



## EFFECT OF WHEAT AND CORN GERMS ADDITION ON THE PHYSICAL PROPERTIES AND SENSORY QUALITY OF CRACKERS

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### ABSTRACT

Crackers are a potential material for the addition of cereal germs as a functional ingredient because they are a popular bakery item. The suitability of cereal germs for crackers production was investigated in this study. The effect of cereal germs incorporation to wheat dough (at level 5, 10 and 15%) on the physical properties (specific volume, volume index, width, thickness and spread ratio) and sensory parameters (appearance, firmness, taste, odor and overall acceptability) of cracker were evaluated. It was shown that wheat and corn germ addition to crackers resulted in decreased specific volume from 1.65 cm<sup>3</sup>.g<sup>-1</sup> (control sample) to 1.52 cm<sup>3</sup>.g<sup>-1</sup> (10% corn germs addition) and volume index 3.20 cm (control sample) to 2.57 cm (15% wheat germ), whereas spread ratio increased from 4.71 (fine wheat flour) to 5.06 (15% corn germ). No significant differences were found between the values obtained for width and thickness for crackers supplemented with 5% wheat germ to control sample. Addition of corn germ and wheat germ at level 15% caused decrease volume index of crackers about 13 and 20%. On the other hand enriched crackers of wheat germ and corn germ at level 15% was increment spread ratio by 5 and 7%. Regarding to sensory properties the overall appearance was affected significantly by addition of wheat and corn germ. Higher addition of wheat and corn germ in the crackers adversely affected firmness, taste and odor of final products. In generally, sensory properties of crackers were markedly affected with addition of cereal germs. The most significant differences were observed in appearance of crackers, when the 15% of wheat or corn germs were added (15 and 30% decreasing of this attribute in compare to control sample, respectively). The results of sensory analysis also showed that the crackers incorporated with wheat germs up to 10% level resulted in products with good acceptability.

**Keywords:** wheat germ; corn germ; cracker; physicochemical properties; sensory quality

### INTRODUCTION

Baking industry is one of the largest organized food industries (Ganorkar and Jain, 2014). Bakery products are daily consumed in large volumes and they provide an intake of dietary fiber and other healthy compounds to consumers (Ktenioudaki and Gallagher, 2012). Demand for health oriented products such as sugar-free, low calorie and high fiber products are increasing. Traditionally, fiber supplementation has focused on the use of milling by-products of cereal grains. All of the milling by-products of wheat, corn, sorghum and other grains, as well as the by-products from the wet milling of corn and wheat, have been investigated as possible fiber supplements (Sudha et al., 2007; McKee and Lantner, 2000). Whole grain foods are rich source of fiber, antioxidants and other nutrients, which have positive influence on human health. Dietary cerealfiber is used more often than fiber from fruits (Karovičová et al., 2015). Incorporation of whole grains in foods can reduce their sensory quality and cause less consumer acceptance. As a result, there are challenges in producing whole grain products to maintain their functionality and quality that are equivalent to the traditional products without whole grain incorporation (Wang et al., 2016).

In baked products, the main effects include a decrease in loaf volume or height, textural modifications (increased crumb hardness, loss of crispiness), changes in appearance (colour, surface properties, density) and taste (Rosa et al., 2015).

The milling process of wheat produces large amount of wheat bran and germ as a by-product. During milling, the endosperm is grinded into smaller particles (white flour) while bran and germ are removed. The wheat germ represents about 2.5 – 3.8% of total seed weight (Bansal and Sudha, 2011). Wheat germ, being a by-product of the flour milling industry, is considered a natural source of nutrients due to their low cost (Tsadik and Emire, 2015). Wheat germ is the most vitamin and mineral rich part of the wheat kernel. In the fact, the germ is actually the embryo of the wheat plant (Tsadik and Emire, 2015).

The germ contains about 10 – 15% lipids, 26 – 35% proteins, 17% sugars, 1.5 – 4.5% fiber and 4% minerals, as well as significant quantities of bioactive compounds such as tocopherol, phytosterols, policosanols, carotenoids, thiamin and riboflavin (Brandolini and Hidalgo, 2012). The wheat germ is therefore a unique source of concentrated nutrients, highly valued as food supplement and offers an appropriate medium to convey these benefits to the human diet (Brandolini and Hidalgo, 2012; Ma et al., 2014). The wheat germ is also characterized by a palatable taste due to its high oil and sugar contents and defatted wheat germ is the ideal ingredient for grain based products. Wheat germ usage in bakery products provides some advantages such as crumb softness and air incorporation. The functional qualities of wheat germ include improving the stability texture, nutritional value and flavour of cereal products (Hayam et al., 2015; Levent and Bilgiçli 2013).

Majzooobi et al., (2012) found that addition of wheat germ above the 15% levels in cake formulation is not suitable for sensory quality. Results showed that all addition levels (10, 20, and 30%) of wheat germ were not negatively affected the taste and odor of cakes.

In recent years, more cereal-based foods have been enriched with wheat germ or its derivatives. Many studies are focused to investigate the effects of raw wheat germ, defatted wheat germ or toasted wheat germ on bread (Rizzello et al., 2011; Sidhu et al., 1999), cookies (Bajaj et al., 1991; Arshad, et al., 2007), cakes (Majzooobi et al. 2012), macaroni, noodle (Ge et al. 2001; Pinarlı et al. 2004), biscuits (Bansal and Sudha, 2011) and tarhana (Bilgiçli and Ibanoglu 2007).

Corn or maize (*Zea mays L. ssp. mays*) is a cereal grain that is widely cultivated on the world. A by-product in dry milling process, not applied in food production until recently, is corn mix consisting of corn grain germ and slight amounts of endosperm and seedcoat. Dry milled corn germ is characterized by high nutritional value (Peksa et al. 2010). The corn has been applied as feed for livestock, forage, silage and grain, and it is also used in industry including transformation into plastics, syrups and alcohol for biofuels. In addition, corn is also widely dispersed in human nutrition (Shi et al., 2016).

Typical corn germ contains 48 – 30.7% of oil, 20.5 – 13% of protein, 9.0 – 12% of starch, 2 – 9.7% of ash, 9.2 – 10.5 % of sugar and 3 – 11.2 % of moisture (Ramirez et al., 2008; Kulakova et al., 1982). Corn germs proteins contained a considerable amount of such essential amino acids as lysine, methionine, tryptophane (Kulakova et al., 1982).

The corn germ comprises 5 – 14% of the weight of a corn kernel, depending on variety and grain size, is high in protein content, dietary fibre and minerals. The proteins in defatted corn germ flour mostly consist of albumin and globulin, and they are balanced in most of the essential amino acids; lysine, a major limiting amino acid in wheat, accounts for 5 – 6% of the total proteins in defatted corn germ, which is more than twice than that in wheat flour (Siddiq et al., 2009).

Defatted corn germ flour being a low source of nutrients and decreased the price of fortified flour blends or finished product besides improving the nutritional profile.

The defatted corn germ flour offers a good potential for its use as an ingredient in a variety of foods, such as bread, cookies, muffins, cakes (Arora and Saini, 2016; Han et al., 2010). In most countries all over the world continuously growing consumption of snack products has made them a considerable component of a human diet. Therefore, snacks nutritive and energetic value should meet strictly determined requirements. These products are often fortified with wholesome or functional components (Peksa et al. 2010). Crackers are becoming a versatile food, and manufacturers are trying to satisfy the demands of consumer by providing the various products (Han et al., 2010). In the present, crackers are enhanced by various healthy ingredients including buckwheat flour (Sedej et al., 2011), rice bran (Yilmaz et al., 2014), pulse flour (Kohajdová et al., 2011; Han et al., 2010), amaranth (Hozová et al., 1997), triticale (Peréz et al., 2003), casava starch (Saeleaw and Schleining, 2010), eggplant flour (Peréz and Germani, 2007; Hempel et al., 2007).

The main objectives of this study were to assess the effect of addition of wheat germ (WG) and corn germ (CG) on the physical properties of crackers (specific volume, volume index, width, thickness and spread ratio) and sensory properties (appearance, firmness, taste, odor and overall acceptability) of crackers.

## MATERIAL AND METHODOLOGY

Wheat flour and commercial wheat and corn germs were purchased from local market and health food shop (Slovak Republic).

Cracker preparation: The soda crackers were prepared according to Han et al., (2010). This procedure involves separate mixing of dry ingredients and separate mixing of liquid ingredients (water, oil) including sugar. The dry ingredients are gradually added to mixed liquid ingredients and after 3 – 4 min, the dough begins to form. The mixed dough was resting for 10 min at room temperature and subsequently the dough was laminated and cut to the circular shape. After that the crackers were baked in electric oven (Model 524, Mora, Czech Republic) at 175 °C for 4 min. Before further experiments, the crackers were cooled for 30 min, packed in sealed polypropylene bags and stored at room temperature. Wheat flour was replaced by 5, 10 and 15% addition of wheat germ and corn germin the recipe for cracker. Control sample was crackers which were prepared without the addition of wheat and corn germs.

Determination of physical parameters of crackers: Crackers were evaluated for their physical properties (volume index, specific volume, diameter (width), thickness, spread ratio) parameters were measured. Determination of thickness, width and spread ratio was performed according to the AACC (1995) method. Diameter (D): To determine the diameter, six crackers were placed edge to edge. The total diameters of the six crackers were measured in cm by using a ruler. The crackers were rotated at an angle of 90 for duplicate reading. This was repeated once more and average diameter was taken in centimetre. Thickness (T): To determine the thickness, seven crackers were placed on top of one another. The total thickness was measured in centimetres with the help of ruler. This process was repeated twice to get an average value and results were taken in cm. The spread ratio was determined by the formula  $W/T$ , where W is the average diameter and T is the average thickness (Kohajdová et al., 2011). Specific volume of crackers was determined using a method described by Bouaziz et al., (2010).

Volume index of samples was determined according to Turabi et al., (2008). In this method, cake sample is cut vertically through the centre and the heights of the sample are set at three various points (B, C, D) along the cross-sectioned cakes using the template. Subsequently the index volume was determined in accordance with following formula:

$$\text{Volume index} = B + C + D \quad (1)$$

Where: C represents the height of the cake at the centre point, B and D represent the heights of the cake at the points 2.5 cm away from the centre to the left and also from the centre to the right side of the cake.

Sensory evaluation of crackers: Sensory evaluation was performed by using 9 trained panelists. The panelists were

**Table 1** The physical characteristics of crackers incorporated wheat and corn germ.

	Specific volume (cm <sup>3</sup> .g <sup>-1</sup> )	Volume index (cm)	Width (T/cm)	Thickness (W/cm)	Spread ratio (W/T)
<b>Control</b>	1.65 ±0.02	3.20 ±0.03	5.00 ±0.01	1.06 ±0.03	4.71 ±0.03
<b>WG 5%</b>	1.58 ±0.03*	2.74 ±0.01*	5.00 ±0.01	1.06 ±0.01	4.71 ±0.01
<b>WG 10%</b>	1.41 ±0.01*	2.68 ±0.01*	4.96 ±0.01*	1.05 ±0.01*	4.72± 0.01
<b>WG 15%</b>	1.32 ±0.01*	2.57 ±0.08*	4.91 ±0.03*	1.00 ±0.02*	4.94 ±0.02*
<b>CG 5%</b>	1.53 ±0.02*	3.17 ±0.03	5.01 ±0.01	1.08 ±0.01	4.64 ±0.01*
<b>CG 10%</b>	1.52 ±0.01*	2.99 ±0.02*	4.98 ±0.01*	1.04 ±0.01*	4.81 ±0.01*
<b>CG 15%</b>	1.34 ±0.01*	2.80 ±0.06*	4.96 ±0.01*	0.98 ±0.01*	5.06± 0.01*

Note: \* indicates a statistically significant differences ( $p = 0.05$ ), WG - wheat germ, CG – corn germ.

students of Faculty of Chemical and Food Technology, (Slovak University of Technology, Slovak Republic). Panelists evaluated the sensory parameters as the odor, firmness, taste and appearance of the crackers using the 9 point hedonic scale with 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely.

Samples were presented simultaneously (Kohajdová et al., 2014). Overall acceptability of crackers was assessed using 100 mm graphic non-structured line segment with the description of extremes (minimal or maximal intensity, from 0 to 100%) (Kohajdová, et al., 2011).

#### Statistical analysis

Statistical analysis: All analyses were carried out in triplicate and average values were calculated. The results were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) and Fisher's least – significant difference (LSD) multiple range test was applied to data establish the significance of differences at the level of  $p = 0.05$ . Statgraphic Plus, Version 3.1 (Statistical Graphic Corporation, Princeton, USA), was used as the statistical software.

## RESULTS AND DISCUSSION

The physical characteristics of crackers are presented in Table 1. The specific volume has a great importance in determining the quality because it is generally influenced by the quality of the ingredients used in the formulation of crackers (Perez and Germani, 2003). Incorporation of WG and CG to crackers significantly reduced specific volume and volume index.

Levent and Bilgiçli (2013) found that increasing the amount of differently addition levels (10, 20, and 30%) of WG in cake formulation decreased the volume and the volume index of cake samples. The highest decreasing of volume index was at 15% addition in crackers with CG (2.80 cm). This might be due to the different flour quality

of the flours with fiber and in general, addition of fiber into wheat flour has a negative effect on the formation of gluten network due to dilution of gluten protein and fiber – gluten interaction (Arshad et al., 2007; Wang et al., 2016). It was also found that higher addition (10 and 15%) of WG and CG markedly decreased thickness of crackers. Same trends in thickness were also described in study of Arshad et al., (2007) for cookies incorporated with various levels of defatted wheat germ flour. No significant differences were found between the values obtained for width of crackers supplemented with 5% WG and CG and the control sample. The results described that addition of WG and CG at a level of 15% significantly increased spread ratio.

Similar increasing in spread ratio was also reported in study Youssef (2015) for biscuits fortified of 15% and 20% of WG. The differences in spread ratio between the control sample crackers and the samples with 5%, 10% addition of WG was not significantly. Our results are comparable with finding of Arshad et al. (2007). It has been suggested that the spread ratio is affected by available water which can be absorbed either by flour or any other ingredient which absorbs water during the dough mixing. Subsequently, the spread ratio is decreased when other ingredients absorbed the water (Arshad et al., 2007). Crackers with 15% addition of CG had higher spread ratio (5.06) in compare to control sample (4.71). Sharma Savita et al., (2012) reported that using corn gluten in cookies concluded in increased the spread ratio. As light increase in spread ratio of crackers was observed at 5 and 10% addition of WG. Another result was observed by Chen et al., (1988). They did not find a significant difference in cookie spread ratio between the control and cookies containing oat and wheat bran. Earlier studies also reported reduction of spread ratio when cereal bran (wheat, rice, and oat) and defatted wheat germ were added (Sudha et al., 2007; Arshad et al., 2007). Significant differences were observed between WG and CG enriched crackers in width, spread ratio and specific volume.

**Table 2** Sensory properties of crackers incorporated with corn and wheat germ with cereal germs.

Addition levels / %		Sensory parameter			
		appearance	taste	odor	firmness
Control	0	9.00 ±0.13	8.92 ±0.05	8.76 ±0.13	8.84 ±0.06
WG	5	8.27 ±0.06*	8.15 ±0.10*	8.46 ±0.08*	8.39 ±0.05*
WG	10	8.61 ±0.03*	8.66±0.11*	8.82±0.09	8.78 ±0.21
WG	15	7.71 ±0.07*	7.93 ±0.05*	8.27 ±0.07*	8.08 ±0.07*
CG	5	7.65 ±0.11*	7.36 ±0.08*	7.15 ±0.09*	8.16 ±0.08*
CG	10	6.41 ±0.11*	6.33 ±0.13*	6.71 ±0.04*	7.86 ±0.08*
CG	15	6.01 ±0.17*	5.84 ±0.05*	6.21 ±0.09*	7.37 ±0.17*

Note: \* indicates a statistically significant differences ( $p = 0.05$ ), WG – wheatgerm, CG – corngerm.

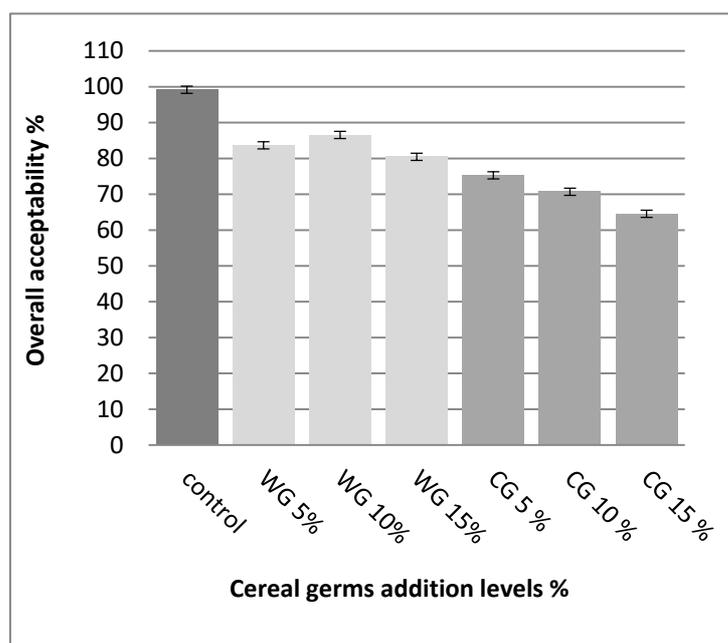
Results of sensory evaluation such as appearance, taste, firmness, odor and overall acceptability are presented in Table 2. The overall sensory quality of crackers decreased with increased cereals germ substitution. Taste is an important sensory analysis attribute of any food because has influence on overall acceptability. The differences in taste of WG and CG crackers were statistically significant. With the increasing addition of CG (range from 5% to 15%), the taste of crackers (range from 7.36 to 5.84) was decreased. The taste of cracker, with higher levels of CG, was characterized with higher intensity of bitter taste (results are not shown). Arshad et al., (2007) described, that the cookies containing more than 15% defatted wheat germ flour as having an after taste and bean flavour. Also it was found, that the crackers with WG and CG addition had significantly reduced firmness than control sample. The overall acceptability is influenced by all the dominant

sensory properties (Ganorkar and Jain, 2014). Cereal germs have beneficial effects on the human health such as diabetes (type2), cardiovascular diseases and some types of cancer as well as improving physical endurance and retarding aging (Hayam et al., 2015; Brandolini and Hidalgo 2012).

Therefore is appropriate to use the cereal germs in the bakery products. On the other hand, the cereal germs incorporated in bakery products represent a problem, because they are sensitive for oxidation and it is reflected in bitter taste of products

The cause oxidation of germs oils is because containing highly unsaturated oxidation fatty acids, which started reacting with the oxygen (Grosh and Laskawy, 1984).

In the future, before using corn germs in the product, it would be appropriate to defat them, to avoid the reduction of sensory parameters which would result in the bitter taste



**Figure 1** Overall acceptability of crackers incorporated.

of the product.

The overall acceptability of crackers with addition of WG and CG is shown in Figure 1. From the results concluded that, this parameter was the highest at 10% addition of WG to crackers. Moreover it was found, that significant difference were recorded in the overall acceptability between the cereal germs and control sample. Crackers with 15% addition of CG had the lowest overall acceptability (64.56%). It could be caused by unpleasant odour and the bitter taste of the crackers.

## CONCLUSION

This study presented effects of addition of different cereals germs (WG and CG) on the physical properties and sensory parameters of crackers. It has been observed that WG and CG addition at higher level (10 – 15%) significantly affected volume index and specific volume of final products. On the other hand width, thickness and spread ratio were remarkable affected only at 15% substitution level WG and CG.

Moreover, it was resulted that incorporation of WG and CG reduced firmness of crackers. Also, it was observed that overall acceptability of crackers showed significant differences between control sample (fine wheat flour based crackers) and crackers, in which 10 and 15% of fine wheat flour were replaced by wheat and corn germ. The results of sensory analysis showed that the crackers incorporated with WG up to 10% level resulted in products with good acceptability. Adding a CG to bakery products is limiting. Results showed that addition higher levels (10, and 15%) of CG markedly negatively affected the taste and odor of crackers.

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