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EFFECT OF POTATO FLOUR SUBSTITUTE TO WHEAT FLOUR ON THE PHYSICAL QUALITY PROPERTIES OF CUPCAKE

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ABSTRACT
In this study, it was investigated that the effect of the replacing of wheat flour with potato flour at various proportions (0, 2.5, 5, 10, 20%) on the quality properties of the cupcake samples. The volume, specific volume, baking loss and volume index values of the cupcake samples decreased significantly (p<0.01) with the increased potato flour level, while the weight, symmetry index, moisture, and ash content values increased. The replacement of wheat flour with the potato flour had a significant (p<0.05) effect on the textural properties of cupcakes. In general, it was observed that potato flour usage had a positive effect on cohesiveness value while it had a negative effect on the springiness value of cupcakes. It was detected that the increase in the potato flour level caused an increase in hardness value especially on the last day of storage. As a result of this study, it was concluded that potato flour may replace with wheat flour up to %5 without any adverse effects on the physical quality properties of the cupcakes.
Keyword: Cupcake, potato flour, quality parameters, textural properties

BUĞDAY UNU YERİNE PATATES UNU İKAMESİNİN KAPKEKLERİN FİZİKSEL KALİTE ÖZELLİKLERİ ÜZERİNE ETKİSİ

ÖZ
Bu çalışmada, buğday ununa farklı oranlarda (%0, 2.5, 5, 10, 20) patates unu ikamesinin kapkeklerin kalite özellikleri üzerine etkisi araştırılmıştır. Patates unu seviyesindeki artışla birlikte kapkeklerin ağırlık, simetri indeksi, nem ve kül içeriği değerleri artarken; hacim, spesifik hacim, pişme kaybı ve hacim indeksi değerleri önemli seviyede (p<0.01) düşmüştür. Buğday ununun patates unu ile ikamesi, keklerin dokusal özellikleri üzerinde önemli (p<0.05) bir etkiye sahip olmuştur. Genel olarak, patates unu kullanımının keklerin kohesivlik değeri üzerinde olumlu bir etkisi var iken, elastikiyet değeri üzerinde olumsuz bir etkisi olduğu gözlenmiştir. Patates unu seviyesindeki artışın, özellikle depolamanın son gününde sertlik değerinde bir artışa neden olduğu tespit edilmiştir. Bu çalışmanın sonucunda, patates ununun, keklerin fiziksel kalite özellikleri üzerinde herhangi bir olumsuz etkisi olmadan %5'e kadar buğday ununa ikame edilebileceği sonucuna varılmıştır.
Anahtar kelimeler: Kapkek, patates unu, kalite parametreleri, tekstürel özellikler

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INTRODUCTION

Potato (*Solanum tuberosum*) is among the most produced products in the world and it is rich in protein, dietary fibre, many minerals, trace elements, bioactive compounds and vitamins (Krinsky and Johnson, 2005, Sandoval et al., 2012). Potato flour has been used as a supplement for different products in the food industry such as noodles, bread, steamed bread, cakes, muffins, biscuits, extruded snacks, and soups (Zhu and He, 2020).

Nowadays, many researchers have focused on the development of new products using potato flour. Addition of potato flour to wheat flour can increase nutritive value in terms of fibre and bioactive compounds of bakery products (Misra and Kulshrestha, 2003). It is stated that the use of potato flour in bakery products is important in terms of improving the development and functional properties of these products (Matter, 2015). However, it has a negative effect on usage at the higher level (Yamul and Navarro, 2020).

The potato flour producing plant in Turkey is only located in Nevşehir. In this plant, potatoes which have low edible and seed value are processed into potato flour and thereby contributing Turkey's economy. The aim of this study was is to investigate the effect of adding potato flour to wheat flour on the physical and textural quality properties of cupcake and to determine the optimum addition level which could be used without lowering cupcake's physical and textural quality.

MATERIAL AND METHODS

Materials

Wheat and potato flour, sugar, sunflower oil, egg, milk and baking powder were purchased from a local market in Nevşehir/Turkey. The wheat flour used in the production cupcake contains 12.80% of moisture, 0.50% of ash, 11.49% of protein and 29.00% of wet gluten. Potato flour contains 6.26% of moisture and 3.20% of ash.

Cupcake preparation

The cupcakes were produced according to the procedure described by Karaoğlu et al. (2008). The cake batter recipe containing 100% wheat flour, 90% sugar, 60% milk, 40% egg white, 40% sunflower oil, 8% egg yolk 1.7% baking powder and 0.5% salt (all percentages are given on flour weight basis). In this study, wheat flour was replaced with 0%, 2.5%, 5%, 10% and 20% of potato flour. The cake batter was prepared at following steps using a mixer (Kenwood KM-242 Prospero): (i) the egg white and salt were mixed for 3 min at 5 speed, (ii) milk and sugar were added and mixed for 3 min at 5 speed, (iii) egg yolk and sunflower oil were added and mixed for 2 min at 5 speed, (iv) flour and baking powder were added and mixed for 4 min at 4 speed. Cupcake papers were fitted into each of 12 wells cupcake pan (Kaiser Gourmet Muffin Pan-Germany). Cupcake papers were filled with 60 g batter and then baked for 35 minutes at 175°C in an electric oven (Arçelik MF44, Turkey).

Methods

Quality measurements

Moisture and ash contents of the materials and the cupcake samples were determined according to AACC methods 44-15.02 and 08-01.01, respectively (AACC, 2003). Cupcake samples were weighed after cooling for one hour at room temperature and volumes of cupcake samples were measured using colza grains. And finally, specific volumes were calculated. Symmetry and volume indexes were measured following the AACC method 10–91.01 (AACC, 2010) with some modifications for cupcakes. Konica Minolta colorimeter (CR-400, Minolta Camera Co., Osaka, Japan) was used to measure the crust and crumb colour of the cupcake samples. Results were expressed in the CIE *L* a* b** colour space (Elgün et al., 2002).

Texture analysis

For texture profile analysis, firstly the crust was removed, and a cylindrical sample (30 mm diameter, 30 mm highness) was taken from each cupcake crumb to be measured. Textural parameters were measured using a texture analyser (TA-XTplus, Stable Micro Systems, Godalming, Surrey, UK) equipped with a 100 mm diameter compression plate (P/100) according to the method described by Karaoğlu et al. (2008).

The application conditions of the TPA method were as follows: pre-test speed 1 mm/s, test speed 2 mm/s, post-test speed 1 mm/s, trigger force 20 g, time 5 s and compression ratio 40%.

Statistical analysis

The obtained data were evaluated using the analysis of variance method to determine the difference among the cupcake samples. Significant differences among individual means were compared by Duncan's multiple range test using SPSS 22.0 for Windows (IBM Corp., Armonk, New York, USA). The standard error of the data from the mean was added and the mean recorded.

RESULTS AND DISCUSSION

Physical properties of cupcakes

The results related to the effect of potato flour on weight, volume, specific volume and baking loss of the cupcake samples are shown in Table 1. The weight, volume, specific volume and baking loss of all baked cupcakes did differ significantly (p<0.01) with increased potato flour level. Cupcake weight increased with the increase in the addition level of potato flour in wheat flour. Weight of control cupcake was 49.79 g and it did not change significantly up to 5% level of substitution of wheat flour with potato flours. Whereas supplementation of wheat flour with potato flour at 20% level, a significant increase in cupcake weight was observed. The specific volume and baking loss of the cupcake samples significantly decreased with increased potato flour level. The specific volume of the cupcake made from control (100% wheat flour) was 2.48 mL/g. However, a significant reduction in specific volume was observed as the level of supplementation with potato flour was increased. Maximum reduction in specific volume (2.06 mL/g) of the cupcake was observed in case of potato flour at 20% supplementation level. This reduction in volume and specific volume of the cupcake might be due to the dilution effect of potato flour on gluten content of wheat flour (Dhingra and Jood, 2001).

Table 1. Effect of potato flour on weight, volume, specific volume and baking loss values of the cupcakes (Mean ± SE)[a]

Potato flour (%)	Weight (g)	Volume (mL)	Specific volume (mL/g)	Baking loss (%)
0	49.79±0.16^{b}	123.33±0.58^{a}	2.48±0.01^{a}	17.00±0.26^{b}
2.5	49.96±0.19^{b}	118.00±2.00^{b}	2.36±0.03^{b}	16.79±0.13^{b}
5	49.52±0.13^{c}	119.00±1.00^{b}	2.40±0.02^{b}	17.52±0.09^{a}
10	50.79±0.06^{a}	113.67±1.15^{c}	2.23±0.02^{c}	15.20±0.18^{d}
20	50.58±0.10^{a}	104.00±2.00^{d}	2.06±0.04^{d}	15.81±0.27^{c}
p	**	**	**	**

[a] Means with different letters in the same column are statistically significant, **p< 0.01

Moisture and ash content of the cupcake samples increased as the level of incorporation of potato flour was increased from 0 to 20% (Table 2). There was a significant difference between the volume-symmetry index values of the control and 20% potato flour cupcakes. Cupcake volume index decreased with increasing potato flour levels. Also, the volume index of control cupcake was significantly higher than composite cupcakes. The symmetry index for the cupcake samples is a measure of cake height, i.e., the relative height between the middle and side portions of a cake. Therefore, a cake having a peak would have a high symmetry index value, whereas flat cakes have a low value (Lee, 2015). The symmetry index of the cupcake samples ranged from 16.33 to 24.00 and significantly increased upon addition of potato flour, with an exception of 2.5% potato flour level.

Table 2. Effect of potato flour on volume index, symmetry index, moisture and ash values of the cupcakes (Mean ± SE)[a]

Potato flour (%)	Volume index	Symmetry index	Moisture (%)	Ash (%DM)
0	130.00±1.00[a]	17.33±0.58[c]	27.32±0.14[c]	0.99±0.02[c]
2.5	124.67±0.58[c]	16.33±0.58[d]	27.60±0.14[b]	1.01±0.02[bc]
5	126.67±0.58[b]	22.67±0.58[b]	27.90±0.07[a]	1.02±0.01[bc]
10	121.67±0.58[d]	24.00±0.00[a]	27.65±0.05[b]	1.06±0.01[b]
20	118.67±1.15[e]	23.00±0.00[b]	27.69±0.08[b]	1.18±0.00[a]
p	**	**	**	**

[a] Means with different letters in the same column are statistically significant, $^{**}p < 0.01$

The Hunter colour *L**, *a** and *b** values correspond to lightness, redness and yellowness, respectively. The crust colour values of baked the cupcake samples were affected by the replacement of potato flour with wheat flour (Table 3). In general, with the addition of potato flour, the crust colour of the cupcake samples became lighter, less red and less yellow. The crumb of the control was darker, less red and less yellow than any other baked cupcake samples. For crumb colour, as the level of potato increased, the *L**, *a** and *b** values increased but a value decreased with the addition of 5% of potato flour. The results indicated that a lighter, redder, and more yellow crumb was obtained as a result of potato flour replacement. The yellow colour of cupcake crumb can be caused by carotenoid pigments found in potato flour. Similar colour properties have also been detected in other studies in which potato flour was incorporated into bakery products (Van Hal, 2000).

Table 3. Effect of potato flour on colour properties of the cupcakes (Mean ± SE)[a]

Potato Flour (%)	Crust colour			Crumb colour		
	L	*a*	*b*	*L*	*a*	*b*
0	44.61±0.28[b]	15.34±0.16[a]	22.18±0.12[a]	69.22±0.16[b]	2.25±0.00[b]	16.01±0.29[d]
2.5	44.46±0.15[b]	15.26±0.07[a]	21.54±0.12[b]	70.77±1.03[a]	2.30±0.05[ab]	17.23±0.36[b]
5	46.71±0.37[a]	14.59±0.01[b]	22.65±0.13[a]	71.52±0.62[a]	2.13±0.07[c]	16.62±0.29[c]
10	45.55±1.31[b]	15.32±0.17[a]	22.47±0.71[a]	71.28±0.03[a]	2.32±0.10[ab]	16.67±0.11[c]
20	45.11±0.15[b]	15.32±0.08[a]	22.57±0.04[a]	69.60±0.07[ab]	2.37±0.02[a]	18.04±0.16[a]
p	**	**	*	**	*	**

[a] Means with different letters in the same column are statistically significant, $^{*}p < 0.05$, $^{**}p < 0.01$

Textural properties of cupcakes

The textural characteristics of the cupcake samples produced by using potato flour at different levels are presented in Figure 1. The hardness is the maximum force applied to the food in the first compression of the TPA curve (Anonymous, 2020). The highest hardness values during storage were determined in the cupcake samples containing 20% of potato flour (Fig 1A). In formulations, containing potato flour (2.5% and 5%) at low levels, hardness values were obtained closer to the control cupcake. Similar results were found by Xing-Li et al. (2016). Researchers found that potato flour improves the hardness of the bread. Also, the hardness values of the cupcake samples increased with storage time. In the present study, it was determined that the addition of potato flour increased the moisture content in the cupcakes. Despite the increase in the cupcake moisture content, the increase in hardness values may be due to the effect of potato flour on reducing the cupcake volume and tightening the cupcake structure.

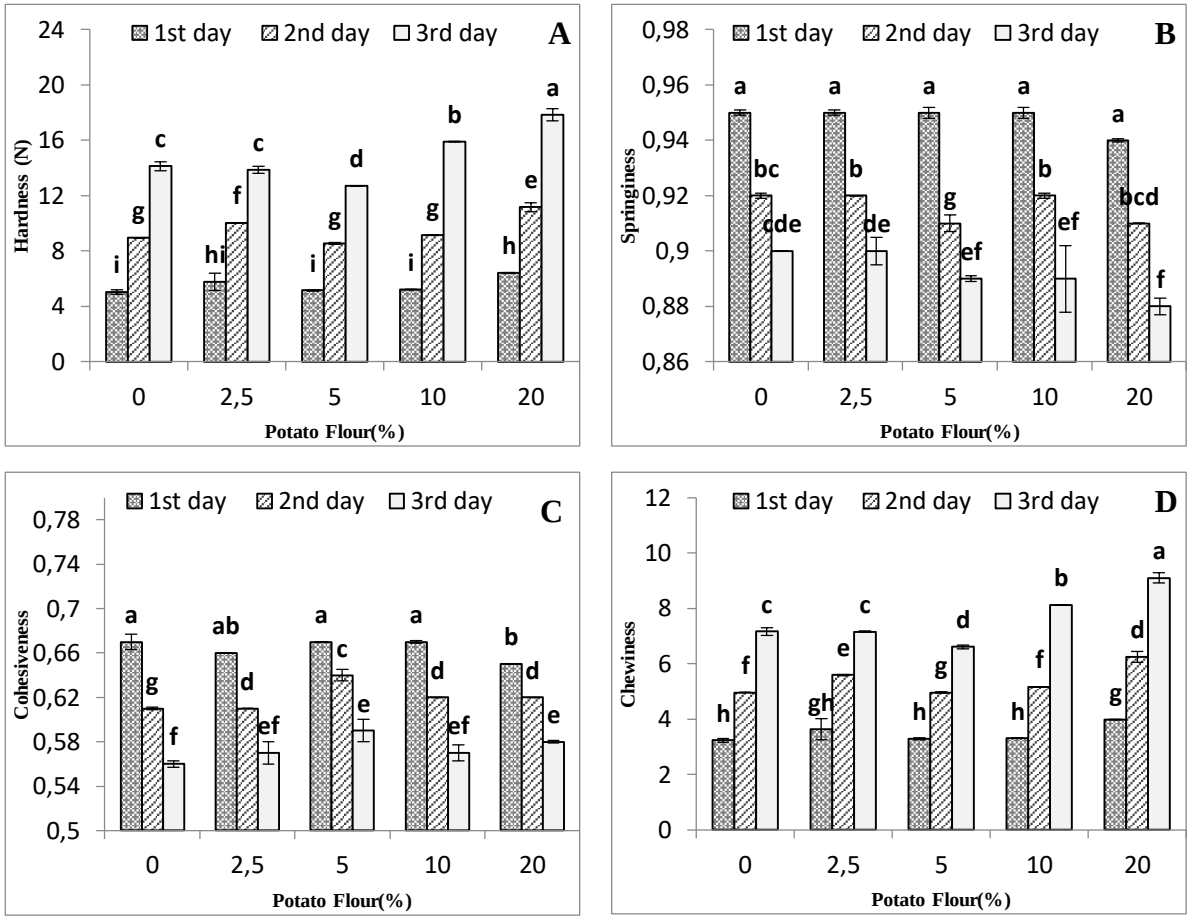

Figure 1. Effect of potato flour on hardness (A), springiness (B), cohesiveness (C) and chewiness (D) of the cupcake.

Springiness is expressed as the rate of returning to the original state before deformation by recovering itself after the deforming force on a product is removed (Anonymous, 2020). Springiness values of cake samples on the first day were not statistically different from each other (Fig 1B). It was observed that there was a significant decrease in springiness values with the increase in storage time and especially the increase in the amount of potato flour on the last day of storage caused a significant decrease in springiness value. It is thought that the use of potato flour decreases the springiness value due to its hardness increasing effect.

Cohesiveness is a parameter that is regarded as an indication of structural integrity. It has been reported that the cohesiveness value is closely related to the moisture level of the product and decreases due to moisture loss during storage (Yalçın and Şeker, 2016). It was observed that the increase in storage time caused a decrease in the cohesiveness values of the cupcake samples (Fig 1C). The highest and lowest cohesiveness values were determined in control cupcake sample on the first and fifth day of storage. The maximum decrease in cohesiveness values depending on storage was determined in control cupcake sample. For this reason, it is possible to conclude that the addition of potato flour helps to preserve the structural integrity of the cakes.

Chewiness is a parameter that correlates to how easily the food breaks down in the mouth and it is calculated from the product of hardness, springiness and cohesiveness (Ben et al., 2017,

Pongjaruvat et al., 2014). Since the values of chewiness were related to hardness, the results obtained were similar to those of hardness. The increase in storage time has led to an increase in the chewiness values of cupcake samples. The highest increase in the chewiness values of the cake samples occurred in the formulation containing 20% of potato flour (Fig 1D). A Similar effect for chewiness has been detected in a study in which potato flour was incorporated into bread formulation (Xing-Li et al., 2016).

CONCLUSION

This work revealed the utilization of potato flour in cupcake production. It was determined that the substitution of wheat flour with potato flour up to 5% (flour basis) did not adversely affect the quality properties such as physical and textural properties of the cupcake. Currently, most of the potato flour used in our country is imported from China. With this study, it is also aimed to emphasize the existence of this factory which is not well known in our country.

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