' to 'like extremely' respectively, was used. Each panellist evaluated five samples of the cookies for the following sensory attributes, colour, surface structure, texture (hardness and brittleness), flavour, odour, mouthfeel, and overall acceptance. Along with that purchasing intent of cookies were evaluated according to Gül and Şen (2017) on a five-point scale (5: definitely would buy, 1: definitely would not buy).

Statistical analysis

All the analysis was done in triplicate. Analysis of variance (ANOVA) was conducted by using the software, statistical package for social science (SPSS 16.0) procedures. Duncan's multiple range test with significance defined at $P < 0.01$ was used to determine significant difference among the various samples.

RESULTS AND DISCUSSIONS

Chemical composition of RF, and gluten-free flour ingredients

Moisture, ash, protein, total dietary fibre and total lipid content of RF and GFF ingredients are given in Table 1.

Table 1. Chemical composition of soft wheat flour, potato starch, corn starch, corn flour and rice flour[1]

Material	Moisture (%)	Ash (% d.b)	Protein (% d.b)	Total lipid (% d.b)	TDF (%)
RF	5.75 ± 0.01^a	4.51 ± 0.05^a	2.6 ± 0.02^b	4.8 ± 0.08^b	61.40 ± 1.15^a
Potato starch	8.30 ± 0.03^c	0.79 ± 0.09^c	0.19 ± 0.91^c	0.45 ± 0.01^e	0.69 ± 0.32^d
Corn starch	8.34 ± 0.02^c	0.69 ± 0.11^c	0.25 ± 0.81^c	0.82 ± 0.02^d	0.47 ± 0.29^d
Corn flour	9.10 ± 0.21^b	1.12 ± 0.03^b	7.14 ± 0.61^a	5.15 ± 1.00^a	9.16 ± 1.09^b
Rice flour	9.29 ± 0.22^b	0.47 ± 0.01^d	7.7 ± 0.52^a	1.25 ± 0.19^c	4.88 ± 1.07^c

[1]Mean values in the same column with different letters are significantly different ($p<0.01$), RF: Rosa flour, TDF: Total dietary Fibre.

Ash and total dietary fibre content of RF were observed significantly higher than other GFF ingredients while its moisture found lower than others. In terms of lipid content, RF ranked second after corn flour with 4.8%. These results suggest that RF is a rich source of dietary fibres, minerals and other nutrients. Since it is a good source of dietary fibre, so it can provide many beneficial effects on health such as; lower risk for developing coronary heart disease, hypertension, stroke, obesity diabetes and certain gastrointestinal diseases (Anderson et al., 2009).

The vegetable material must contain more than 50% dietary fibre to identify it as antioxidant dietary fibre (Saura-Calixto, 1998). According to this statement,RF could be interesting for the potential use as afood ingredient to improve the fibre profile of food products.

Total phenolic and antioxidant capacity of RF

TPC and DPPH antiradical activity of RF were calculated as 414.2 g/kg GAE (Gallic acid equivalent) and 73.15 IC_{50}, µg/ml. In the present study antiradical activity of RF was found higher when compared with the results of Sakač et al. (2015), who determined DPPH scavenging activity of light buckwheat flour which is used in gluten-free formulations as IC_{50} 1.61 mg/ml.

Chemical composition of cookies

The addition of RF to GFF has slightly affected the moisture, aw and ash content of GFC (Table 2). These values were an expected result because of the higher moisture and ash content of RF (Table 1) than the amount of other GFF components.

Table 2. Chemical composition of GFC supplemented with RF[1]

RF (%)	Moisture (%)	Aw	Ash (%)	pH	Protein (%)
0	5.11±0.13[b]	0.36±0.00[c]	2.05±0.03[c]	7.33±0.12[a]	4.80±0.11[a]
2.5	5.83±0.28[ab]	0.42±0.01[b]	2.03±0.03[c]	7.11±0.03[b]	4.24±0.25[b]
5	6.10±0.10[a]	0.41±0.00[b]	2.21±0.01[b]	7.00±0.05[bc]	4.26±0.25[b]
7.5	6.14±0.70[a]	0.42±0.00[b]	2.22±0.01[b]	6.91±0.03[c]	4.02±0.03[bc]
10	6.42±0.23[a]	0.44±0.00[a]	2.56±0.01[a]	6.88±0.08[c]	3.70±0.10[c]

[1]Mean values in the same column with different letters are significantly different (p<0.01), RF: Rosa flour, Aw: Water activity

The pH and protein ranged from 7.33 to 6.88 and 4.80 to 3.70, respectively. Both of them decreased with increase in RF concentration. The decrease in the protein content of GFC was due to the decrease at the concentration of corn and rice flour which had high protein content in the formulations. A similar dilution effect on protein content was previously reported on cookies substituted with an unripe plantain flour (Garcia-Solis et al., 2018).

Total dietary fibre content of cookies

The dietary fibre content of the RF supplemented gluten-free cookies are given in Table 3.

Table 3. Total dietary fibre, TPC and antioxidant activity of GFF supplemented with RF[1]

Addition level of RF (%)	Total dietary fibre (%)	TPC (g/kg GAE)	Antiradical activity DPPH IC_{50} mg/ml
0	5.73±0.02[d]	0.92±0.67[d]	ND
2.5	5.23±0.20[d]	61.40±1.52[c]	ND
5	6.76±0.02[c]	105.09±1.18[b]	7.92±0.05[a]
7.5	8.23±0.07[b]	125.97±1.07[b]	6.95±0.08[b]
10	10.21±0.09[a]	169.61±2.15[a]	5.81±0.02[c]

[1]Mean values in the same column with different letters are significantly different (p<0.01), RF: Rosa flour, ND: Not detected, TPC: Total Phenolic content, GAE: Gallic acid equivalent

Total dietary fibre content of the GFC was found to be significantly different (P<0.01) after the addition level of RF more than 2.5%. This significant increase can be associated with the higher content of dietary fibres in RF. An increase in dietary fibre content of GFC by fibre addition was also described by Garcia-Solis et al. (2018). On the other side, authors Sakač et al. (2015) found lower total dietary fibre (2.94 g/100 g) in gluten-free cookies containing 30 % light buckwheat flour.

Total phenolic content and antioxidant capacities of cookies

TPC and antioxidant capacities of cookies enriched with RF are presented in Table 3. It is obvious that increasing RF levels resulted in remarkable increases in the TPC and antioxidant activity of GFC. TPC content of GFF was increased from 0.92 g/kg GAE to 169.61 g/kg GAE by the addition of RF at 10% level. It is noteworthy that, while control GFC with no added RF and GFC with 2.5% added RF, did not shown any antiradical activity, whereas the antioxidant activity of 5%, 7.5% and 10% RF containing cookies were increased gradually due to their higher total phenolic content. Similar results were found in gluten-free cookies supplemented with light buckwheat flour (Sakač et al., 2015) and sugar beet molasses (Filipcev et al., 2016).

Geometrical properties of cookies

Geometrical properties of cookies are presented in Table 4.

Table 4. Geometrical properties of GFC supplemented with RF[1]

RF (%)	Width (W, mm)	Thickness (T, mm)	Spread ratio (W/T)
0	70.75±0.80^{a}	9.31±0.55^{b}	7.60±0.38^{a}
2.5	64.41±0.26^{b}	11.76±0.69^{a}	5.47±0.33^{b}
5	63.61±0.17^{bc}	11.40±0.91^{a}	5.58±0.43^{b}
7.5	62.62±0.25^{c}	10.87±0.47^{ab}	5.76±0.26^{b}
10	61.32±0.44^{d}	10.81±0.25^{ab}	5.67±0.16^{b}

[1]Mean values in the same column with different letters are significantly different (p<0.01), RF: Rosa flour.

A significant difference (p<0.01) was occurred between geometrical properties of control and RF supplemented GFC. Control cookies with no RF had the highest width and spread ratio whereas had the lowest thickness. There was a progressive decrease observed in the width values of RF added GFC. Hydrophilic nature of the RF may be led to decrease in width values of cookies. After the addition of RF, the content of free water in the empty spaces of the gluten network could be limited which indicates high compactness of this network (Nawrocka et al., 2016) which led to obtaining more compact cookies.

Color values of cookies

Surface color with texture and flavour of cookies are the main features considering the preference of consumers. Surface colour values of cookies are shown in Table 5. The addition of RF affected significantly (P<0.01) the L, a, and b values of GFC.

Table 5. Color and textural properties of GFC supplemented with RF[1]

RF (%)	L	a	b	H (g)	F (mm)
0	60.3±0.17^{a}	6.0±0.09^{d}	20.6±0.01^{a}	8228.1±92.65^{a}	40.59±0.02^{c}
2.5	48.6±0.16^{b}	8.1±0.06^{c}	9.9±0.69^{b}	4646.2±194.61^{b}	41.49±0.24^{b}
5	42.1±0.27^{c}	10.2±0.11^{b}	6.5±0.05^{c}	4229.7±126.23^{c}	42.91±0.05^{a}
7.5	37.6±0.88^{d}	10.9±0.31^{a}	4.2±0.06^{d}	4135.6±91.76^{d}	42.69±0.25^{a}
10	34.2±0.78^{e}	11.4±0.32^{a}	3.7±0.04^{d}	4083.5±63.05^{e}	42.82±0.36^{a}

[1]Mean values in the same column with different letters are significantly different (p<0.01), RF: Rosa flour, H: Hardness, F: Fracturability

Control cookies with no added RF were found lighter than RF added GFC (Figure 1). Substitution of RF caused a gradual decrease in both lightness and yellowness values and a increase in redness. Lower L and b values observed for RF cookies are possibly related to the specific darker colour of RF (Table 1). At the same time, the formation of colour widely known as browning, is the result of Maillard reaction and caramelisation (Purlis, 2010).

Figure 1. Photographs of the cookies, from left to right: control, and Gluten-free cookies (GFC) with 2.5-5-7.5-10% RF added

Textural properties of cookies

The texture values, hardness and fracturability of GFC are presented in Table 5. There was a significant difference detected between the hardness values of control and RF added cookies. RF supplementation was led to a sharp decrease in the hardness of GFC. This should result from the higher moisture and total lipid content of RF (Table 1). Although there was a gradual decrease in hardness values of GFC in increasing levels of RF, it is not as noticeable as the drop was seen between control and RF containing cookies. Supplementation of RF was causedby a slight increase in the fracturability values of RF cookies as compared with control. Increasing concentrations of RF, except 2.5% level, did not affect significantly the fracturability of GFC.

Sensory properties of cookies

Sensory evaluation scores for GFC added with four different levels of RF are shown in Figure 2. There was a tendency towards the higher scores for 10% RF containing cookies, whereas their surface structure was scored lowest. Brittleness, mouthfeel, flavour and aroma points were increased, more prominently with cookies made with RF when compared with control cookie. Among all cookies, 7.5% RF added GFC were scored higher regarding odour, aroma and mouth feel.

General acceptability and purchasing intent of cookies were shown in Figure 3. These values were scored slightly higher at 2.5 and 5% enrichment levels. They became more dominant at the 7.5 addition level of RF. However, further increase of RF level to 10% led to decrease in the overall acceptability and in purchase intent of GFC. The lowest acceptance level and purchasing intent were reported for cookies made with 2.5% RF and control.

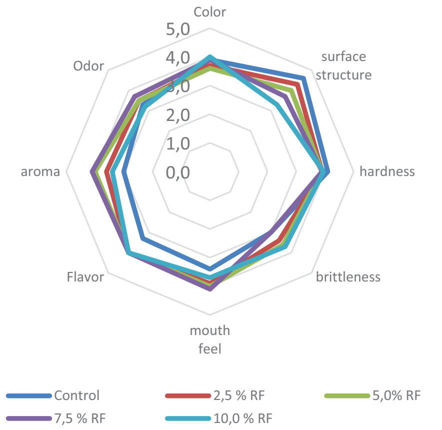

Figure 2. Sensory attributes of cookies supplemented with Rosa flour (RF)

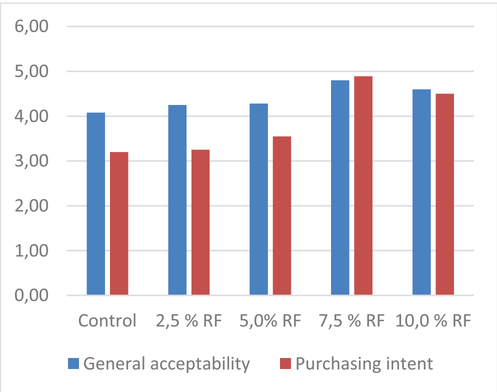

Figure 3. General acceptability and purchasing intent of cookies, RF: Rosa flour

CONCLUSIONS

The addition of RF in to GFC at an increasing rates lead to a slight increase on moisture, aw and ash content while pH and protein content of GFC were affected adversely. It is obvious that increasing RF levels resulted in remarkable increases in the total dietary fibre, total phenolic content and antioxidant activity of GFC. Sharp decrease on the spread ratio and hardness were observed when the RF was added to GFC formulations. However its increasing concentrations did not lead to a significant differences both on spread ratio and fracturability. Addition of RF made GFC darker and redder than control samples. Odour, aroma and mouth feel of GFC supplemented with 7.5% RF was scored higher. At the same time its overall acceptability and purchasing intent were found higher than other cookie samples.

When all of these constituents are evaluated together, they may have various beneficial effects on human health. However, gluten-free products have lower dietary fibre, and phenolic compounds due to the based on starch or other compounds have limited nutritional content. The overall results showed that the gluten-free cookies with acceptable quality and improved nutrition could be prepared from RF up to 7.5% level. As a result, it can be suggested that the petals of *Rosa damascena* Mill. can be used to enhance nutritional and sensorial profiles of gluten-free cookies.

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