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Effect of Wheat Germ on Quality of Wheat Bread Dough

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Abstract

The most interesting component of wheat is the wheat germ that is recognized as a secondary product in the industry of wheat milling; it has fascinating nutritional values that cannot be ignored. However, it has slender usage due to its significant chance of rancidity and the negative effect it causes the dough quality. Investigation in this study showed that how wheat germ affects the rheological quality of dough and the influences on the final product by its addition to bread, also to find out the best and most amount of wheat germ addition with the best bread quality that is unrecognizable by customers. For this intention, divergent quantities of the mille draw germ of wheat (5%, 10%, 15%, and 20%) were added to the flour used for making bread dough. Afterward, the dough's rheological characteristics and the endmost quality characteristics of the bread were analyzed and compared to the control sample from both the Sensory evaluation and physical evaluation sentiments. Wheat germ insertion to dough flour caused an increase browning of the dough but decreased dough firmness, stretch-ability, and dough strength. The more the amount of the additional wheat germ to the wheat dough, the more the changes appeared, including decreasing extensibility and strength in addition to taste the difference. The bread made from dough with the highest amount of inserted wheat germ dispensed the smaller volume, less elasticity, and cohesiveness, while more firm and darker in color of both crust and crumb of the product. All bread acquired allowable out comes in the sensory examination, yet inserting of wheat germ with a rate of (20% to flour) decreased appearance, texture, and overall acceptability outcomes of bread. Consequently, the addition of the germ worsens the rheology attribution of dough, lessen gelatinization temperature and qualification of bread, so it has to be added in a particular amount to keep both nutritional value and the quality of the bread as high as possible.

Keywords: Germ, Rheology, Physical, Sensory, Dough, Bread

1. INTRODUCTION

The rheology of the dough of wheat flour has been a very interesting topic for chemists of cereal technology. The deformation and flow behavior of doughs are acknowledged to be the secret of bakery products' manufacturing success[1]. Rheology is an enduring field for the people who are new to it[2]. The phrase dough rheology is commonly correlated with physical properties measured during the mixing and proofing of dough at low temperature during fermentation. However, the differences in dough's physical properties do not disappear at the end of this low-temperature stage of the process. They conserve at least some of their flow characteristics until late in the baking process and the consequences of any differences are reflected, by differences in the baked bread crumb. The flow and consistency characteristics of the dough are considered to be primarily protein or gluten dependent[3]. However, the effect of starch gelatinization on bread baking performance has been assessed using water-rich slurries in technically limited instrumental systems such as the amylograph. Starch gelatinization does not take place under the same conditions in slurry as it does in dough of reduced water availability. Rheology in the bakery industry has focused on the characterization of the quality of bakery materials. Plainly the role of rheology as a measure of physiochemical changes that occur during dough processing has been established. Nearly all dough ingredients affect the rheology of dough to a certain extent, but most of the properties are derived from the flour, water, yeast, and air. Several minor ingredients affect rheology less such as salt, fats, enzymes, and emulsifiers. Most studies have centered on the role of the gluten protein fractions glutenin and gliadin. The gliadins are a group of smaller proteins that contribute to the viscosity of dough. Glutenin proteins have larger average molecules and are responsible for the elastic component of a dough's behavior. It is a distortion to assume that only gluten proteins affect the rheology of a dough. It is only after their proteins interact with other components in the flour and dough that the viscoelastic nature of dough emerges[4]. The germ of wheat is the inestimable portion of wheat grain nutritionally. It is a substantial originator of beta vitamins, vitamin E, dietary fiber, protein, and minerals (zinc, magnesium, iron, potassium, calcium) [5]It is a by-product of the milling process at the industries of obtaining white flour. The protein content of wheat germ is noticeably high (over 20%), which is in the formation of globulins and albumins, and its amino acid composition is counter poised since its lysine proportion is higher than endosperm[6]. Being an essential source of Vitamin E makes wheat germ stand out and present as a disjoined entity. The amount of prolineand glutamine is half of the flour, and double amounts of alanine, asparagine, glycine, arginine, lysine, and threonine [7].Additionally, the antioxidant activity of wheat germ constituents is high. It also has an advantageous for human bifido-bacteria's growth. Therefore, wheat germ has an incredible nutritional feature and remarkable prospective for certain supplement use [8].There is also a considerable content of fat in wheat germ and noteworthy mass of biological active molecules that can help the growth of the embryo of a plant. Amongst these particles, the lip-ases and the lip-oxygenases can dissect lipids and commence the oxidation of the rancidity process [9]. The reason behind the low short-life of the germ of wheat is behind the presence of high unsaturated fatty acid content; this also affects the flour with the added germ. Besides, bread dough gets weak with the addition of wheat germ since it is rich in glutathione, which is a dominant reducer that breaks the disulfide bonds that lead to the weakening of the gluten network [10].Ascribed to the nutritional values of wheat germ, here is a plentifully early production of wheat germ around the world lately. The utilization of wheat germ is not at a progressed level yet[11].The wheat germ addition to baking products has been inspected using different outlooks. The raw wheat germ was used in a few of the studies to insert to the products, and some others integrate de-fatted wheat germ, processed wheat germ with heat, or both to secure products better effects than raw wheat germ and obtain longer life to the product. The well-organized detachment of wheat germ from wheat acts as an essential commercial factor. An amount of 0.4- 0.5 percent by weight of the germ can be separated with nowadays technology [12].The wheat germ application began to appear too late, and most of it

is predominantly used in silage configurations. Therefore the wheat germ' susageis still developmental, and the irreplaceable wheat germ origin has not been considerately, rationally, and systematically employ[13]. Wheat germ oil that is obtained from wheat germ is practically superior animal proteins and is plentiful in several amino acids, especially the essential amino acids methionine, lysine, and threonine. Wheat germ supplies three times more protein, six-fold more minerals, and fibers, seven-fold more fat, and fifteen times more sugars, as compared to white flour that is composed of just the endosperm of the wheat [14]. Utilizing the protein of wheat germ in bakery products, especially in bread [15], cookies, biscuits, and muffins, and in comminuted meat products[16]. There are some studies on the protein of wheat germ for its independent functionality [17].Therefore, wheat germ is a nutritionally rich food additive; it is a kind of excellent natural protein fortification food material[18]. The popularity of fortification of wheat flour with wheat germ has become real. Attention was focused on the details of the most micronutrients deficiencies; they are health and economic interest. Choice of acceptable fortificants and their rates, choosing of an applicable fortification vehicle, storage condition, suitableness and bio-availability of fortified flours. The selection and levels of proper fortificants are one of the main factors while aiming for a successful fortification process of wheat flour. The fact about its rich nutritionally and appetizing, most of the nutrition scientists pay tribute to wheat germ as "Source of life and the natural nutrient house of the treasure of health of mankind." However, the wheat germ affects the quality as well as the recover quality of the flour. The wheat germ addition to flour can influence on the rheological attributes of dough and the end most bread quality, from both the sensory and physical viewpoints[19].This study of ours aimed to observe the characteristics of rheological, physical, chemical, and sensory evaluation of the different addition rates of wheat germ to bread dough sample.

2. METHODS AND MATERIALS

2.1 Raw Materials

The cultivar of wheat was Australian Krichauff which obtained from Sulaimanyah Agriculture Research Center was used in this study. The wheat grain was milled with home power electronic miller; PRH stainless steel grain grinder 200g powder machine 1200w commercial electric grain mill for pill hurb corn, then sieved with (355mm) sieve. Then flour was used alone as control and mixed with different percentages 5%, 10%, 15% and 20% of wheat germ that was obtained from Asos Flour Industry in Sulaimani that was separated by special electric sieves with (1355 – 1400 mm), then milled at the laboratory by home power electric miller again the same as the Kricauff wheat grains.

2.2 Dough Preparation

Modified bulk fermentation method was used in the loaf bread baking test. Hence 100 gm of flour blends with 2% dry instant yeast, 1.5% salt, 4% sugar, 4% dried full fat milk, 2% vegetable oil and water in accordance to the water absorption result from the farinograph test of the samples, all these mixes together. Then the dough was labeled and left for fermentation 30 ±5 ℃in the fermentation chamber of the incubator that is provided at the University of Sulaimani, Food Science and Human Nutrition Department's Cereal Technology Laboratory. The Dough was punched and left for 15 min at 30 ±5 ℃ in the fermentation chamber of the incubator. Afterward, the dough was divided into three replications of 75 gm; pieces were rounded and sheeted then rolled and panned. Then proofing was at 30 ℃±5 for 50 mines, then the proofed doughs were put in the oven that was preheated at 200 ±5 ℃for 20 minutes. Moreover, then the bread parameters and sensory evaluation characters like volume crust color, symmetry, bake uniformity, texture, grain, crumb color, odor, taste, and texture were evaluated according to the AACC method number 10-12.01.[20]

2.2.1 Rheological Characteristics of Dough

Amylograph and Farinograph procedures were used for rheological characteristics according to AACC methods 61-01.01 and 54-21.02, respectively.[21, 22]

2.2.2 Baking Volume

AACC method 10-05.01 was used tomeasure the loafvolume by displacing with rapeseed. [23]

2.3 Chemical Composition of Flour Samples

The following methods were used for flour analysis, as shown in Table 1.

According to AACC 39-70.02 method[24], NIRFlex near-infrared spectroscopy was used to calculate fat, moisture, ash, and protein contents, it is available at Sulaimanyah Quality Control Directorate. The determination of carbohydrate content was by difference from the sum of the flour contents including protein, fat, moisture and fiber that were deducted from 100, as outlined in the AOACmethod[25].

2.4 Method of Statistical Analysis

For the statistical tests of variance analysis, least significant difference (ANOVA) test and XLSTAT 2016 software, were used.

3. RESULTS AND DISCUSSION

Data in Table 1.1 and Table 1.2 for rheological properties indicates that there were significant differences between treatments in terms of all of the characteristics, regarding water absorption, developing time, stability, time to break Farinograph quality number and gelatinization temperature. All of them decrease with increasing the rate of wheat germ in their sample, while tolerance mixing index increase with increase the rate of the wheat germ in the samples. Since the flour sample was a whole wheat flour sample and the fiber content was already high with the wheat germ addition the amount of fiber may be changed that is why as much as the wheat germ rate increased the water absorption rate decreased, since the water holding capacity decreased in agreement with [26].Flour with higher ash contents and darker color causes difficulty in dough handling and processing, ash may physically damage the gluten network, in addition, the presence of non-starchy networks forming polysaccharides such as pentosans affects the rheological properties of wheat flour doughs.[4]

Table 1.1: Impact of the wheat germ addition on the rheological properties of dough (Farinograph)

Treatments	Absorption of Water(%)	Develop-ingTime (Min.)	Stability (Min.)	Tolerance Index of Mixing (FU)	Break Down Time (Min.)	Farinofraph Quality Number Degree
Krichauff Control	82.233 a	8.933 a	9.900 a	31.667 d	12.667 a	126.667 a
Krichauff 5%	81.200 a	4.467 c	1.900 b	122.167 c	5.867 b	58.667 b
Krichauff 10%	81.467 a	5.867 b	1.867 b	104.333 c	6.267 b	62.667 b
Krichauff 15%	83.400 a	5.067 c	1.500 b	207.667 b	5.233 b	52.333 b
Krichauff 20%	77.200 b	4.633 c	1.367 b	266.667 a	4.900 b	49.000 b

Table 1.2: Impact of the wheat germ addition on the rheological properties of dough (Amylograph)

Name of cultivar	Gelatenization Temperature
Krichaulf Control	79.5℃
Krichaulf 5%	78℃
Krichaulf 10%	76.5℃
Krichaulf 15%	75℃
Krichaulf 20%	72℃

Appendix 1: Descriptive statistics of the effect of wheat germ addition on gelatinization temperature

Variable	Observations	Obs. with missing data	Obs. without missing data	Min.	Max.	Mean	Std. deviation
Gelatenization Temperature	5	0	5	72.000	79.500	76.200	2.885

As it is shown in Table 2, non-remarkable differences were noticed among the treatments since the wheat flour is whole wheat flour that already contains much fiber that could be a reason to prevent the volume change a lot with the wheat germ adding in agreement with [27]. Meanwhile, the slight change might be due to the action of reducing of the presented glutathione that is found in wheat germ or due to the dilution of gluten proteins available in wheat germ, this causes the gluten network to weaken that has the responsibility of holding gas for creating bigger bread volume. So it was decided to confine the wheat germ inserting to a low rate that doesn't exceed 20 %, data showed in table 2 are with the agreement of those who reported[28].

Table 2: Impact of germ addition on the volume of the loaf

Treatments	Volume (cm3)	Weight (gm)	S L V
Krichauff Control	143.333 a	70.667 a	2.027 a
Krichauff 5%	160.000 a	70.667 a	2.263 a
Krichauff 10%	143.333 a	71.333 a	2.008 a
Krichauff 15%	156.667 a	72.000 a	2.175 a
Krichauflf 20%	143.333 a	72.667 a	1.975 a
S L V = Specific loaf volume			

Figure 1: Laofs with the wheat germ addition

Data in Table 3 and Appendix 2 indicate that there were significant differences between treatments in terms of adding different percentages of wheat germ. The amount of fat, protein, and ash increases with the increase in the rate of wheat germ addition. This conceivably is due to the wheat germ adding that is rich in fat, protein, and ash content which increase the viscosity of the paste and this may lead to competing on water content between all wheat and germ component that leads to rising the viscosity pick faster than the control and this leads to lower the gelatinization temperature present data are with agreement with those whom [14], while the rate of carbohydrate decreases.

Table 3: Impact of wheat germ addition on the chemical composition of flour

Cultivars	Moisture	Fat	Protein	Ash	Total Carbohydrate
Krichauff Control	9.75	2.26	13.66	1.73	72.6
Krichauff 5%	9.71	2.48	14.02	2.19	71.6
Krichauff 10%	10.02	2.81	14.52	3.13	69.52
Krichauff 15%	9.72	2.99	15.04	3.09	69.16
Krichauff 20%	9.64	3.74	16.33	3.81	66.48

Appendix 2: Descriptive statistics of the effect of wheat germ addition to the flour on the chemical composition

Variable	Observations	Obs. with missing data	Obs. without missing data	Min.	Max.	Mean	Std. deviation
moisture	5	0	5	9.640	10.020	9.768	0.147
Fat	5	0	5	2.260	3.740	2.856	0.570
Protein	5	0	5	13.660	16.330	14.714	1.043
Ash	5	0	5	1.730	3.810	2.790	0.826
Total Carbohydrate	5	0	5	66.480	72.600	69.872	2.375

Table 4 shows significant differences regarding bread volume, and the biggest volume was obtained by using 5% wheat germ despite the control data showed in table 4 are with those whom reported[14].The loaf volume's significant difference is very evident while in the rapeseed volume indication was not available since the sensory evaluation was done a while after the volume was calculated and this time may cause the beginning of the staling process to the loaf. These results are agreed with those whom reported [29], that indicated the negative effect of staling on the volume of the loaf, this might be due to the limited aging of the separated wheat germ at ambient temperature, a problem which has been an obstacle to its applications in many food products with the agreement of [30]. The highest symmetry, bread texture, crumb color aroma, and taste were obtained by using 5% & 10% of wheat germ. The emulsion agent present in wheat germ which leads to producing desirable and uniform air bubbles in the dough and final product similar results, that is why the addition of 5% of the wheat germ was more desirable to add in such cases. Significant differences appeared between the treatments in terms of crust and crumb colors; this may be due to the carotenoids, tocopherols, and phenolic-compounds that are concentrated mostly in the wheat germ [31]. The symmetry of form, uniformity of bake and texture significant differences may be due to the high fiber comprehend of wheat germ particles that might disorganize the gluten network ormation mechanically and moreover enforce gas cells to enlarge these results are agreed with those whom reported[32]. The loaf with no germ addition was noticed of having higher comprehensive appropriateness desirability in terms of taste and odor than bread that contains different amounts of germ, and note worthy there were differences found between the control bread and the bread with wheat germ addition, these results are in consensus with those whom reported[26]. The cause of this might be due to the existence of free fatty acid in wheat germ that commonly contributes to the flavor of soapy and bitterness in food, the presence of free fatty acid in the untreated oil is oftentimes high with the range of (5–25%), specially Furanoid Fatty Acids[33]. Wheat germ oil is ordinarily might have piquant flavor and odor be determined by the oil's oxidative action also it is dark in color[34]and varies depending on germ rancidity these results are in correspondence with those whom reported[35]

Table 4: The Addition impact of the germ of wheat on the sensory evaluation characters of the wheat loaf

Treatments	Volume (10)	Color of Crust 8)	Form Symmetry (5)	Bake Uniformity (3)	Texture of Crust (4)	Bread Grain (15)	Color of Crumb (10)	Odor (10)	Taste (20)	Texture (15)
Control	9.300 aa	7.767 aa	4.167 aa	2.800 aa	3.267 aa	14.833 aa	9.567 aa	9.400 aa	19.467 aa	14.667 aa
5%	8.233 b b	7.200 aa	3.500 ab b	2.733 aa	3.400 aa	12.700 b b	8.300 b b	8.833 ab a	17.167 b b	13.767 b b
10%	7.100 c c	6.233 b b	3.300 ab bc	1.933 ab b	2.367 b b	12.367 b b	6.933 c c	8.100 bc b	16.167 c c	12.067 c c
15%	6.833 cd d	6.033 b b	3.167 b bc	1.633 b b	2.200 bc b	10.767 c c	6.367 c cd	7.200 c c	16.167 c c	10.267 d d
20%	6.600 d d	5.767 b b	2.733 b c	1.300 b b	1.667 c c	10.000 c d	6.133 c d	5.867 d d	15.133 d d	9.100 e e

4. CONCLUSION

The sensory assessment confirmed that there were significant differences between treatments in terms of adding different rates of wheat germ, regarding volume, bread texture, crumb color, symmetry, and aroma. The closest results to one another and with the control were 5% and 10% of wheat germ addition that was acceptable by both of the consumers and laboratory tests.

The chemical composition of the samples had significant differences since the wheat germ is rich in fat, protein and ash content, and lessened carbohydrate rate. The rheological characteristic of the dough is another significant factor determining the quality of the bread. Elasticity, on the other hand, affects the capacity of holding gas of the dough, that must be extensible to prevent the rupture of the membranes between gas cells [36]. It was conducted that there were notable differences between the control and the different rates of insertion of wheat germ to the flour samples, in a manner that the germ of wheat insertion to flour decreases water absorption rate due to competing for the water absorption between wheat and inserted germ components which lower the gelatinization temperature, it decreased developing time, stability time, breaking time and farinograph quality number as well. While it effected on increasing tolerance mixing index, in conclusion, wheat germ addition could be a valuable process in bread making, in terms of its nutritional quality. However, the formulation with its share should be optimized by balancing its rate to prevent adverse effects on rheological, chemical, physical, and sensory indices.

REFERENCES

[1] J. F. Steffe, Rheological methods in food process engineering: Freeman press, 1996.

[2] J. A. Menjivar, "Fundamental aspects of dough rheology," in *Dough rheology and baked product texture*, ed: Springer, pp. 1-28,1990

[3] B. Khatkar, "Rheology and Chemistry of dough," *Post-graduated diploma in bakery science and technology. Directorate of Distance Education Guru Jambheshwar University of Science and Technology*, 2004.

[4] H. Faridi and J. M. Faubion, *Dough rheology and baked product texture*: Springer Science & Business Media, 2012.

[5] J. Petrović, A. Fišteš, D. Rakić, B. Pajin, I. Lončarević, and D. Šubarić, "Effect of defatted wheat germ content and its particle size on the rheological and textural properties of the cookie dough," *Journal of texture studies*, vol. 46, pp. 374-384, 2015.
[6] Y. Ge, A. Sun, Y. Ni, and T. Cai, "Some nutritional and functional properties of defatted wheat germ protein," *Journal of agricultural and food chemistry*, vol. 48, pp. 6215-6218, 2000.
[7] Y. Hemery, X. Rouau, V. Lullien-Pellerin, C. Barron, and J. Abecassis, "Dry processes to develop wheat fractions and products with enhanced nutritional quality," *Journal of Cereal Science*, vol. 46, pp. 327-347, 2007.
[8] G. O. Phillips and P. A. Williams, *Handbook of hydrocolloids*: Elsevier, 2009.
[9] F. Galli, F. Venturi, F. Bartolini, O. Gava, A. Zinnai, S. Chiara, *et al.*, "Shaping food systems towards improved nutrition: A case study on Tuscan Bread Protected Designation of Origin," *International Food and Agribusiness Management Review*, vol. 20, pp. 533-552, 2017.
[10] B. S. Kamel and C. E. Stauffer, "Advances in baking technology," 1993.
[11] G. Yiqiang, "Nutrition value and application of wheat germ [J]," *Science and Technology of Food Industry* vol. 1, 1999.
[12] E. S. Posner and Y. Li, "Method of separating wheat germ from whole wheat," ed: Google Patents, 1991.
[13] G. Yiqiang, S. Aidong, and C. Tongyi, "The nutrition value and application deliberation of wheat germ," *China Science & Technology of Food Industry*, vol. 1, pp. 52-53, 1999.
[14] S. Al- Hooti, J. Sidhu, J. Al Saqer, and A. Al Othman, "Effect of raw wheat germ addition on the physical texture and objective color of a designer food (pan bread)," *Food/Nahrung*, vol. 46, pp. 68-72, 2002.
[15] V. Cakmakli, E. Kose, and K. Kemahlioglu, "Effects of addition of crude and stabilized wheat germ together with a mixture of improvers on dough and bread characteristics," *Gida*, vol. 20, pp. 243-248, 1995.
[16] R. Gnanasambandam and J. Zayas, "Quality Characteristics of Meat Batters and Frankfurters Containing Wheat Germ Protein Flour 1," *Journal of food quality*, vol. 17, pp. 129-142, 1994.
[17] B. VANI and J. Zayas, "Wheat germ protein flour solubility and water retention," *Journal of Food Science*, vol. 60, pp. 845-848, 1995.
[18] Y. Ge, A. Sun, Y. Ni, and T. Cai, "Study and development of a defatted wheat germ nutritive noodle," *European Food Research and Technology*, vol. 212, pp. 344-348, 2001.
[19] M. Majzoobi, S. Farhoodi, A. Farahnaky, and M. Taghipour, "Properties of dough and flat bread containing wheat germ," *Journal of Agricultural Science and Technology*, vol. 14, pp. 1053-1065, 2012.
[20] AACC International. Approved Methods of Analysis, 11th Ed. Method 10-12.01. Baking Guidelines for Scoring Experimental Bread Method. AACC International, St. Paul, MN, 2000.
[21] AACC International. Approved Methods of Analysis, 11th Ed. Method 61-01.01. Amylograph Method for Milled Rice Measurement of Alpha-Amylase Activity with the Amylograph Method. AACC International, St. Paul, MN, 2000.
[22] AACC International. Approved Methods of Analysis, 11th Ed. Method 54-21.02. Rheological Behavior of Flour by Farinograph: Constant Flour Weight Procedure Method. St. Paul, MN, 2000.
[23] AACC International. Approved Methods of Analysis, 11th Ed. Method 10-05.01. Guidelines for Measurement of Volume by Rapeseed Displacement Method. St. Paul, MN, 2000.
[24] AACC International. Approved Methods of Analysis, 11th Ed. Method 39-70.02. Near-Infrared Reflectance Method for Hardness Determination in Wheat Method. St. Paul, MN, 2000.
[25] W. Horwitz, 13 th ed Washington, DC: Association of Official Analytical Chemists of Official Methods of Analysis (AOAC), pp. 56-132.1980
[26] M. Gómez, J. González, and B. Oliete, "Effect of extruded wheat germ on dough rheology and bread quality," *Food and Bioprocess Technology*, vol. 5, pp. 2409-2418, 2012.
[27] C. Lai, R. Hoseney, and A. Davis, "Effects of wheat bran in breadmaking," *Cereal Chem*, vol. 66, pp. 217-219, 1989.
[28] J. Sidhu, S. N. AL- Hooti, J. M. AL- Saqer, and A. AL- Othman, "Studies on the development of pan bread using raw wheat germ," *Journal of Food Quality*, vol. 24, pp. 235-247, 2001.
[29] D. Axford, K. Colwell, S. Cornford, and G. Elton, "Effect of loaf specific volume on the rate and extent of staling in bread," *Journal of the Science of Food and Agriculture*, vol. 19, pp. 95-101, 1968.
[30] M. Majzoobi, S. FARHOUDI, A. Farahnaky, and M. Taghipour, "Properties of dough and flat bread containing wheat germ," 2012.
[31] S. Žilić, A. Serpen, G. Akıllıoğlu, M. Janković, and V. Gökmen, "Distributions of phenolic compounds, yellow pigments and oxidative enzymes in wheat grains and their relation to antioxidant capacity of bran and debranned flour," *Journal of Cereal Science*, vol. 56, pp. 652-658, 2012.
[32] M. Salmenkallio- Marttila, K. Katina, and K. Autio, "Effects of bran fermentation on quality and microstructure of high- fiber wheat bread," *Cereal Chemistry*, vol. 78, pp. 429-435, 2001.
[33] W. Grosch, U. C. Konopka, and H. Guth, "Characterization of off-flavors by aroma extract dilution analysis," ed: ACS Publications, 1992.
[34] T. Wang and L. A. Johnson, "Refining high-free fatty acid wheat germ oil," *Journal of the American Oil Chemists' Society*, vol. 78, pp. 71-76, 2001.
[35] A. Brandolini and A. Hidalgo, "Wheat germ: not only a by-product," *International journal of food sciences and nutrition*, vol. 63, pp. 71-74, 2012.
[36] K. Mani, A.-C. Eliasson, L. Lindahl, and C. Tragardh, "Rheological properties and breadmaking quality of wheat flour doughs made with different dough mixers," *Cereal chem*, vol. 69, pp. 222-225, 1992.