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Effect of melon seed powder on the quality characteristics of cupcakes

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ABSTRACT

Enriching cereal-containing functional foods in the changing food industry is highly attractive. Examining the use of nutrient-rich melon seed powder (MSP), a waste, in bakery products is valuable in sustainability. Within the scope of the study, the use of MSP as an alternative raw material to whole wheat flour (WWF) in cupcake formulation was investigated. Four formulations containing varying proportions of MSP (0%, 10%, 20%, 30%) were evaluated. Depending on the increase of MSP substitution, an increase was observed in the protein, fat and total ash ratios of the cupcakes. The addition of MSP to the product caused browning in the colour of the cupcakes and an increase in hardness values while causing a decrease in their specific volumes. According to the sensory analysis results, while the control cake was the most liked group, it was determined that MSP addition could be used up to 20% in terms of general acceptability and odour in cake production.

Keywords: Functional Food, Melon Seed, Cupcake, Nutritive Value

Introduction

Cereal-based foods are among the most consumed from the earliest times of humanity. For this reason, it is aimed to improve public health by enriching cereal-based foods with some components with functional properties and presenting them as "functional food" (Aksoylu et al., 2012). While these substitutions affect the nutritional values of the products, they also directly affect the functional properties such as increased gel-forming, stabilising, and water and oil-holding capacities (Khan et al., 2016). In this direction, waste products such as fruit peel, seed and pulp are becoming widespread in the enrichment of bakery products (Mirabella et al., 2013). Melon seeds are among the products that have attracted attention in evaluating food waste in recent years.

Melon seed is a precious product due to its rich composition. The chemical composition of melon seed contains 15-25% protein, 15% fibre, B and C vitamins, iron, magnesium, potassium, calcium, phosphorus minerals and 20-40% fat. The fat content of melon seeds is also precious. 59.0% linoleic acid and 26.4% oleic acid in it is highly effective on heart and brain health (Ok, 2020).

When the literature is examined, some studies have been found in which melon seed flour is used for enrichment in the production of gluten-free lokma, noodles and muffins. Dabral and Sharma (2021), in which the effect of melon seed flour on muffins was evaluated, it was seen that only the sensory properties of the cakes were examined. In this direction, the study aimed to evaluate the effects of using melon seed powder in different proportions on the cakes' physical, chemical, textural and sensorial properties. The study is considered to be valuable in terms of waste assessment and sustainability.

Materials and Methods

Melon fruits, whole wheat flour, sugar, fresh whole eggs (approximately 65% of egg content is white and 35% is yolk), full-fat milk powder, shortening, baking powder, and vanilla were purchased from the local market in Kütahya, Türkiye.

Preparation of Melon Seed Powder

Melon Seeds Powder (MSP) was prepared according to the method described by Kılmanoğlu et al. (2022). Melon seeds were separated from the melon fruits using a knife and pre-frozen at -40°C for 2 h. Then, the seeds were dried in a freeze-dryer (CoolerMed, Türkiye) for 24 h. Lyophilization was carried out at a vacuum of 0.04 mbar and at -50°C. Dry samples were ground in a mill (Ozlem, Türkiye). Melon seed powder is kept in sealed glass containers at ambient temperature (22°C ±2) until analysis.

Preparation of Cupcakes

Cupcakes were prepared according to the method described by Gadallah et al. (2022). The formulation of cupcakes is given in Table 1. Sugar and shortening were mixed in a mixer (KitchenAid, USA) for 3 min at slow speed and then at medium speed for 2 min. Then, eggs were added and mixed at medium speed for 2 min. Milk powder and baking powder were added and mixed for 4 min. The prepared dough weighed 40 g, was put into cake moulds, and baked in an electric oven (Venarro, Türkiye) at 180°C for 30 minutes. The baked cupcakes were cooled for 1 hour and kept in sealed bags until the analysis.

Table 1. Formulation of Cupcakes

Samples	WWF (g)	MSP (g)	Fresh Whole Egg (g)	Sugar (g)	Shortening (g)	Baking Powder (g)	Milk Powder (g)
Control	100	0	85	60	50	4	3
10% MSP	90	10	85	60	50	4	3
20% MSP	80	20	85	60	50	4	3
30% MSP	70	30	85	60	50	4	3

WWF: Whole Wheat Flour, **MSP:** Melon Seeds Powder

Determination of Chemical Properties

The total protein content of WWF, MSP and cupcakes was determined by AOAC Method 979.09 (used as Conversion factor 5.70). Fat analysis was performed according to AACC Method 30-25.01. Total ash content was determined using the AOAC Method 923.03. The cupcakes' moisture content was determined using an infrared moisture analyser (RADWAG MAG 50, Poland). Oil holding capacity (OHC) and water holding capacity (WHC) were determined according to the methods described by Bin Ramli et al. (2010).

Determination of Physical Properties

The weight (g) of the samples was measured using a precision balance after 1h of cooling. The rapeseed displacement method was used to determine the volume of the cupcakes (Lee and Hoseney, 1982). The specific volume of cupcakes was calculated from the volume divided by weight. The baking loss was calculated according to Equation 1 (Altunakar, 2003).

Baking Loss= (Wd-Wc)/Wd*100 (Equation 1)

Wd: Dough weight before baking

Wc: Post-baking weight of the cake

Determination of Colour Properties

L, a, b values of cupcakes, MSP and WWF were determined with a colourimeter (PCE-CSM 4 Colorimeter, Türkiye). The colour properties of the flour and powder were determined using a rig belonging to the device. After the cupcakes were baked and cooled, measurements were obtained on the crust and crumb of the cupcakes (Su et al., 2005; Akbaş and Kılmanoğlu, 2022).

Determination of Sensory Characteristics

The sensory evaluation was conducted with 15 semi-trained panellists (9 females, 6 males) selected from Kutahya Dumlupinar University Pazarlar Vocational School staff and students. The cakes were coded after baking and presented to the panellists randomly. Panellists were asked to evaluate the samples for colour, hardness, taste, odour and overall acceptability. A scoring scale 5 was used (1: the minimum likes, 5: the maximum likes) (Bozdoğan et al., 2019).

Texture Analysis

The method specified by Tuna Ağirbaş et al. (2022) was used to carry out the texture analysis of the cupcakes. The hardness values of cupcakes were determined using TA, XT Plus C Texture Analyzer (Stable Micro Systems, England). The samples were cut in 2.5 cm diameter and 2 cm height dimensions and analysed using an aluminium cylindrical probe with a diameter of 36 mm. Cupcakes were compressed to 50% of their original thickness with a load cell of 5 kg and a test speed of 2 mm/s. The time between two compressions was determined as 30 sec.

Statistical Analysis

SPSS Statistic 22 (SPSS INC., Chicago, IL, USA) software package was used for statistical analysis. The significance of the difference ($p<0.05$) between the obtained data was determined using the Tukey test and revealed by one-way analysis of variance (ANOVA). All analyses were repeated three times and are given with their standard deviations.

Results and Discussion

The results obtained from the physicochemical, functional and colour measurements of WWF and MSP are shown in Table 2. The moisture content of MSP was lower than WWF, while the fat, protein and ash content were higher. Another study reported that fruit kernel flour has higher protein, fat and total ash content than wheat flour (Çelik and Pozan, 2020). For this reason, cupcakes produced with MSP are expected to contain more ash and protein than those prepared with whole wheat flour.

In the production of bakery products, the water-holding capacity of flour plays a critical role in forming texture in foodstuffs (Zayes, 1997). In addition to flour's protein and starch components, lipids in the product also affect the water-holding capacity (Sissons, 2008). Because MSP contains more fat than WWF, the water-holding capacity of MSP has been calculated to be lower than that of WWF. Fişek (2021) reported that oil components reduce the water-holding capacity.

Components with high oil-holding capacity act as emulsifiers and improve the viscosity and texture of foods (Aydın, 2020). When the oil holding capacities of flours were examined, the oil holding capacity of MSP was lower than that of WWF. This result can be interpreted as a reduction in the water and oil binding capacity due to the binding of lipids in melon seeds to hydrophobic groups and amylose units (Fişek, 2021).

The L value, which means the degree of white to black colour, recorded the lowest value in MSP (71.74±4.44) compared to WWF (90.07±0.43), while the redness (a) and yellowness (b) values of MSP were significantly higher than WWF.

Table 2. Physicochemical, functional, and colour properties of WWF and MSP

Sample	WWF	MSP
Moisture (%)	9.26 ±0.04	4.94 ±0.03
Total Ash (%)	1.12 ±0.07	6.44 ±0.06
Fat (%)	4.01 ±0.08	20.06 ±1.14
Protein (%)	13.64 ±0.10	17.22 ±0.07
WHC (g/g)	3.01 ±0.02	2.41 ±0.01
OHC(g/g)	2.05 ±0.01	1.60 ±0.00
L	90.07 ±0.43	71.74 ±4.44
a	1.47 ±0.36	7.28 ±0.05
b	9.84 ±0.58	29.13 ±0.49

WWF: Whole Wheat Flour, **MSP:** Melon Seed Powder, **WHC:** Water Holding Capacity, OHC: Oil Holding Capacity

Chemical analysis results of cupcakes are presented in Table 3. The cupcake content of fat significantly increases with the addition of MSP. This is because the fat content of MSP is more than WWF. It is stated that fruit and vegetable seeds have a high-fat content and enrich the product in terms of fat (Bialek et al., 2016).

It revealed that the moisture of cupcakes decreased proportionally to the addition of MSP. However, this decrease was not statistically significant ($p>0.05$). The decrease in moisture contents was interpreted as MSP containing less hydrophilic components due to its high-fat content (Manthey et al., 2004). Some studies show that seed powder-added cupcakes have low water holding capacity, which is coherent with our results (Khan et al., 2016; SZidan and Suliman, 2022).

When the total ash content of the cupcakes is compared, it can be said that it increases as the MSP addition rate increases, but only the cupcake with 30% MSP significantly differs when compared to the control. Generally, the increase in the ash content of the products is important because it is associated with increased functionality. Ambigaipalan and Shahidi (2015) reported that the ash content of cakes prepared with palm kernel flour (2.5% and 5%) increased significantly.

The water-holding capacity is related to the amount and structure of the hydrophilic components in the molecular structure and their position to interact with water at the surface in the tertiary structure (Zayes, 1997). In food with high-fat content, the lipid component can easily form complex structures with starch through weak bonds or remove the hydrophilic groups of starch from water due to its hydrophobic structure (Fişek, 2021). It can be said that the WHC of cupcakes significantly decreases depending on the increase in MSP addition. This is related to the fact that the water-holding capacity of MSP is less than WWF (Fişek, 2021).

It was seen that the increase in MSP addition caused a decrease in the oil-holding values of the cupcakes. The change in oil holding capacity was statistically significant ($p<0.05$). It can be interpreted that the cupcakes' oil holding capacity decreases as the cupcakes' oil content increases. Joshi et al. (2015) reported that increased water and oil holding capacity was observed in samples with reduced fat content.

Table 3. Chemical analysis results of powder and cupcakes

Sample	Moisture (%)	Total Ash (%)	Fat (%)	Protein (%)	WHC (g/g)	OHC (g/g)
Control	25.71±1.62 ^{a}	1.74±0.01 ^{bc}	15.25±0.07 ^{a}	9.04±0.72 ^{a}	2.51±0.01 ^{d}	3.29±0.03 ^{d}
10% MSP	24.85±1.14 ^{a}	1.72±0.02 ^{b}	15.37±0.06 ^{a}	10.02±1.22 ^{a}	2.34±0.004 ^{c}	3.2±0.01 ^{c}
20% MSP	24.76±1.48 ^{a}	1.85±0.02 ^{bc}	16.33±0.06 ^{b}	14.36±0.49 ^{b}	2.21±0.01 ^{b}	2.74±0.01 ^{b}
30% MSP	24.58±0.34 ^{a}	1.88±0.00 ^{c}	17.87±0.02 ^{c}	15.14±0.69 ^{b}	2.11±0.02 ^{a}	2.41±0.01 ^{a}

WWF: Whole Wheat Flour, **MSP:** Melon Seed Powder, Control: cupcake without melon seed powder, **10% MSP:** cupcake with 10% melon seed powder, **20% MSP:** cupcake with 20% melon seed powder, **30% MSP:** cupcake with 30% melon seed powder, **WHC:** water holding capacity, **OHC:** oil holding capacity, Different letters within a column indicate significant differences at $p<0.05$

The raw materials used in bakery products directly affect the product's colour. Product colour is also one of the most critical parameters affecting the acceptability of the product (Aljobair, 2022). The crumb and crust colour analysis results of cupcakes are shown in Table 4. While L and a values were not statistically significant for the crumb colour of cupcakes, b values were different. It was stated that the increase in b value was due to the carotenoids that give the melon seed powder its unique colour (Çelik and Pozan, 2020). Regarding the crust colour, the highest L and b values were observed in the control cupcake, while the lowest values were recorded in the cupcakes with 30% MSP. Ayoubi et al. (2022) reported that adding pomegranate peel powder caused a decrease in the brightness (L), b and a value of the cakes. Other studies stated that there are decreases in the L, b and a value of the products depending on the substitution rate (Sung et al., 2020; Gül and Şen, 2017).

Table 4. Crumb and crust colour analysis results of cupcakes

Samples/ Parameters	Crumb Colour			Crust Colour		
	L	a	b	L	a	b
Control	54.35±2.01^{a}	6.16±0.73^{a}	21.14±0.45^{a}	46.65±0.28 ^{c}	16.51±0.55^{ab}	31.16±0.43 ^{c}
10% MSP	51.28±2.47^{a}	6.69±1.13^{a}	22.97±1.76^{ab}	42.43±2.39^{bc}	17.38±0.66^{b}	29.69±2.60^{bc}
20% MSP	51.53±1.93^{a}	8.01±0.35^{a}	25.19±1.24^{b}	39.90±2.64^{b}	15.53±2.15^{ab}	24.48±3.22^{ab}
30% MSP	51.27±3.01^{a}	7.32±1.00^{a}	24.61±0.97^{b}	33.17±1.00^{a}	13.85±0.41^{a}	22.93±2.45 ^{a}

MSP: Melon Seed Powder, Different letters within a column indicate significant differences at p<0.05

Figure 1. Images of Cupcake Samples control, 10% MSP, 20%MSP, and 30% MSP (from left to right, respectively)

Table 5. Some characteristics of cupcake and dough samples

Sample	pH	Specific Volume (mL/g)	Baking Loss (%)	Hardness (g)
Control	6.82 ±0.01^{b}	2.63 ±0.05^{c}	16.67 ±2.21^{a}	2198.18 ±140.61^{a}
10% MSP	6.72 ±0.01^{a}	2.16 ±0.03^{b}	15.45 ±1.63^{a}	2237.73 ±105.36^{ab}
20% MSP	6.71 ±0.04^{a}	1.72 ±0.00^{a}	14.94 ±0.09^{a}	2596 ±22.96^{ab}
30% MSP	6.69 ±0.01^{a}	1.59 ±0.01^{a}	15.67 ±0.73^{a}	2854.23 ±189.33^{b}

MSP: Melon Seed Powder, Different letters within a column indicate significant differences at p<0.05

The pH of the dough and specific volume, baking loss and hardness values of cupcakes were presented in Table 5. When the pH values were examined, it was seen that the pH decreases as the addition of MSP increases. This pH decrease was significant compared to the control. In a study on cupcakes with bitter melon powder addition (3%, 6%, 9%, 12%), the cupcakes' pH decreases as the addition rate increases (An, 2014). MSP contains about 5 times higher lipids than whole wheat flour and, therefore, contains a high percentage of fatty acids. The pH of cupcakes with MSP is thought to decrease due to their fatty acids.

The addition of MSP significantly affected the specific volumes of the cupcakes. Specific volume was lower in formulations with reduced whole wheat flour. This situation showed parallelism with the texture data. The increase in the substitution ratio caused a decrease in the specific volume and increased the hardness values of the cupcakes. The data obtained by Lotfy and Barakat (2018) was found to be parallel with the study. Adding MSP causes dilution in the amount of gluten in the cupcake mix and reduces the viscoelastic network formed by gluten (Batista et al., 2018; Akbaş and Kılmanoğlu, 2022). Gluten protein contributes to the increase in the volume of the product by providing gas retention during cooking (Akubor and Ishiwu, 2013; Bustos et al., 2015).

Baking loss is reported as damage caused by gas leakage during the cooking process. It is essential for the cake's structural return and shelf life (Kim et al., 2012). In our study, the effect of MSP addition to cakes on baking loss was not statistically significant. Tuna Ağirbaş et al. (2022) found that different fruit seed flours (apricot, sour cherry, pomegranate, and pumpkin seed flour) did not cause a notable change in the baking loss of the cake. Similar results have also been reported in adding other raw materials with high-fat content to the cake (Bozdoğan et al., 2019; Grasso et al., 2020). Marchetti et al. (2018) emphasised that baking loss is essential for the food industry, and the lower the cooking loss, the higher the yield.

The hardness of a food product is one of the most significant factors determining its consumer acceptability. Therefore, the determined hardness is not desired to be very different from the values the consumers know (Batista et al., 2018). Adding MSP in cupcakes affected textural properties significantly ($p<0.05$). As the substitution ratio increased, the hardness values of the cupcakes also increased. The softest cupcake was controlled. This situation was interpreted as a decrease in the gas holding capacity with the weakening of the gluten network structure after the reduction of wheat flour. The decrease in volume has also led to the formation of products with a more complex structure (Ayoubi et al., 2022). The results were determined to be similar to other studies (Chang et al., 2015; Baltacıoğlu and Uyar, 2017; Gül and Şen, 2017). Polak et al. (2019) reported positive correlations between hardness and moisture data in cake production. In our study, a decrease in the moisture values of the cupcakes was recorded after the addition of MSP.

The sensory analysis results of the cupcakes produced with the addition of MSP at different rates are given in Figure 2. The most liked cake in terms of smell is the cake with a 20% MSP addition. In other scales, it was determined that the control cake got the highest score, and the addition of MSP negatively affected the results. When the colours of the cakes were examined, browning was observed on the cake surfaces as the MSP ratio increased (Figure 1). Gadallah et al. (2022) reported that adding pomegranate peel flour caused differences in the crust colours of the cakes. In another study, Baltacıoğlu and Uyar (2017) stated that the increase in the addition of pumpkin powder causes browning on the cake surfaces. Regarding taste, the most popular cake after the control cake is the 20% MSP-added cake. The least preferred cupcakes were the cupcakes with 30% MSP. Dabral and Sharma (2021) stated that adding melon seed powder and oat flour improved the taste characteristics of the cake samples and increased the overall taste. Consequently, the control cupcake was the most liked with a general acceptability score of 4.31, while the cupcakes with 10%-20% MSP were equally appreciated. Çelik and Pozan (2020) reported that the overall acceptability of noodle samples was adversely affected due to the increased addition of melon seed powder. These results are similar to our study.

Conclusion

Our study results show that melon seed powder's functional properties are higher than wheat flour. With increased MSP substitution in all cupcakes, higher protein, fat and total ash content was noted compared to the control cupcakes. MSP is a waste today. However, due to the approaching climate crisis, it has been understood how valuable sustainability is in the food industry and how important it is to evaluate waste. With the study, it has been shown that this waste product can be evaluated in improving the functional properties of bakery products and can be added to the product at a rate of 20% without affecting consumer demands. For future studies, it is recommended to evaluate the functionality of melon seed powder by determining its properties, such as dietary fibre content, fatty acid composition, and phenolic and antioxidant contents.

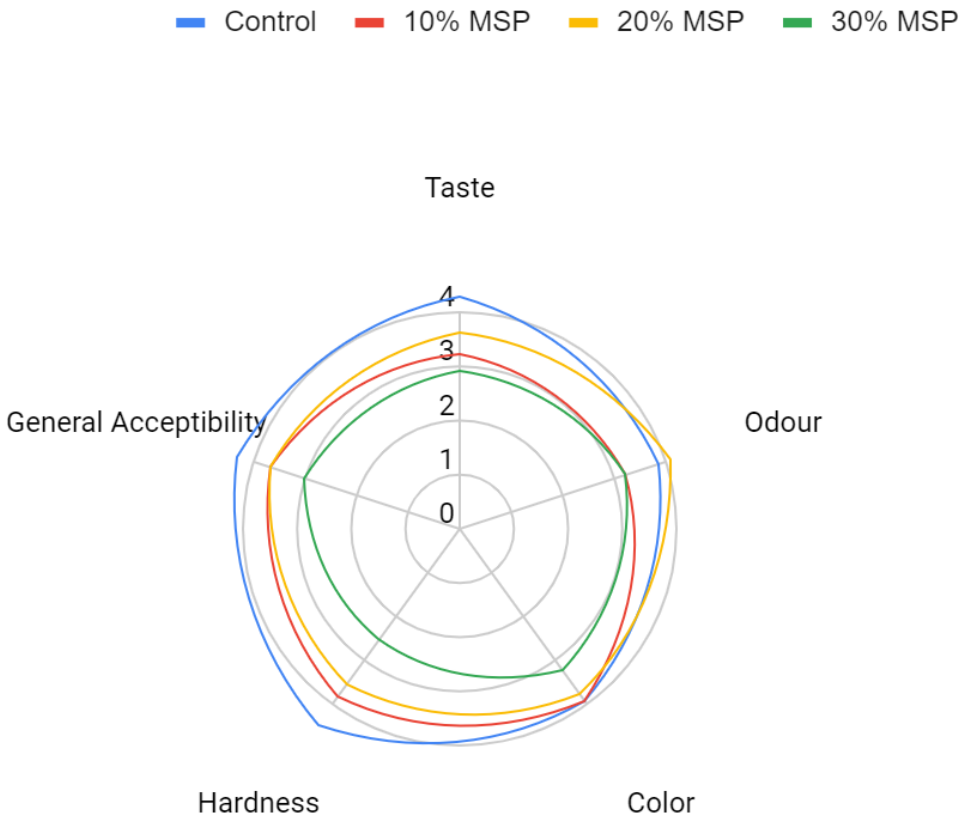

Figure 2. General acceptability index values of sensory evaluation of cupcake samples (MSP: Melon Seed Powder)

Compliance with Ethical Standards

Conflict of interests: The author(s) declares that for this article, they have no actual, potential, or perceived conflict of interest.

Ethics committee approval: Authors declare that this study includes no experiments with human or animal subjects.

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