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Effects of Percentage and Particle Size of Wheat Germ on Some Properties of Batter and Cake

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ABSTRACT

Wheat germ, a highly nutritive part of wheat kernels, is separated during milling as a by-product. In this study, wheat germ was used to supplement cakes. Different levels of the germ (0, 5, 10, 15 and 20%) at different particles sizes (280, 585, 890 and 1,195 µm) were added to a cake recipe. The results showed that with increasing the germ level and particle size, batter consistency and density of the cakes increased significantly, while the height of the cakes decreased. With increasing the germ level and its particle size, the crumb became slightly yellow while the crust color and the textural parameters (TPA test) remained unaffected. Determination of the sensory attributes of the samples showed that the particle size was negatively correlated with the crumb color and texture of the cakes, while other sensory parameters remained unaffected. In general, 15% of germ was the highest level and 280 µm was the most suitable particle size (as recognized by the panelists) for the production of an appropriate germ cake.

Keywords: Batter, Cake, Particle size, Physical properties, Wheat germ.

INTRODUCTION

Cakes are popular, ready to eat and low price foods, therefore, enrichment of these products with minerals, vitamins and fibers is of great importance. Wheat germ is a highly nutritive part of wheat which is separated during milling as a by-product and has the potential to be used for food supplementation (Shurpalekar *et al.,* 1978; Ragaee *et al.,* 2006). It has been used for supplementation of cookies by Bajaj *et al.* (1991) who indicated that the cookies containing 30% germ were of superior overall acceptability. Arshad *et al.* (2007) reported that by the replacement of 15% defatted germ, cookies with higher nutritional quality and improved sensory attributes were obtained. With the aim of reducing the sugar content of the sponge cake, Baeva *et al.* (2000) produced a diabetic cake using wheat germ. Little information was found in the literature to show the effects of wheat germ on cakes. It has been documented that the particle size of the fibers used for the production of fiber-rich cake had some influence on the physicochemical properties of the final product (Gómez *et al.,* 2010). Accordingly, selection of the suitable particle size of the germ may be important for the production of germ cake. The objectives of this study were to determine the appropriate level and particle size of the wheat germ to produce acceptable germ cakes.

MATERIALS AND METHODS

Wheat germ and cake flour (with extraction rate of 72% according to the manufacturer) were obtained from Sepidan milling factory, Zarghan, Iran. Other ingredients for cake making were purchased

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from the local market. Chemicals for analytical tests were obtained from Merck, Germany.

Determination of the Chemical Composition

The chemical compositions of the germ based on dry weight (including 11.68±0.40% moisture, 30.64±0.35% crude protein, 11.70±0.40% crude fat, 5.34±0.25% crude fiber and 4.55±0.10% ash) and the flour (including 11.50±0.30% moisture, 9.35±0.40% crude protein, 0.43±0.20% crude fat, 0.30±0.05% crude fiber and 0.52±0.10% ash) and the moisture content of the cakes (13.5±0.5%, dry weight basis) were determined according to the AACC methods (1383) (Methods 46-12, for protein, 44-15 for moisture, 08-01 for ash, 50-20 for fat and 32-15 for crud fat content).

Milling of the Germ

The germ (with average particle size of 1,500 µm, as determined by sieving) was milled using a laboratory mill (Alexanderwerk, Model WEL82, Remscheid, Germany) and sieved manually to obtain four different particle sizes of 280, 585, 890 and 1,195 µm. Then they were packed and sealed in polyethylene bags and stored at -18ºC.

Production of Batter

First the whole eggs (20 g) and sugar (37.5 g) were beaten using a professional cake mixer (Moulinex, Model HM 1010, Beginning, China) until white foam was formed. Then invert syrup (37.5 g) with Brix 70 (produced by boiling 250 g sugar in 100ml of water and 2ml of 11% acetic acid), yoghurt (18.5 g) and oil (37.5 g) were added to the foam and mixed slightly. Baking powder (Hermin, Karaj, Iran) and vanilla powder (2.5 g each) were mixed well with wheat flour (100 g) and added gradually to the foam and mixed gently. To include germ in the recipe, the flour was replaced with 0, 5, 10, 15 and 20% of the germ of different particle sizes. The combination treatments of the germ level and particle size (26 individual experiments) were determined by response surface methodology using statistical software of Design Expert 6 (State Ease, USA) (Table 1).

Table 1. Different treatments as determined by the Design Expert software for the effect of particle size and germ level on wheat germ cake.

Experiment number	Particle size (µm)	Germ level (%)
1	282	20
2	427	10
3	1500	10
4	750	10
5	750	10
6	282	10
7	750	5
8	427	20
9	282	0
10	427	10
11	1500	0
12	1500	20
13	1500	20
14	282	20
15	427	15
16	427	0
17	750	10
18	427	5
19	282	0
20	750	20
21	1500	15
22	750	15
23	282	15
24	282	5
25	1500	5
26	750	0

Determination of the Batter Consistency

100g of the batter at ambient temperature (20±0.5ºC) was poured in the reservoir of a

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Bostwick consistometer and left for 2 minutes and then the distance moved by the batter (cm) during 15 seconds was determined. The higher values correspond to the lower batter consistency (Baeva *et al.,* 2000).

Baking of Cakes

Equal portions of the batter (20 g) were poured on greased paper inside round cake moulds (5×3 cm diameter-height). Then the moulds were placed in an electrical baking oven (Karl Welker kg, Venusberg str, Germany) and baked at 200ºC until a golden brown crust was formed (22 minutes). The cakes were then left at ambient temperature to cool down for 1 hr and removed from the moulds, packed and sealed in polyethylene bags and kept at room temperature.

Determination of the Cakes Volume and Height

The volume of the samples was determined using the rapeseed displacement method (Baeva *et al.,* 2000). A digital caliber was used to measure the cake heights.

Color Determination

The color parameters of the cakes crust and crumb were evaluated using a modified method of Yam and Papadakis (2004). High resolution pictures of the samples were taken separately by a digital camera (Finepix, Model JZ300, Beijing, China). Resolution, contrast and lightness of all images were set to 300 (dpi), 60% and 60%, respectively. To determine the crust color, pictures were taken from the whole crust, while to determine the crumb color the sample was sliced horizontally from the middle of the cakes and then the pictures were taken. The pictures were saved in JPEG format and analyzed quantitatively using the Adobe Photoshop 8 software and the color parameters of *L* (lightness), *a* (greenness-redness) and *b* (blueness yellowness) values were determined in the "*Lab*" mode of the software.

Measurement of the Cakes Texture

The texture of the cakes was studied using a Texture Analyser (TA-XT2, Stable Micro System Ltd., Surrey, UK). Texture Profile Analysis (TPA) test was carried out by performing a two bite compression test at pretest speed of 5 mm s^{-1}, test speed of 0.25 mm s^{-1}, time interval of 10s and strain deformation of 25%. To determine the texture of the cakes, 1 cm of the top of the cake was removed to make the surface level. Then, the rest of the sample was tested using a cylindrical probe with a diameter of 80 mm. From the force-distance curve, the ratio of the positive area under the first and second compression was defined as cohesiveness. The distance that the food recovered its height during the time that elapsed between the end of the first bite and the start of the second bite was defined as springiness (elasticity). The slope (gradient) of force-deformation curve and maximum force of the first bite of TPA test were taken as indications of crumb hardness.

Sensory Evaluation

Cakes were served to 12 in-house semi-trained panelists (6 males and 6 females, age between 20-30 years) and were evaluated for color, texture, taste and overall acceptability using a ranking test. The panelists were asked to compare the samples and score them from 0 (for the worst) to 5 (for the best) sample. To avoid confusion of the panelists as a result of so many samples to evaluate, the test was performed at two stages. First; the effect of particle size on the sensory evaluation of the samples was determined by making cakes with different particle sizes of the germ, but of constant

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level. Second; to determine the best level of the germ, cakes were made from different levels of the germ but of constant particle size (which was selected as the most suitable particle size in the previous stage). All the sensory tests were performed in isolated standard booths under standard condition (Watts *et al.,* 1989).

Statistical Analysis

The experiments were performed in a completely randomized design and conducted in triplicates and the mean values and standard deviations were calculated. Analysis of variance (ANOVA) was performed and the results were separated using the Multiple Range Duncan's test ($\alpha < 0.05$) using the statistical software of SPSS 16. To model the data and estimate any non-linearity in the relationships between the parameters under study and to obtain the best model (i.e. quadratic model) Design-Expert 6.0.2 and D-optimal Response mode was used. All variables and their interactions with significant effect in each model were kept and any variable or interactions without significant effect were removed as indicated by the software (Farahnaky and Hill, 2007). Therefore, all the experiments were performed using 26 samples.

RESULTS AND DISCUSSION

Chemical Composition of the Germ and Cake Flour

Batter Consistency

Determination of the batter consistency at ambient temperature showed that it increased with increasing the germ particle size and level (Figure 1). This may be attributed to the higher water absorption of the germs with larger sizes. Gómez *et al.* (2010) reported that the density of batter increased with increasing the particle size of the fibers used. Fibers and proteins in the germ can absorb water and increase the consistency of the batter. They may also interact with proteins, starch and other hydrocolloids of the flour and form a network which can trap some water and hence increase the batter consistency (Gómez *et al.,* 2007). At ambient temperature, most of the sugars remain insoluble since the water is insufficient to dissolve them, however, the soluble portion may enhance the viscosity of the batter. Another possible explanation is an emulsion effect that occurs when mixing so that the incorporation of air and its distribution into small bubbles is affected. Thus, the higher the particle size of the germ, the larger the formed bubbles. Furthermore, the batter consistency increased with increasing the level of fats in batter recipe. The result is in agreement with McWatters (1978) who indicated that increasing the consistency of the dough made by replacing the flour with non-wheat flours, is attributed to the rapid partitioning of free water to hydrophilic sites during mixing. Apparently, the glutathione had no significant effect on cake batter consistency since there is a weak gluten network in the batter.

Batter consistency must be sufficient to retain the air incorporated during mixing and

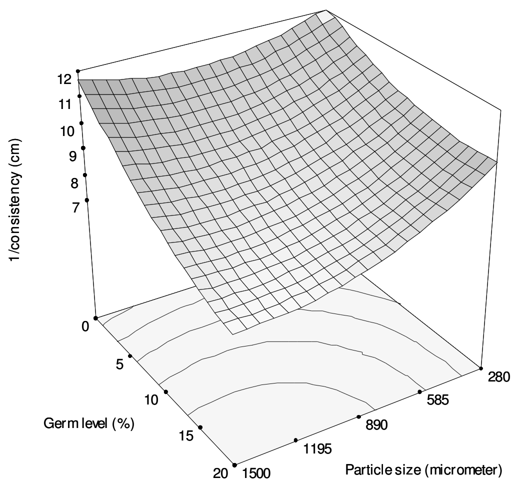

Figure 1. Consistency of batter at ambient temperature as a function of germ level and particle size.

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the CO_2 produced by the sodium bicarbonate during baking. If the consistency of the batter is too low, air bubbles will escape quickly during baking resulting in a low cake volume (Pomeranz, 1988). Moreover, some large starch granules sink easily and accumulate at the bottom of the cake leading to the formation of a rubbery layer underneath of the cake. Very high batter consistency is not suitable either, since it dose not allow enough air bubbles to form during batter mixing and can impede expansion (Gómez *et al.,* 2010; Hoseney, 1994). The empirical model obtained from Design Expert software (Table 2) indicates the simultaneous effect of the germ level and particle size on the batter consistency with high correlation (R^2= 0.92, P< 0.05).

Physical Properties of the Cakes

Height and Density

With increasing the level and particle size of the germ, the height of the cakes decreased (Figure 2). Reduction in cake height may indicate that less air bubbles were formed in the batter to contribute to cake volume during baking. This can be attributed to the increase in batter consistency (as shown in Figure 1). Consequently, the density of the cakes increased slightly with increasing the germ level and particle size (Figure 3). Air distribution in the batter plays an important

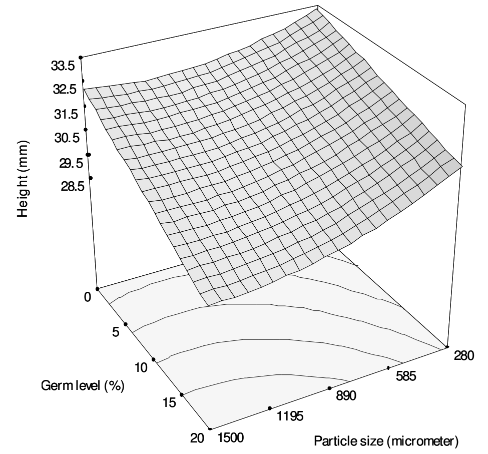

Figure 2. Height of the germ cakes as a function of germ level and particle size.

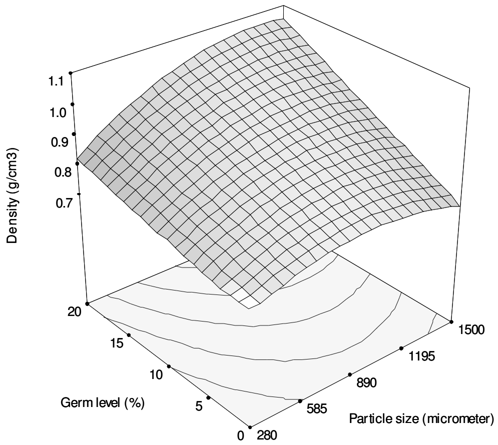

Figure 3. Density of the germ cakes as a function of germ level and particle size.

Table 2. Equations obtained in the D-Optimal mode of response surface methodology (given by Design Expert software) in terms of actual factors: effect of wheat germ level (%) and particle size (μm) on each measured parameter of the cakes. Regression coefficients (R^2) between the actual and predicted values are given.

Parameter	Equations in terms of actual factors: Effect of %wheat germ and storage time	R^2
1/Consistency (cm)	*13.2 -4.6E-003×Particle size-0.2×Germ level+2.4E-006×Particle size^2+6.8E-003×Germ level ^{2}-1.1E-004×Particle size×Germ level*	0.92
Height (mm)	*34.4 -4.1E-003×Particle size-0.1×Germ level+1.7E-006×Particle size^2-5.6E-005×Particle size×Germ level*	0.75
Density (g cm^{-3})	*0.6+3.9E-004×Particle size+4.8E-003×Germ level-2.0E-007×Particle size^2+8.1E-006×Particle size×Germ level*	0.86
Crumb *b*-Value	*44.8+0.01×Particle size+1.1×Germ level -7.1E-006×Particle size ^{2}-0.03×Germ level^2*	0.67

role and with increasing the number of bubbles, the mobility and coalescence increase. Therefore, the bubbles outflow easier during baking causing more diminution of the cake volume and height. The results are in agreement with those of Arshad *et al.* (2007). It has been indicated that sugars and lipids which are present in the germ, can affect starch gelatinization process and its structural changes after cooking depending upon their type and concentration (Moore and Hoseney, 1986; Chang *et al.,* 2004; Torley and van der Molen, 2005). If these components delay starch gelatinization, most of the air bubbles may escape during baking and the cake may have low volume and high density. Gómez *et al.* (2010) indicated that if the cake recipe contains baking powder, the density of the batter will have no correlation with the cake volume. If it is too dense, the CO_2 produced from baking powder during baking cannot increase the height of the cake. Table 2 shows the empirical model obtained from Design Expert software for the simultaneous effects of the germ level and particle size on the cake height and density with high correlations (R^2 obtained for cake height and density were 0.72 and 0.86, respectively).

Cake Texture

No significant effect of the germ level on crumb hardness was observed that is in agreement with observations made by Arshad *et al.* (2007). Gómez *et al.* (2008) and Gómez *et al.* (2010) reported a strong correlation between bread and cake volume and their firmness. However, in this study no correlation between the height of the cake and its hardness was found. This can be related to the presence of other components of the germ particularly lipids which can compensate for the hardness and leave it unaffected.

The average cohesiveness of about 0.8 found for all cakes indicates that the first bite destroyed about 20 percent of cake structure, i.e. it weakened the structural integrity of cake texture (data not shown). However, statistical analysis showed no significant effect of the germ on the cohesiveness of the cakes. Gómez *et al.* (2010) found no correlation between volume and cohesiveness of the cakes made with different levels of fibers. Elasticity data of the samples calculated by the recovery of the height of compressed sample between the first and second bites of TPA test indicate that neither germ level nor particle size had a significant effect on this parameter. This confirms no effect of germ level or particle size on springiness of the cake samples.

Cake Color

In general, the color of the cake crust is affected by the Millard and caramelization reaction during baking, while the crumb color is affected by the components used in the formulation. The results indicated (data not shown) that the L-value of the crust decreased slightly with increasing the germ level. Moreover, the *a*- and *b*-values increased slightly with increasing germ level. However, these changes were not significant. Furthermore, no pattern could be determined for the effect of germ particle size on the color parameters of the crust.

Determination of the crumb color revealed that the *L*-value of the crumb decreased slightly with increasing germ level. Moreover, *L*-value of the crumb increased slightly with increasing the particle size. The *a*-value of the crumb showed no pattern with increasing germ level, whilst it decreased with increasing the particle size. None of these changes were significant and they had very low correlations with germ level or particle size. However, the *b*-value of the crumb increased with increasing the germ level and decreased with increasing the particle size (Figure 4). These results may indicate that increasing the germ level could increase the yellowness of crumb color due to the presence of yellow pigments in the germ. Table 2 shows the effect of the germ level and particle size on

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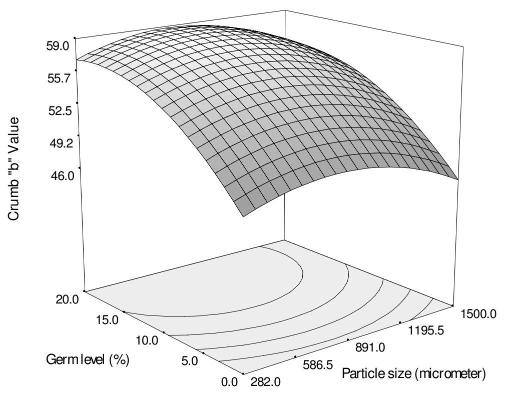

Figure 4. The blueness-yellowness (*b*-value) of the cake crumb as a function of germ level and particle size.

the *b*-value of cake crumb with good correlation (R^2= 0.67).

Sensory Evaluation

To determine the effect of particle size on the sensory characteristics of the samples, cakes were made using a constant level of germ but of different particle sizes. The results (Figure 5-A) showed that the scores given to the texture of the cakes decreased with increasing the particle size. The panelists indicated that the crumb became slightly grainy and course when higher particle sizes were added. A strong negative correlation between the texture and particle size was determined (R^2= 0.96). For crust color, no correlation (R^2= 0.23) between the particle size and the color was found (data not shown). However, the crumb color has a fair correlation (R^2= 0.50) with particle size (Figure 5-B). No obvious correlation between the particle size and the taste of the samples was obtained (data not shown). Amongst different particle sizes, the smallest one (i.e. 280 μm) had less undesirable effects on the sensory attributes.

To determine the best level of the germ, cakes were made with different levels of the germs with constant particle size of 282 μm. The results (Table 3) showed that the scores obtained for taste decreased significantly when a higher level of the germ (> 10%) was used. The panelists indicated that the taste became too sweet and felt oily in the mouth. Furthermore, they could not distinguish any changes in the crust color. Crumb color, however was affected by the germ level and the scores decreased with increasing the germ level. This can be related to the increase in yellowness of the crumb. The texture of the cakes was affected adversely when more than 15% of the germ was included in the cake recipe. This can be attributed to the increase in the softness of the samples. No significant changes of the textural properties of the samples could be determined instrumentally (using TPA), however, the panelists were able to recognize these changes. The overall acceptability of the samples remained the same for the samples containing 0-10% of the germ, however, at higher levels the overall acceptability decreased significantly. This can be related to the reduction in the taste, crumb color and texture quality of the

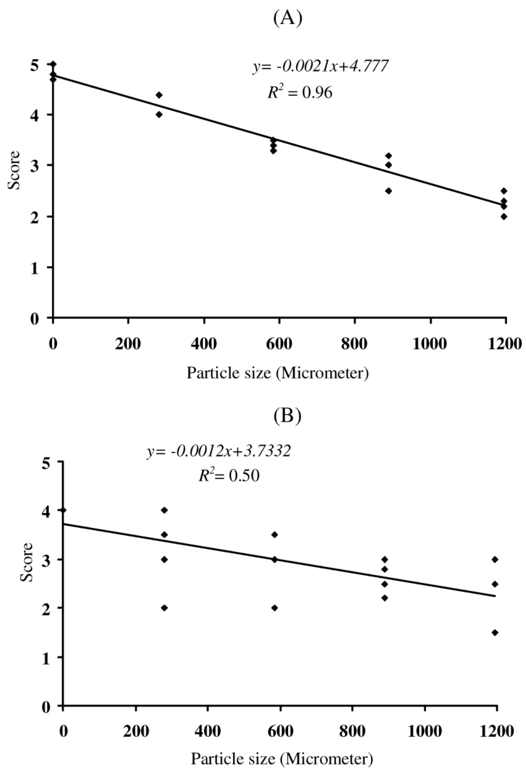

Figure 5. Evaluation of the texture (A) and crumb color (B) of the cakes made from different particle sizes of the germ as determined by the taste panels.

Table 3. Sensory evaluation of the cakes made with different levels of the germ with the particle size of 280 μm*.

Germ level (%)	Taste	Crust color	Crumb color	Texture	Overall acceptability
0	4.0 ± 0.2^a	4.2 ± 0.2^a	4.6 ± 0.2^a	4.5 ± 0.2^a	4.5 ± 0.2^a
5	4.2 ± 0.2^a	4.0 ± 0.3^a	4.0 ± 0.3^b	4.2 ± 0.2^a	4.3 ± 0.2^a
10	4.3 ± 0.3^a	4.2 ± 0.3^a	3.5 ± 0.2^{bc}	4.0 ± 0.3^{ab}	4.0 ± 0.3^{ab}
15	3.7 ± 0.2^b	3.8 ± 0.2^a	3.3 ± 0.4^c	3.7 ± 0.2^b	3.7 ± 0.2^b
20	2.5 ± 0.2^c	3.7 ± 0.3^a	2.8 ± 0.2^d	3.0 ± 0.2^c	3.0 ± 0.3^c

* Values are the Mean of triplicates±Standard deviation. Different letters in each column show the statistical differences (P< 0.05).

samples with increasing the germ level. From the sensory evaluation results, it can be concluded that increasing the germ level to more than 15% is not suitable for the cakes made in this study and higher levels of the germ can deteriorate the quality of the cakes.

CONCLUSIONS

Wheat germ without any pretreatment for glutathione inactivation can be used in cake recipe. However, it can have some effects on physicochemical properties of batter and the resultant cake. The chemical composition and level of the germ used in the cake recipe, as well as its particle size are determining factors affecting the quality of the batter and cakes and should be controlled to attain an acceptable product. Based on the results, the batter consistency increased with increasing germ level and particle size. This may affect batter handling particularly when industrial cake production is considered. Accordingly, the volume of the cake decreased which may affect the quality of the cakes adversely. Textural properties of the cakes including cohesiveness and elasticity were not affected by either the germ level or particle size. Addition of germ was able to slightly increase the yellowness of the crumb, while the crust color remained unaffected. From the sensory evaluation results it was found that the particle size of the germ had significant effects on the texture and crumb color, while other quality attributes of the cakes were not affected. Accordingly, the cakes made with the smallest particle size (i.e. 280 μm) received the highest scores. The highest level of the germ was 15% to maintain the sensory attributes of the cakes.

REFERENCES

1. AACC. 1983. *Approved Methods of the American Association of Cereal Chemists*. 8th Edition, American Association of Cereal Chemists, Inc., St. Paul, Minnesota, USA.
2. Arshad, M. U., Anjum, F. M. and Zahoor, T. 2007. Nutritional Assessment of Cookies Supplemented with Defatted Wheat Germ. *Food Chem.,* **102:**123-128.
3. Baeva, M. R., Panchev, I. N. and Terzieva, V. V. 2000. Comparative Study of Texture of Normal and Energy Reduced Sponge Cakes. *Nahrung Food*, **44:** 242-246.
4. Bajaj, M., Kaur A. and Sidhu, J. S. 1991. Studies on the Development of Nutritious Cookies Utilizing Sunflower Kernels and Wheat Germ. *Plant Foods Hum. Nutr.,* **41:** 381-387.
5. Chang, Y. H., Lim, S. T. and Yoo, B. 2004. Dynamic Rheology of Corn Starch-sugar Composites. *J. Food Eng.*, **46:** 521-527.
6. Farahnaky, A., and Hill, S. E. 2007. The Effect of Salt, Water and Temperature on Wheat Dough Rheology. *J. Texture Stud.*, **38:** 499-510.
7. Gómez, M., Ronda, F., Cabellero, P. A., Blanco, C. A., and Rosell, C. M. 2007. Functionality of Different Hydrocolloids on the Quality and Shelf-life of Yellow Layer Cakes. *Food Hydrocol.*, **21:** 167-173.

[DOR: 20.1001.1.16807073.2012.14.4.19.5]

8. Gómez, M., Oliete, B., Pando, V., Ronda, F. and Caballero, P. A. 2008. Effect of Fermentation Conditions on Bread Staling Kinetics. *Eur. Food Res. Tech*., **226:** 1379-1387.
9. Gómez, M., Moraleja, A., Oliete, B., Ruiz, E. and Caballero, P. A. 2010. Effect of Fiber Size on the Quality of Fiber-enriched Layer Cakes. *LWT*, **43:** 33-38.
10. Hoseney, R.C. 1994. *Principals of Cereal Science and Technology.* 2nd Edition, American Association of Cereal Chemists, Inc. Minnesota, USA. 270P.
11. McWatters, K.M. 1978. Cookie Baking Properties of Defatted Peanut, Soybean and Field Pea Flours in Baking Powder Biscuits. *Cereal Chem.*, **55:** 853-863.
12. Moore, W. R. and Hoseney, R. C. 1986. The Effect of Flour Lipids on the Expansion Rate and Volume of Bread Baked in a Resistance Oven. *Cereal Chem*., **63**: 172-174.
13. Pomeranz, Y. 1988. Composition and Functionality of Wheat Flour Components. II. *Wheat Chemistry and Technology*. American Association of Cereal Chemists, Inc. St Paul, Minnesota, USA. PP. 219-370.
14. Ragaee, S., Abdel-Aal, E. S. M. and Noaman, M. 2006. Antioxidant Activity and Nutrient Composition of Selected Cereals for Food Use. *Food Chem*., **98**: 32-38.
15. Shurpalekar, S. R. and Haridas Rao, P. 1978. Wheat Germ. In: "Advances in Food Research", (Ed.): Chichester, C. O.. Academic Press Inc., New York, USA, **23:** 187-304.
16. Torley, P. J. and van der Molen, F. 2005. Gelatinization of Starch in Mixed Sugar Systems. *LWT*, **38:** 762-771.
17. Watts, B. M., Ylimaki, G. L., Jeffery, L. E. and Elias, L. G. 1989. *Basic Sensory Methods for Food Evaluation*. The International Development Research Center. Ottawa, Canada.
18. Yam, K. L., S. and Papadakis, E. 2004. A Simple Digital Imaging Method for Measuring and Analyzing Color of Food Surfaces. *J. Food Eng*., **61**: 137-142.

تاثیرات درصد و اندازه ذرات جوانه گندم بر برخی ویژگی‌های خمیر و کیک

م. مجذوبی، ن. داراب‌زاده، ا. فرحناکی

چکیده

جوانه گندم، به عنوان بخش مغذی دانه، در طی فرایند آسیاب جداسازی و به عنوان یک محصول جانبی به شمار می‌رود. در این مطالعه، جوانه گندم برای غنی سازی کیک به‌کار رفت. درصدهای مختلف جوانه (۰ ، ۵ ، ۱۰ ، ۱۵ و ۲۰٪) با اندازه ذرات مختلف (۲۸۰ ، ۵۸۵ ، ۸۹۰ و ۱۱۹۵ میکرومتر) به فرمول کیک اضافه شدند. نتایج نشان دادند که با افزایش میزان و اندازه ذرات جوانه، قوام خمیر و دانسیته آن به طور معنی داری افزایش یافت در حالی که ارتفاع کیک کاهش پیدا کرد. با افزایش مقدار جوانه و اندازه ذرات آن مغز کیک کمی زرد شد در حالی که رنگ پوسته و پارامترهای بافت کیک که به کمک آزمون TPA اندازه گیری شدند بدون تغییر باقی ماندند. تعیین خصوصیات حسی نمونه‌ها نشان داد که اندازه ذرات ارتباط معکوسی با رنگ مغز کیک و بافت آن داشت در حالی که سایر خصوصیات حسی محصول تغییری نکرد. در مجموع ، ۱۵٪ بیشترین مقدار جوانه و ۲۸۰ میکرومتر

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مناسب‌ترین اندازه ذرات (که توسط اعضاء گروه چشایی تشخیص داده شد) برای تولید کیک جوانه گندم تعیین گردید.

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