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Development of a procedure for the production of oat-supplemented wheat bread

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ABSTRACT

Oat (Avena Sativa L.) is characterized by a high content of protein with a favorable amino acid composition, β-glucans, and unsaturated fatty acids. This study aimed to determine the factors affecting the physical properties and sensory value of bread made of wheat combined with oats. The research was to investigate the effects of (i) the proportion of added oat flour (15, 20, 30%); (ii) the fermentation time (60, 75, 90, 105 min); and (iii) baking temperature (200, 210, 220°C) for baking time (10, 15, 20 min) to bread quality with added oat flour. The quality assessment criteria include hardness, moisture content, specific volume, color, and sensory value of the product. According to the results, the most acceptable proportion of oat flour supplement in all of the criteria of bread was found to be 20%. The fermentation time of 90 minutes provided the best texture and highest sensory value for the bread. Oat-wheat bread was baked at 210°C for 20 minutes to obtain a good taste, helping the bread to have a crispy texture, smooth surface, and an attractive yellow-brown color.

1. INTRODUCTION

The demand for trendy food that has high quality and healthy foods, especially those with high sensory value, is of increasing interest. Therefore, supplementing the nutrition of commonly consumed staple food products, such as bread, becomes an effective means of alleviating nutritional problems. Some of the cereal flours were used to replace a part of wheat flour to improve the nutritional quality of bread. Among them, oat (*Avena sativa* L.) is unique among all cereal grains for human food, animal feed, health care, and cosmetics because it contains many valuable nutrients (Varma et al., 2016). Oat provides an important source of carbohydrates, proteins, fats, and natural healthy compounds such as phenolics, soluble fiber, vitamins, and minerals (Joyce et al., 2019). Oat beta-glucan (OBG) is a viscous polysaccharide found in oats (3-7%) and is considered the main active ingredient in oats with various nutritional and functional properties, mainly cholesterol-lowering and antidiabetic effects (Andrade et al., 2015). With the nutritional composition and the health value of oats mentioned above, oats can replace a part of wheat flour in bread processing to help increase the soluble fiber, vitamins, and minerals, to improve the nutrition and sensory value, as well as good for consumers' health. The study was conducted in order to develop an oat-wheat bread-making process, determine the proportion of added oats, and create the optimum conditions for the fermentation and baking process.

2. MATERIALS AND METHOD

2.1. Materials

Materials for the study include wheat flour (Interflour Vietnam Company), iodized salt (Laria Trading Co., Ltd.), *Saccharomyces cerevisiae* (Mauripan dry yeast, AB Mauri Vietnam Limited), Instant oatmeal (Xuan An Nutrition Food Co., Ltd), sugar (Bien Hoa Sugar Joint Stock Company).

2.2. Research methods

2.2.1. Preparation and processing

Prepare materials, including wheat flour, instant oatmeal (powder), and other ingredients (sugar, salt, yeast, water), are calculated as a percentage of the total dough weight (100%). All ingredients were put into the automatic dough-kneading machine to knead the dough for approximately 40 minutes. After kneading, the dough was taken out and incubated at room temperature for 75 minutes. After fermentation, the dough was divided into parts, each about 100g, then roll the dough into a circle and let the dough rest for 40 minutes before baking. The oven was preheated for 10 minutes at 180ºC; the semi-products were placed in the oven and baked as follows in two periods: the first period was 10 minutes at 180oC, and the second period was 10 minutes at 220ºC. After baking, the bread was cooled down, and analyzed the quality characteristics.

2.2.2. Experimental design

Experiment 1: Investigate the levels of added oat to the quality of oat-wheat bread

The materials were prepared according to the description in 2.2.1. At the mixing stage, oat was added in 4 levels, such as 10%, 20%, and 30%, which replaced wheat flour in the dough. Thereafter, the bread processing was continued following the description in 2.2.1.

Experiment 2: Investigate the effect of fermentation time on the quality of bread oat-wheat bread

The materials were prepared according to the description in 2.2.1 with the level of added oat that was provided in experiment 1. The fermentation time was changed at 60 minutes, 75 minutes, 90 minutes and 105 minutes, respectively. Thereafter, the bread processing was continued following the description in 2.2.1.

Experiment 3: Investigate the effect of baking temperature and time on the quality of bread oat-wheat bread

The materials were prepared according to the description in 2.2.1 with the level of added oat that was provided in experiment 1, and the fermentation time was selected in experiment 2. The baking process was changed as follows: baking temperature 200ºC, 210ºC, 220ºC, and baking time at 10 minutes, 15 minutes, and 20 minutes. Thereafter, the bread processing was continued following the description in 2.2.1.

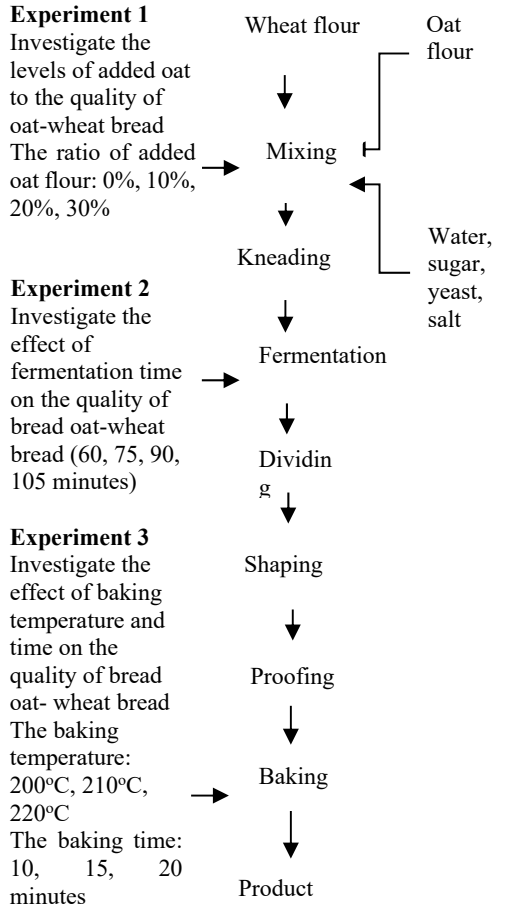

Figure 1. General experimental flow diagram

2.2.3. Analytical criteria and analysis methods

Analytical criteria: Moisture content (Pham & Bui, 1991); color (Luo, 2002); the specific volume of bread after baking (James Bitrus et al., 2020); Texture (Young Modul formula).

Sensory evaluation (Herbert Stone et al., 2012): Sensory evaluation of bread supplemented with oat by quantitative descriptive method QDA (Qualitative Descriptive Analysis). Set up a sensory evaluation committee (10 members) who are knowledgeable about the sensory evaluation of products. Sensory quality of bread products supplemented with oat flour is described in terms of colour, odor, taste and texture. The sensory sheet was used to build a descriptive scale from 1 to 5 for evaluating each attribute of the bread.

Table 1. Sensory sheets for oat-wheat bread

Target	Score	Product description
Color	5	The crust has yellow-brown color, and the color is uniform.
	4	The crust has yellow-brown color; the color is relatively uniform.
	3	The bread crust is dark brown or light yellow; the color is uniform.
	2	The bread crust is dark brown or light yellow; the color is not uniform.
	1	The bread crust has black color (burning).
Textur	5	The bread has crispy crust and soft crumb, the cross section of bread is smooth and contains small air holes.
	4	The bread has hardy crust and soft crumb, the cross section of bread is smooth and contains medium air holes.
	3	The bread has a hardy crust and a soft crumb; the cross-section of the bread is not smooth and is a little bit sticky.
	2	The bread has a soft crust; the crumb is sticky.
	1	The bread is very hard and does not rise.
Odor	5	The bread has the strong aroma of oats.
	4	The bread has the light aroma of oats.
	3	The bread does not have the aroma of oats
	2	The bread has only the aroma of wheat.
	1	The bread has a burning smell.
Taste	5	The bread has the strong taste of oat.
	4	The bread has a slight taste of oat.
	3	The bread has without a taste of oats.
	2	The bread has a little bit salty
	1	The bread has a little bit of bitter

Data collection and analysis: The experiments were arranged in a randomized design with 3 replications. The results of the experiments were statistically analyzed using the program Stagraphics Centurion 15.1. The mean, standard deviation processed by Microsoft Excel software. ANOVA (Analysis of variance) and LSD (Least Significant Difference) test at 5% significance level to conclude about the difference between average of the trials. The difference at the significance level of the treatments at the 95% confidence level. The best result selected from the previous experiment was used as the fixation condition for the subsequent experiments.

3. RESULTS AND DISCUSSION

3.1. Effect of the levels of added oats on the quality of oat-wheat bread

3.1.1. Effect of the levels of added oat on the color and structure of oat-wheat bread

Color is an important visual attribute of food appearance that contributes to consumers' choices. It is one of the important factors in evaluating the quality of the final product. The oat flour supplement that has been created for bread has its own characteristics. The bread color became darker and yellower with the increasing percentage of added oats (Table 2).

Table 2. Effect of the levels of added oat on the color of oat-wheat bread

Percentage (%)	L*	b*
0	66.65 ± 1.01^{b}	21.27 ± 1.05^{c}
10	57.97 ± 0.97^{a}	19.58 ± 0.84^{b}
20	57.73 ± 1.17^{a}	19.55 ± 1.02^{b}
30	56.99 ± 0.95^{a}	18.66 ± 0.75^{a}

Note: Means with the same letters a, b, c in the column are not significantly different at the 5% level.

By adding oat flour, the brightness (L*) and yellowness (b*) of the bread were significantly lower than that of the control sample. The difference in color may be because of the protein content and type of protein of the flour that was used to produce the bread. The natural color of instant oatmeal is bright yellow; therefore, the color of the bread was made by supplemented oats that became more yellow than the normal bread. The results were consistent with the report of Salehifar and Shahedi (2007); these authors concluded that the levels of

added oats from 0% to 40% in bread processing led to reducing the L* and b* values of products. As the percentage of added oat flour increased, the color of the bread turned browner. Specifically, the bread with 20% added oat achieved the desired bright brown color for consumers.

In the process of making bread, the hardness is one of the important parameters and it was used as an indicator of bread quality (Szczesniak, 2002). The results in Table 3 showed that the hardness of breads decreased when the levels of added oat increased in the blend formula. The texture of the control sample was significantly harder than others, and the breads were 30% oat and had the softest structure. This is probably because the fat in oats was higher than in wheat. Moreover, fats had softening properties and played a role as the lubricant in bread processing (Salehifar & Shahedi, 2007).

Table 3. Effect the levels of added oat on the structure and moisture content of oat-wheat bread

Percentage (%)	Hardness (kPa)	Specific volume (cm^3/g)	Moisture content (%)
0	5.52±0.056^{c}	2.86±0.04^{d}	37.42±0.43^{ns}
10	3.10±0.076b	2.63±0.03c	37.45±0.45ns
20	2.97±0.057^{ab}	2.46±0.03^{b}	37.73±0.30^{ns}
30	2.91±0.053a	2.15±0.02a	37.95±0.89ns

Note: Means with the same letters a, b, c in the same column are not significantly different at the 5% level.

Expansion is also a parameter for the quality of bread, which is determined by the specific volume of the bread. The expansion is influenced by the ingredients and processing parameters. According to the results shown in Table 3 and Figure 2, the specific volume (volume/weight) of bread significantly decreased when increasing the levels of added oats. The addition of oats significantly reduced the specific volume of the bread compared with the control sample. Oat was added with a high concentration, leading to a decrease in the protein concentration in the dough, especially gliadin and glutelin. These proteins in wheat could form a gluten network, which provided the desired texture and volume of bread (Anjum et al., 2007). In the other hand, the protein in oats could not create the gluten network. The fiber content in oats also significantly reduced the elasticity of the dough.

Figure 2. The degrees of expansion and the cross section of oat-wheat bread with different levels of added oat

The moisture content of the bread has an effect on the shelf life of the product. According to several of the studies on the bread, the average moisture value was approximately 35% (Yen et al., 2015) and did not exceed 43% (Man et al., 2011). The results in Table 3 showed that the moisture content of the bread was slightly increased by levels the added oat, but there was not a statistically significant difference. However, the starch of oats had higher water absorption than other cereals; therefore, the bread was added oats that had higher moisture content, leading to prolonged retrogradation phenomena (Rosell et al., 2001).

3.1.2. Effect of the levels of added oat on the sensory value of oat-wheat bread

The sensory of bread making with wheat-oat was evaluated by descriptive scoring method. The results in Table 4 showed that the color, odor, taste, and texture of the bread were changed when the products were added oat with different levels.

Table 4. Effect of the levels of added oat on the sensory value of oat-wheat bread

Oat (%)	Color	Texture	Odor	Taste
0	3.7±0.6^{a}	3.8±0.6^{b}	3.1±0.5^{a}	3.2 ±0.6^{a}
10	3.9±0.5^{a}	3.9±0.5^{bc}	3.8±0.6^{b}	3.9 ±0.8^{b}
20	4.2±0.6^{ab}	4.4±0.5^{c}	4.5±0.7^{c}	4.3 ±0.6^{b}
30	4.6 ±0.5^{b}	3.0±0.8^{a}	3.9±0.8^{bc}	4.5 ±0.5^{b}

Note: Means with the same letters a, b, and c in the same column are not significantly different at the 5% level.

Table 4 showed that the sensory evaluation score of color, odor, and taste gradually increased following the increase of levels of added oats. The score was highest in the proportion of 20% and 30% of added oats; the bread had a beautiful and uniform yellow-brown color and had the characteristic flavor of bread in harmony with the light aroma of oats. However, the sensory evaluation score of texture

reached the highest value in the breads, which were added 10% and 20% oat, had a crispy crust, and were soft with uniform air holes.

In summary, the bread contained 20% oat, which replaced wheat flour in the mixing step, providing the bread with a good texture and harmonious taste compared with the control sample. Therefore, the 20% added oats that were chosen as the appropriate level for the bread production and were used for the subsequent experiments.

3.2. Effect of the fermentation time on the quality of oat-wheat bread

3.2.1. Effect of the fermentation time on the color and structure of oat-wheat bread

In bread production technology, the fermentation stage of wheat flour plays a decisive role in the quality of bread. The chemical energy required for yeast because of intracellular sugar metabolism provides yeast that can break down sugars by anaerobic respiration or alcoholic fermentation. In dough, yeast growing under anaerobic conditions causes alcoholic fermentation of sugar and produces the CO_2. The CO_2 is the agent that causes bread to rise; the gas produced will be trapped in the gluten networks. When baking bread at high temperatures, the gas will increase the volume of the dough; the gluten network will stretch and form air pockets containing the gas, causing the porosity of bread (Nguyen, 2022). The results in Table 5 showed that the fermentation time was slightly influencing the color of bread due to the changing volume of bread.

Table 5. Effect of the fermentation time on the color of oat-wheat bread

Time (mins)	L*	b*
60	56.82±0.92^a	17.93±1.20^a
75	56.78±1.11^a	18.49±1.21^b
90	56.87±1.03^a	18.88±1.10^b
105	57.02±1.21^b	20.20±1.15^c

Note: Means with the same letters a, b, and c in the same column are not significantly different at the 5% level.

The results in Table 6 and Figure 3 showed that the fermentation time was longer (from 60 to 90 minutes), the volume of the bread would increase. The fermentation time was longer; the CO2 was produced more, which caused the increase in a specific volume of bread. However, the breads were fermented for 105 minutes; during the baking process, the expansion of the bread would be decreased. The amount of CO_2 was generated too much, leading to an increase in the pressure inside the bread and causing the gluten network to crack. The gas escaped from the bread, causing the reduction of bread expansion.

However, the fermentation time increased causing the hardness and moisture content of breads decreased (Table 6). Gray and Bemiller (2003) reported that the generation of organic acids caused a decrease in the pH value of the dough. The low pH affected the activity of endogenous proteases and bacterial hydrolytic enzymes, as well as the structural components (starch, gluten, and arabinoxylan), led to decreased dough elasticity and the hardness of bread (Thiele et al., 2002; Galle et al., 2011).

Table 6. Effect of the fermentation time on the structure and moisture content of oat-wheat bread

Time (mins)	Hardness (kPa)	Specific volume (cm^3/g)	Moisture content (%)
60	3.38±0.30^c	2.44±0.04^a	38.69±0.90^b
75	3.31±0.43^b	2.48±0.03^c	37.98±0.72^{ab}
90	3.27±0.61^b	2.48±0.03^c	37.54±0.82^{ab}
105	3.18±0.52^a	2.46±0.02^b	36.62±0.54^a

Note: Means with the same letters a, b, and c in the same column are not significantly different at the 5% level.

Figure 3. The degrees of expansion and cross section of oat-wheat bread with different fermentation times

3.2.2. Effect of the fermentation time on the sensory value of oat-wheat bread

The results in Table 7 showed that the bread with a fermentation time of 90 minutes achieved the highest sensory scores of all criteria compared with others. The bread had a smooth surface, soft and spongy crumb, thin and crispy crust, attractive color, and a slight aroma of oats. When the fermentation time increased to 105 minutes, the texture of the bread was less elastic; the surface was not smooth, had the smell of yeast, and obtained lower sensory value. Otherwise, the bread was fermented for a short time (60, 75 minutes), which had a hard

structure, lower expansion, and the lowest sensory value.

Combining the results of physical-chemical properties and the sensory evaluation, the fermentation time of 90 minutes was chosen as an optimum condition for oat-wheat bread processing and used for the subsequent experiments.

Table 7. Effect of the fermentation time on the sensory value of bread products

Time (mins)	Color	Texture	Odor	Taste
60	4.0±0.4^{a}	3.6±0.6^{a}	4.0±0.6^{b}	3.9±0.5^{b}
75	4.3±0.6^{b}	3.7±0.4^{a}	3.9±0.5^{a}	4.0±0.6^{c}
90	4.5±0.5^{c}	4.3±0.4^{b}	4.3±0.6^{c}	4.0±0.4^{c}
105	4.4±0.5^{bc}	3.9±0.8^{ab}	3.8±0.6^{a}	3.5±0.5^{a}

Note: Means with the same letters a, b, c in the same column are not significantly different at the 5% level.

3.3. Effect of baking time and temperature on the quality of oat-wheat bread

The baking process is an important stage in bread production; most of the physicochemical and biochemical phenomena occur. During the baking process, water is released, and the gelatinized starch binds to the free water present in the dough, leading to a porous structure and formation of the crust (Thuy et al., 2013). At the beginning of the baking process, the temperature gradually increases, causing the enzyme system to increase activity. When the temperature reaches 40°C, the CO_2 bubbles will separate to form small air bubbles, these air bubbles will continue to expand to make the bread expand. When the dough temperature is about 50°C, the protein chains on the outside of the dough begin to denature. Protein molecules release the water and bind with other molecules to form a network, as well as create the structure of the bread. As the temperature increases, the structure of the bread loses water, becomes hard, and changes the shape of the bread. At the same time, the breadcrumb also became dryer and more elastic (Man et al., 2011). At a temperature of 140 – 150°C, reducing sugars and amino acids will participate in the Maillard reaction to give the bread a characteristic color and odor (Hoi et al., 2009; Gobbetti & Gänzle, 2013).

3.3.1. Effect of baking time and temperature on the color of oat-wheat bread

The color of the bread has a noticeable change when baking at different temperatures. Table 8 showed that the baking modes had a strong effect on the brightness value (L*) and the intensity of the yellow-brown color (b*) of the oat-wheat bread; there was a statistically significant difference of L* and b* values in the different baking modes.

Table 8. Effect of the baking time and temperature on the color of bread products

Temperature (°C)		Time (mins)		
		10	15	20
L*	200	65.5±0.6^{cC}	60.0±0.6^{cB}	59.6±0.3^{cA}
	210	63.8±0.9^{bC}	58.0±0.3^{bB}	57.8±0.5^{bB}
	220	61.8±0.4^{aC}	55.9±0.6^{aB}	55.2±0.6^{aA}
b*	200	20.1±0.6^{aA}	20.5±0.5^{aA}	22.6±0.8^{aB}
	210	20.2±0.6^{aA}	20.8±0.5^{aA}	22.8±0.4^{aB}
	220	21.0±0.3^{bA}	21.8±0.2^{bAB}	23.2±0.5^{bB}

Note: Means with letters a, b, and c in the same column, or the letters A, B, and C in the same row, are significantly different at the 95% level.

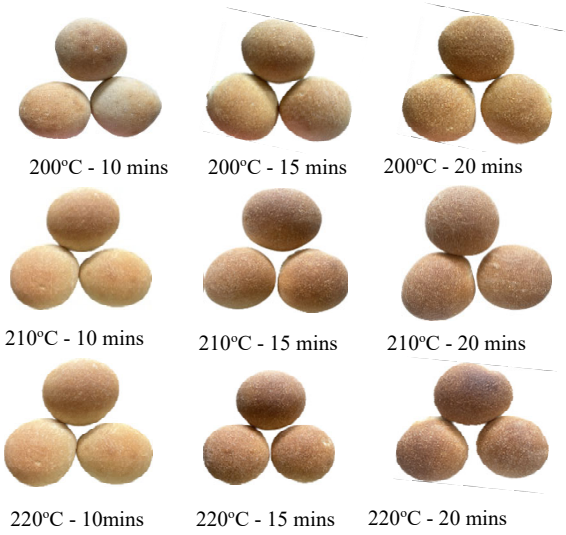

Figure 4. The color of oat-wheat bread at different baking temperatures and times

The baking temperature was inversely proportional to the L* value. The baking temperature increased, leading to the bread becoming darker and turning yellow-brown color, corresponding to the decreasing L* value and increasing b* value. According to Hoi et al. (2009), high temperature promotes Caramel and Maillard reactions that give color to baked goods. In addition, the color intensity of the crust depends on the content of amino acids and reducing sugars in the dough and also depends on baking modes. At a baking temperature of 210°C for 20 minutes, the oat-wheat bread was done, as well as had a uniform and beautiful yellow- brown

color. The products were more attractive than the bread with other baking modes (Figure 4).

3.3.2. Effect of baking time and temperature on the structure of oat-wheat bread

Volume expansion, crust formation, yeast inactivation and enzyme activity, protein coagulation, and starch gelatinization are the most obvious changes observed during the baking process (Chang, 2006). The volume of the finished bread is 10 - 30% larger than the volume of the dough. The volume of the bread depended on the rate of crust formation, as well as depended on the temperature and humidity of the hot air in the baking machine. Prolonged baking time or increased temperature resulted in a statistically significant difference in the specific volume of oat-wheat bread, as indicated by Table 9. When the baking temperature increased from 200°C to 220°C, the specific volume of oat-wheat bread increased, but there was no significant difference between 210ºC and 220°C. It might be because the formation of crust was very fast at a baking temperature of 210°C, leading to the stop of the increasing of specific volume (Zhang & Datta, 2006). Similarly, Nguyen et al. (2022) reported that the expansion of traditional bread (100% wheat flour) increased following the baking temperature from 220ºC to 230ºC, and the expansion of the bread decreased when the baking temperature was raised to 240ºC. At the shortest baking time (10 minutes), the oat-wheat bread had a high moisture content, so the volume of bread did not rise well. When increasing the baking time to 15-20 minutes, the volume of the oat-wheat bread is significantly improved.

Table 9. Effect of the baking time and temperature on the structure and moisture content of oat-wheat bread

Temperature (ºC)		Time (mins)		
		10	15	20
Specific volume (cm^3/g)	200	2.1 ± 0.8^{aA}	2.2 ± 0.6^{aB}	2.4 ± 0.5^{aC}
	210	2.2 ± 0.9^{bA}	2.4 ± 0.5^{bB}	2.5 ± 0.5^{bC}
	220	2.3 ± 0.5^{cA}	2.5 ± 0.7^{bB}	2.5 ± 0.8^{bB}
Hardness (kPa)	200	2.6 ± 0.1^{aA}	$2.7\pm0.1A^{a}$	3.4 ± 0.1^{cB}
	210	3.4 ± 0.1^{bC}	3.2 ± 0.1^{bB}	2.8 ± 0.3^{aA}
	220	2.5 ± 0.1^{aA}	2.8 ± 0.1^{aB}	3.2 ± 0.1^{bC}
Moisture content (%)	200	44.7 ± 0.1^{bB}	39.5 ± 0.1^{bA}	39.1 ± 0.1^{cA}
	210	39.9 ± 0.1^{aB}	39.4 ± 0.1^{bB}	37.3 ± 0.1^{bA}
	220	39.7 ± 0.1^{aC}	38.4 ± 0.2^{aB}	35.7 ± 0.1^{aA}

Note: Means with letters a, b, and c in the same column, or the letters A, B, and C in the same row, are significantly different at the 95% level.

In Table 9, statistical results showed that the baking mode affected the texture and moisture content of bread products. The higher the baking temperature and the longer the baking time, the oat-wheat bread became harder and dryer. At the baking temperature of 200ºC, the oat-wheat bread was soft inside, but cracks appeared on the surface. The structure of oat-wheat bread was not good compared with higher baking temperatures (210ºC and 220ºC). The moisture content of the bread decreased with increasing baking time and temperature. Losing moisture occurred on the surface of bread and depended on the baking mode (Tamaroh & Sudrajat, 2021). The results in Table 9 showed that the oat-wheat bread was baked at 220ºC for 20 minutes, which had the most water loss, leading to the bread structure being very dry and hard. At a temperature of 200ºC for 10-15 minutes, the baking mode was not sufficient enough, leading to the structure of the bread being very soft. At a temperature of 210ºC for 20 minutes, the baking mode was optimum for oat-wheat bread; the bread had good texture, and the moisture content met the technical requirements.

3.3.3. Effect of baking time and temperature on the sensory value of oat-wheat bread

Table 10. Effect of the baking time and temperature on the sensory value of oat-wheat bread

Temperature (ºC)		Time (mins)		
		10	15	20
Color	200	2.1 ± 0.3^{aA}	3.2 ± 0.4^{aB}	4.1 ± 0.5^{bC}
	210	2.9 ± 0.5^{bA}	4.0 ± 0.4^{bB}	4.3 ± 0.6^{cC}
	220	3.1 ± 0.5^{cB}	4.2 ± 0.4^{cC}	1.8 ± 0.6^{aA}
Texture	200	2.1 ± 0.3^{aA}	2.3 ± 0.4^{aB}	3.2 ± 0.4^{aC}
	210	2.2 ± 0.4^{bA}	3.5 ± 0.5^{bB}	4.2 ± 0.6^{bC}
	220	2.2 ± 0.4^{bA}	4.1 ± 0.3^{cC}	3.2 ± 0.4^{aB}
Odor	200	2.8 ± 0.6^{aA}	3.2 ± 0.4^{aB}	3.3 ± 0.4^{bB}
	210	3.1 ± 0.3^{bA}	4.3 ± 0.4^{bB}	4.3 ± 0.4^{cB}
	220	3.4 ± 0.5^{cB}	4.4 ± 0.5^{bC}	2.4 ± 0.7^{aA}
Taste	200	3.8 ± 0.4^{cA}	4.0 ± 0.6^{bB}	4.3 ± 0.4^{bC}
	210	3.5 ± 0.5^{aA}	4.3 ± 0.6^{cB}	4.4 ± 0.5^{bB}
	220	3.6 ± 0.5^{bB}	3.8 ± 0.9^{aC}	2.3 ± 0.4^{aA}

Note: Means with letters a, b, and c in the same column, or the letters A, B, and C in the same row, are significantly different at the 95% level.

According to Hoi et al. (2009), the bread color intensity depends on the temperature of the baking chamber and the baking time. During baking, nearly 70ºC flavored compounds are formed, such as carbonyl group (aldehydes and ketones), complex esters, alcohols, and organic acids. Aldehydes and

ketones cause the bread's aroma, also forming colored substances. Baking mode greatly affects the smell and taste of bread; when baking at high temperatures and for a long time, odor and taste compounds will be formed due to the reaction of Caramel and Maillard reaction, leading to the burning smell of crust.

The results in Table 10 showed a statistically significant difference was found in the color of the oat-wheat breads, which were treated by different baking modes. The baking mode at 200^{o}C for 10-20 minutes had the lowest scores in all of sensory criteria. The crust was soft, and the crumb of the bread had little expansion. The baking mode at 220^{o}C for 10-20 minutes had medium scores in all of the sensory criteria. The crust was brown and very hard, burning smell. The oat-wheat bread was baked at 210^{o}C for 20 minutes, which obtained the highest scores in all of the sensory criteria. In this baking mode, the crust has a nice, uniform yellow-brown color. The results in Table 9 showed that the bread is baked at 210^{o}C for 20 minutes that is a suitable baking mode. The bread has a thin, crispy crust and a smooth surface with a yellow-brown color; the crumb is soft and spongy and has the harmonious taste of oats.

4. CONCLUSION

Oat (*Avena sativa* L.) is an underutilized cereal and is considered as a rich source of protein, minerals, soluble fiber.., especially beta-glucan that is good for the health of consumers. The research aimed to create oat-wheat bread production to provide a new type of healthy bread. The optimum proportion of added oat was 20% providing oat-wheat bread had attractive color, good texture had a characteristic smell and taste of oats. The oat-wheat bread was fermented for 90 minutes and baked at 210oC for 20 minutes, which produced the product with a crispy texture, smooth surface, and yellow-brown color. Individuals who have allergies to gluten or suffer from cholesterol and diabetic conditions will find the oat-wheat bread to be a promising and healthy food option.

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