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Effect of soy flour and flour improvers on nutritional value, texture, colour and sensory characteristics of wafer biscuits

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ABSTRACT

Biscuits are a popular and desirable snack food by consumers. Still, the quality of these products decreases during the storage process, so this study focuses on improving the wafer's quality and nutritional value and reducing their fragility by partially replacing wheat flour with soybean flour in the following proportions: 5% (T1), 10% (T2), 15% (T3), 20% (T4), and adding ammonium carbonate in different quantities .he sensory evaluation results showed that the best wafer treatment was supported with 15% soy flour and 150 g of ammonium carbonate. At the same time, the mean for sensory evaluation is 8.80. Also, the results of the chemical analysis (protein, moisture, fat, carbohydrate, ash, fibre)texture and colour after direct manufacturing and after three months of storage. The result showed a significant increase in the percentage of protein and fat from 6.56±0.30 to 12.19 ± 0.35, 11.56±0.1 to 19.64±0.55, respectively the moisture content was higher in the control was 3.88±0.02 for wafer sample 2.47±0. while fibre was 1.93±0.15, the carbohydrates in the control sample were higher than in other treatments. Texture and colour were improved compared with the control. Conclusions: Commercial-batter biscuits with high nutritional value content and high-quality properties can be prepared by replacing wheat flour with 15% soy flour and adding 150 g of ammonium carbonate.

Keywords: wafer, plant protein, flour, soy flour, wheat

INTRODUCTION

Wafers are snack foods with a sweet taste, crispy texture, and delicate structure that make them acceptable to consumers **[1]**. They are made by mixing wheat flour, fat, sugar, salt, and sodium bicarbonate with water, letting it sit at room temperature for 25 minutes, heating it to 160 and 190 °C, then cooling it **[2]**. Maintaining the appropriate level of crispness of wafer biscuits during the shelf life is one of the challenges faced by wafer biscuit manufacturers **[3]**. The quality of the wafer, its shelf life, its sensory properties (flavour, colour, taste, and texture), and the volume changes that cause the crispiness of the wafer is affected by the properties and qualities. The raw materials used in the manufacture of wafer biscuits **[4]** are represented by the absorption of moisture by the main components used in the manufacture of wafer biscuits, which occurs during the transportation of the product from the factory to the consumer or storage **[5]**. The partial replacement of wheat flour with soy flour and the addition of flour improvers is a method to improve the quality of wafer biscuits, the hydration rate, and the crumb structure **[6]**. It also improves the health benefits as it contains beta-carotene pigment, which acts as an antioxidant **[7]** and improves the nutritional value, as soybeans are a source of high nutritional value protein, fibre, vitamins and minerals **[8]**. Soybeans are rich in polyunsaturated and monounsaturated linoleic and linolenic, essential fatty acids for human health **[9]**. Soybean flour has higher levels of antioxidants than wheat flour, such as ascorbic acid, daidzein, Geniestein, Carnosol, romantic acid, and catechin **[10]**. They contain β-carotene pigment, which increases the batter wafer's ability to absorb water **[11]** improves product elasticity **[12]** and the crust colour of the final product **[13]**, reduces the level of wafer crispness and preserves sensory quality during the shelf life **[14]**

Additionally, roasted soy flour enhances the flavour and texture of the wafer making it softer and low crisper **[15]**. Also, it indicates that adding 7% soybean flour to wafer biscuits improved the colour and reduced viscosity **[16]**.

The researchers noticed a highly significant link between batter viscosity and the water level ($p < 0.05$). Increasing the water level reduces viscosity **[17]**. When the amount of water added to the wafer batter is approximately less than 150% of the flour weight, the completeness of the sheet decreases, resulting in thicker sheets. Using less water (140%) significantly increased the viscosity, causing issues such as problematic batter deposits and incomplete sheets. The addition of gluten when water is less than 150% appears to affect viscosity **[18]**.

The water's temperature and the batter's viscosity affect the sheet's quality. The water temperature should be around 20°C to prevent gluten strand formation. The batter's viscosity in warm conditions drops if the flour has a high α-amylase activity. Using the batter within 10-30 min could minimise the unfavourable effect on viscosity. So, the moisture barrier property of the packaging is designed to protect the contents from potential damage caused by humidity, liquid spills, or other moisture **[19]**.

The importance of research is to overcome the main defect of wafers, which is their high fragility. They are very soft in texture and cannot retain their sensory qualities or the desired level of brittleness during their shelf life. This requires. Find a formula for a wafer biscuit that helps overcome the defects of offers, such as fragility, poor texture, colour, and decreased nutrition value. This requires determining the best percentage of soybean flour and ammonium carbonate to add to the wafer biscuit formulation, besides investigating the effect of adding different ingredients on the sensory, physical, and chemical properties and nutritional values of wafer biscuits.

Scientific Hypothesis

Adding ratios and quantities of soy flour and ammonium carbonate can extend the shelf life of the products and enhance their quality parameters. It can also improve the nutritional value, colour, texture, and sensory properties and reduce the crispness and fragility of the wafer.

MATERIAL AND METHODOLOGY

Wafer ingredients:

Wheat flour were obtained from Gulf Industrial Development, Southern Amman Mills, Jordan. Toasted soy flour and lecithin were purchased from (Sonic Biochem Extraction Pvt Ltd, Madhya Pradesh, India). Sodium chloride and potassium iodate were obtained from Amra Salt Factory, Sahab, Jordan. Non-hydrogenated palm oil was bought from Johor, Malaysia; sodium bicarbonate and AC was bought from China; potato starch was purchased from Nowamyl S.A., Poland; protease and xylanase enzymes were obtained from Orba Biokimya Simbiyotek, Turkey, table 1 shows the weight of the ingredients used in the control treatment.

Table 1 The weight of the ingredients used in the wafer dough preparation as a control treatment.

Ingredient	Ammount
White Flour	60 Kg
Water	0.89L
Salt	100 g
Sodium bicarbonate	200 g
Palm oil	1 L
Lecithin powder	10 g
Lemon salt	10 g
Potato Starch	100g
Yeast extract	50g
Enzyme	30g

Chemicals

Chemical reagents in the experimental design were of analytical grade quality. They were purchased from Sigma-Aldrich, Japan, Leica Biosystem, USA, and Sulfuric acid (brand A, chemically pure, Khimlaborreaktiv LLC, Ukraine). Phenolphthalein solution (NaOH,) (Novokhim), Kharkiv, Ukraine). Sodium hydroxide.

Instruments

Texture analyser (6700 TVT; Perten, Sweden), Kjeldahl (VAP 450; Gergardet, Germany), Gerber (Funke Gerber, Denmark), Oven (TR 240; Nabertherm, Germany), muffle furnace (Nat 30/65; Nabertherm, Germany), and pH meter (S400; Mettler Toledo, Switzerland) spectrophotometer (X-rite VS-450, UK). On Colour software for Colourimeters (CyberSoft, UK) calculated the CIE Lab values viscometer Fungilab Expert (Fungilab Leading Viscosity Techno Lab, Spain). Analyzer (Sartorius MA45, Goettingen, Germany), mixer (YILMAZ REDUKTOR, Turkey).

Laboratory Methods

The test was carried out on wafer biscuits immediately after manufacturing and after three months of storage as Figure 1.

Viscosity Measurement: The viscosity of the batter was measured using the Fungilab Expert viscometer (Fungilab Leading Viscosity Techno Lab, Spain). The viscosity should be 8 CP and not more than 18 CP. It is judged by adjusting the viscosity based on the data from batter mixers and ovens **[20]**.

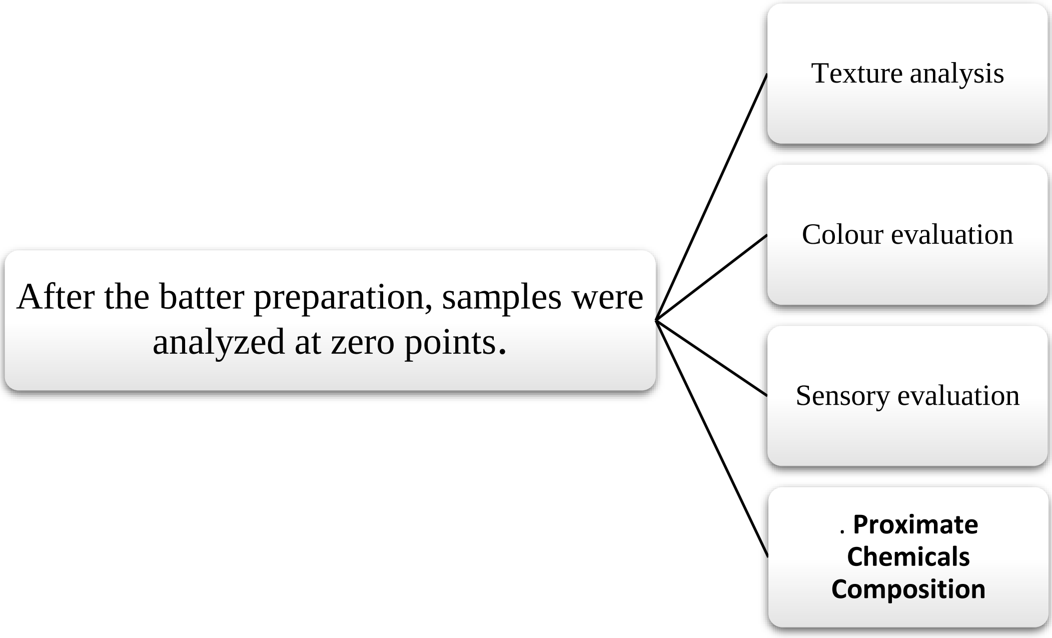

Figure 1 The test was carried out on wafer biscuits.

Chemical Analysis:

The wafer composition of moisture, fat, protein, fibre, and ash was determined by Standard AOAC methods **[21]**. Total carbohydrates were calculated as: 100 − (protein + fat + moisture + ash + fibre).

Sensory Evaluation of Wafer Biscuits:

The sensory properties, appearance, texture, colour, toughness, taste, and overall quality of all the samples of the wafers were evaluated by the 15-member panel of experts according to the hedonic scale (9 points) and rated as follows: 1 point= dislike very much; 9 points = like very much **[22]**.

Texture analysis:

Texture profile analysis (TPA) assesses hardness, a prevalent test that measures several texture attributes simultaneously. The TPA curve (force-time or force-displacement) measures texture parameters. The texture analyser (TVT6700, Perten, Sweden) was equipped with a 15 kg load cell, and a stainless-steel cylinder probe (673040) was used. The probe height and diameter are 45 and 40 mm, respectively **[23]**, **[24]**.

Measurement of the colour of wafer biscuits:

The colour intensity of the top and bottom surfaces of the biscuit colour measuring System (Chroma Meter CR-450, Minolta LTD Japan) was used to calculate the CIE lab system. The colour system, i.e., L*, a with the CIE LAB system, where the results are expressed as follows: (L*) a luminance or lightness component [L = 0 (black), L = 100 (white), (a* values) component for greenness (−a) to redness (+a), and the (b*) component from blueness (−b) to yellowness (+b). A light trap calibrated the colourimeter, and a white colourimeter CR-300 (Ramsey, NJ, USA) was used **[25]**.

Shock test:

The shock Test exposes the wafer to various conditions, such as heat and cold. The sample was exposed to heat in the oven at 40–45 °C for a whole day. On the second day, it was exposed to cooling to 0 °C for a whole day, and the procedure was repeated. Subsequently, the taste, colour, texture, and quality were checked.

The samples that have been shocked tested are kept for some time to check if there is a change in the characteristics and quality of the wafer sheet. The shock test results were assessed by a hedonic scale at point 9 and rated as follows: 1 point= dislike very much; 9 points = like very much **[22]**.

Description of the Experiment

This experiment used a factorial design with three factors: the amount of soy flour, AC, and storage time at the beginning. Through sensory evaluation, the researchers determined the best percentage replacement of white flour with soy flour and the amount of AC added to the batter wafer. After that, the quality of the products was measured.

Sample preparation:

Preparing wafer dough fortified with soybean flour:

The wafer biscuits were produced by weighing all ingredients found in (Table 1) with partial replacement of wheat flour with soy flour 5%, 10%, 15%, 20 %, then mixing all ingredients using a blender for two minutes) (dough temperature 18 – 20 °C, humidity 17%), then left at room temperature for 25 minutes.

Preparing wafer dough According to the following transactions:

- T1: In the control treatment, 3 kg of Soybean flour (which represents 5% of wheat flour) and 57 kg of wheat flour were used.
- T2: 6 kg of Soybean flour (10% of wheat flour) and 54 kg of wheat flour (90% of wheat flour in the control).
- T3: 9 kg of Soybean flour represents 15% of wheat flour and 51 kg of wheat flour (85% of wheat flour in the control).
- T4: 12 kg of Soybean flour represents 20% of wheat flour, and 48 kg of wheat flour represents 80% of wheat flour in control.

Preparing wafer dough fortified with ammonium carbonate (AC):

Weighing every compound in Table 1 with an addition of 50, 100,150, and 200 g of ammonium carbonate (AC) and the mixture for two minutes at a temperature of approximately 18 – 20 °C and a humidity of approximately 17%. Then, let it sit at room temperature for 25 minutes.

Prepared the following treatment:

- T5: It consists of formula treatment T3, adding 50g of (AC) Instead of sodium carbonate.
- T6: It consists of formula treatment T3 with the addition of 100g of (AC) Instead of sodium carbonate
- T7: It consists of formula treatment T3 with 150g of (AC)Instead of sodium carbonate.
- T8: It consists of formula treatment T 3 with 200g of (AC)Instead of sodium carbonate.

Treatment is chosen according to sensory evaluation:

- T9: It consists of formula T3 with the addition of 150g ammonium carbonate Instead of sodium carbonate.
- T10: It consists of formula treatment T0 with adding 150gm AC (without soy flour)
- T11: It consists of formula treatment T7 without AC
- T0: Control treatment:

The manufacture of wafer biscuits is as follows:

Wafer dough was put in the flat wafer baking system's oven. The oven was adjusted to 119/220°C, and the wafer batters were baked for 2 minutes until done. Then, they were removed.

The wafer sheets from the baking machine were cooled to room temperature (25 °C). The cream is then put inside the crispy wafer and put in the cooler (10° C).

Number of samples analysed: 72 samples.

Number of repeated analyses: All measurements of instrument readings were performed three times.

Number of experiment replications: The number of repetitions of each experiment to determine one value was three.

Statistical Analysis

1. First, data analysis was done with SPSS version 28.
2. Data were analysed using IBM software, and a p-value of less than 0.05 was considered statistically significant.
3. The mean and standard deviation were used to express the scale data.
4. The ideal percentage to add soy flour and AC was examined using a one-way ANOVA.
5. Repeated action to analyse the chemical compositions of different flours used in wafer batters was examined by MANOVA.

RESULTS AND DISCUSSION

The result of the sensory evaluation shows (Table 2) that the best amount of soy flour that was added instead of wheat flour to the same ingredients used in treatment T0 (control) is 9 kg of soy flour (representing 15% of wheat flour)It received the highest sensory rating which was 8.80 ± 0.41 While replacing wheat flour in percentage (5.0 % or 20.0%) with soy flour, it got the lowest averages of 4.33 ± 0.97 and 4. ±0.51, respectively researcher that when adding a percentage higher than 15% or less than this, it was less accepted by the panellist.

Table 2 shows the sensory evaluation results for the control sample and wafer biscuits prepared by partially replacing wheat flour with soy soybean flour and adding ammonium carbonate.

The wafer was prepared by Replacing wheat flour with a different % of soy flour	Mean score	Control-Mean score	The wafer was prepared by Replacing wheat flour with a different % of soy flour and adding ammonium carbonate	Mean score
The wafer was prepared by replacing wheat flour with 5 % of soy flour.	4.33 +0.97	8.87±0.35a	The wafer was manufactured by replacing 15 % wheat flour with of soy flour and adding 50 g ammonium carbonate	4.20+0.41
The wafer was prepared by replacing wheat flour with 10 % of soy flour	7.27 ±0.94	8.87±0.35a	The wafer was manufactured by replacing 15 % wheat flour with soy flour and adding 100 g ammonium carbonate	7.20 0.33
The wafer was prepared by replacing wheat flour with 15 % of soy flour	8.80± 0.41	8.87±0.35a	The wafer was manufactured by replacing 15 % wheat flour with soy flour and adding 150 g of ammonium carbonate	8.93± 0.26
The wafer was prepared by replacing wheat flour with 20 % of soy flour	4.40± 0.51	8.87±0.35a	The wafer was manufactured by replacing 15 % wheat flour with soy flour and adding 200 g ammonium carbonate	4,20+0.46

Note: Different superscript letters indicate significant differences ($p \leq 0.05$) in the same row; all, values are expressed as the mean ±SD (standard deviation).

The fortified wafer biscuits with ammonium carbonate (AC)

Ammonium carbonate (AC) is a common leavening agent in the biscuit and crackers industry. AC improves the texture and volume of wafers **[23]**. The sensory evaluation of wafer biscuits fortified with four amounts of ammonium carbonate is 50.0g, 100.0g, -150g, and 200.0g, as explained (Table 2). The results showed that the Wafers from a formula fortified with more or less 150 g of ammonium carbonate obtained a lower acceptability rating than wafer biscuits fortified with 150 gm of ammonium carbonate.

This result may be due to ammonium, which reduces colour contrast and enhances wafer bulk and texture **[26]**. If used at the correct rate, a percentage would be less than 01% of the mixture weight **[27]**. Ammonium also improves texture, and this is due to the decomposition of AC at low temperatures **[28]**, the generation of carbon dioxide, and the lower pH value **[29]**.

Effect of partial replacement wheat flour with soy flour on sensory acceptance of wafer biscuits:

Table 3 shows the results of the sensory evaluation of wafer biscuits prepared by Partial replacement for wheat flour with soy soybean flour and the addition of ammonium carbonate

The results showed no significant differences between the treatments T9 and the control sample after manufacturing immediately ($p > 0.05$). The mean score was 8.87±0.35 and 8.17±0.35, respectively. The researchers noted from Table 3 that the sensory evaluation score of the control sample decreased as storage continued. After the first month, it decreased to 6.33±0.95 and 4.67±0.62 after the third month of storage, the lowest degree of sensory evaluation.

These results mean that the problem of fragility can be overcome by fortifying the dough of Wafer biscuits with specific proportions of soy flour and AC.

Table 3 Sensory evaluation of wafer biscuits prepared with partial replacement of wheat flour with soy soybean flour and ammonium carbonate.

Time	T9	T0	Sample number
zero time	8.87±0.35a	8.17±0.35a	3
1month	8.73±0.59a	6.33±0.95b	3
2months	8.80±0.56a	6.73±0.96b	3
3months	8.53±1.03a	4.67±0.62b	3

Note: Different superscript letters indicate significant differences ($p \leq 0.05$) in the same row; all values are expressed as the mean ±SD (standard deviation).

The chemical composition of the wafer biscuit prepared of partial replacement of wheat flour with soy soybean flour and ammonium carbonate

The raw materials, such as the type of flour and its content of gluten, carbohydrates, fibre, and (fermentation time), had an impact on the viscosity of the batter, which affected its properties and nutritional value of the final product **[4]**. Table 4 shows the chemical composition of the wafer biscuits manufactured by replacing wheat flour with 15% soy flour, with A C or without AC, and the control sample. (T9, T10, T0)The researchers noted from Table 4 that the fortified wafer with soy flour had lower moisture content than the control sample, where the moisture content was 3.88±0.02 for the control sample and 2 .47±0.13 for the fortified wafer; this can be attributed to the increase in the proportion of soy flour that is added to the sample reduces the moisture content in the supplemented biscuit **[30]** because soybean flour contains β-carotene pigment which increases the ability of the wafer ' to absorb water and retention of moisture in the crumb of the baked products **[31]**. Also, soy flour contains a greater amount of total dry solid with high emulsifying properties compared to wheat flour and has low moisture. This is in agreement with the findings of **[32]** that an increase in the proportion of soy flour reduces the moisture content of biscuits. Meanwhile, **[33]** published that the non-enzymatic browning rate increases when water activity is high in food. This is considered one of the major problems that occurs during the processing and storage of dehydrated and semi-moist foods. This reaction leads to a darkening of colour and protein insolubility when reducing sugars, proteins, or free amines. This finding does not agree with the finding **[34]** that recommended moisture levels should be between 6% and 11% for obtaining an acceptable crispy wafer. This range does not apply to wafers, according to **[35]**, as for the protein and fat content. There was a significant increase in the percentage of protein t in-fortified wafers with soy flour, which increased from 6.56±0.30 to 12.47±0.29 to T9; the baked products that are wheat-based have content low in the quantity and quality of proteins, and it's deficient in some essential amino acids. Therefore, fortifying wheat-based baked products with protein-rich materials such as soybeans could be the approach to overcoming malnutrition. **[36]** while fat increased from 12.47±0.47 to 20.26±0.29. This is due to soy flour containing more protein and fat than wheat flour. Our results agree with those who reported that soy flour contains 20–24% fat, while wheat flour contains 0.9–1.1%, most of which is unsaturated **[37]**. Also, as for the ash, the results revealed no statistically significant differences between the samples of soy flour and AC or with soy flour without AC and the control sample at zero time and after three months of production ($p < 0.001$), which expresses the amount of mineral salts in food. But the values of carbohydrate content (65.17±0.59a, 64.25±0.55a, 77.78±0.62b) in the fortified samples were lower than that in control, at zero time and after three months of production ($p < 0.001$). As for the fibre content in fortified wafer biscuits with soy flour (with or without AC) and control were 1.93±0.15, 1.70±0.0, and 2.06±0.15 and these results indicate that there were no statistically significant differences between the samples of their fibre content, respectively, at zero time and after three months of production.

It has been reported that a high dietary fibre intake helps to prevent and reduce the risk of several diseases, including diabetes, obesity, cardiovascular diseases, and hypertension **[38]**. Also, soy flour contains more fat than wheat flour **[39]**. These results are in agreement with **[38]**. Soybeans are rich in polyunsaturated and monounsaturated fatty acids, including linoleic and Linolenic, which are essential for human health **[39]**.

Table 4 Chemical composition for standard formulations of wafer.

The chemical composition of various flours used in wafer batters	Times of measurement	T9	T10	T0 Control
Fat (M±SD)	Time 0	19.75±0.06a	20.26±0.29a	12.47±0.29b
Fat (M±SD)	after 3 month	19.75±0.06a	20.26±0.29a	12.47±0.29b
Carbohydrates (M±SD)	Time 0	64.25±0.55a	65.17±0.59a	75.78±0.62b
	After 3months	65.09±0.44a	65.10±0.55a	75.79±0.32b
Fiber (M±SD)	Time 0	1.93±0.15a	1.70±0.0a	2.06±0.15b
	After 3months	2.10±0.26a	2.070±0.0a	1.90±0.10b
Protein	Time 0	11.77±0.77a	12.19±0.35a	6.56±0.30b
	After 3months	11.77±0.10a	12.28±0.22a	6.95±0.37b
Ash (M±SD)	Time 0	1.56±0.05a	1.47±0.06a	1.29±0.03b
	After 3months	1.48±0.08a	1.40±0.05a	1.28±0.04b
Moisture (M±SD)	Time 0	2.47±0.13ab	2.40±0.10a	3.88±0.02b
	After 3months	2.53±0.10ab	2.41±0.04a	3.95±0.09b

Note: Different superscript letters indicate significant differences ($p \leq 0.05$) in the same row; all values are expressed as the mean ±SD (standard deviation).

The effect of partial replacement wheat flour with soy flour on texture wafer biscuits

The results in Table 5 showed that the wafer biscuits made with partial replacement of wheat flour with soy flour had a hardness value of 3138.0, higher than the control wafer's 2556.4. Perhaps the increased hardness is due to the increased protein content in soybean flour. This result agrees with other studies that reported increased protein content causes higher hardness **[40]**. Some studies report that higher fibre content is generally linked to an increase in the wafer's hardness **[41]**. Moisture level affects the texture of the wafers by softening the starch and protein matrix, which alters the strength of the wafer sheets **[42]**. The raw materials, such as the type of flour and its content of gluten, carbohydrates, fibre, and time after mixing (fermentation time), had an impact on the viscosity of the batter **[43]**, which affects texture, properties, and nutritional value. of the final product **[44]**. Low starch levels cause low gelatinisation, which might increase the hardness of wafer biscuits **[45]**. The hardness level of the samples during the storage period decreased, especially the control sample.

Table 5 Investigating the effect of adding different ingredients on the texture of the wafer batters.

times	wafer		
	T9 Texture hardness g	Texture hardness g	T0 Texture hardness g
zero time (M±SD)	3138.0a	2878.37	2556.43a
One month(M±SD)	2878.03	2735.6	1438.82
Two months (M±SD)	3075.07	2805.18	15789.2
Three months(M±SD)	3413.9	3162.1	2096.93
Test values	F=2.544, p=0.252	F= 1.61. P= 0,612	F=1.030, p=0.417

Note: All values are expressed as the mean ±SD (standard deviation
T9"Wafer with 15% soy flour plus ammonium carbonate Force (g)(Hardness)
T10 Wafer with 15% soy flour Force (g)(Hardness

The effect of soy flour and flour improvers on the colour of wafer biscuits

Colour is one of the most important components of food quality, indicating a product's quality. Colour measured based on CIE L*, a*, b* colour. L scale: Light vs dark where a low number (0 – 50) indicates dark and a light number (51 – 100) b* yellowness index scale: Yellow vs blue where a positive number indicates yellow and a negative number indicates blue **[46]**. The results of the data analysis show (Table 6) that there are no significant differences between all treatments immediately after manufacturing and after three months of storage; this means that the addition of soy flour did not affect colour (L* brightness) colour and the readings ranged between 70.93±64 to 74.02±0.02, greater than 50, an indicator of light a* redness index). For commercial batter wafer colour evaluation at different points in time, the samples remained unchanged after 3 months of storage.

The results of data analysis show that (a* redness index) for AC + soy four was 3.29±0.29 and commercial batter control was 3.91±0.36, which is the lowest compared with AC + wheat flour was 5.77±0.24, which is the highest at zero time. All numbers are positive. The data analysis results show no significant differences between all treatments immediately after manufacturing and after 3 months of storage. In contrast, a higher b* value led to a higher yellow-ness.

Variations in the batter formulations cause differences in the wafer sheet's colour, which is affected by moisture content, the amount of reducing carbohydrates, and free amino acids) and baking conditions (time and temperature) **[47]**.

Table 6 The effect of storage duration on the colour of wafer biscuits.

storage duration	**Treatments**			
	T 10	**T9**	**T11**	**Control**
		(L* brightness)		
Time zero (M±SD)	72.51±0.85a	74.02±0.02a	72.24±1.75a	74.69±1.71 a
First month(M±SD)	73.73±1.45a	73.34±0.31a	71.34±0.36a	72.77±1.37 a
Two months (M±SD)	73.47±0.47a	72.33±0.29a	74.45±0.33a	75.45±0.40 a
Three months(M±SD)	71.70±0.61a	70.93±64a	73.19±0.74a	74.69±1.71a
		a* redness index)		
Time zero (M±SD)	5.77±0.24a	3.29±0.29b	4.47±0.48 c	3.91±0.36 d b c
First month(M±SD)	4.80±0.90 a	2.53±0.29 b	3.09±0.13 c b	3.36±0.47 d b c
Two months (M±SD)	5.61±0.47 a	2.78±0.20 b	2.43±0.09 c b	5.35±0.49 a
Three months(M±SD)	5.12±0.12 a	2.59±0.26 b	4.13±0.24 c	3.99±0.42 d c
		b* yellowness		
Time zero (M±SD)	27.47±0.56a	26.66±0.81a	27.63±0.19a	28.07±1.71a
First month(M±SD)	26.68±0.33a	25.08±0.39 a b	26.41±0.44a	27.58±1.0 a c
Two months (M±SD)	28.89±0.79a	25.90±0.23b c	24.31±0.31c	31.72±1.18d
Three months(M±SD)	31.33±0.80a	22.56±0.44b	27.63±0.32c	28.07±1.61d

Note: difference letters indicate significant differences ($p \leq 0.05$) in the same row; all values are expressed as the mean ±SD (standard deviation).

Shock Test:

The wafer was repeatedly exposed to various conditions (heat and cold) to check for a change in the characteristics of the wafer, and the panellist rated their sensory score. The results in Figure 2 have revealed that at time zero (production time), there were no statistically significant differences in the sensory mean scores between the four groups ($p > 0.05$ for all). In contrast, after four days of wafers' batter processing of the shock test, results exhibited that T9, T10, and T11 significantly had a higher mean sensory score than the control group ($p = 0.005$, respectively). The AC with soy flour had a higher mean sensory score than the control group ($p \leq 0.001$. No statistically significant mean differences were noted between the three manipulated groups ($p > 0.05$ for all Samples).

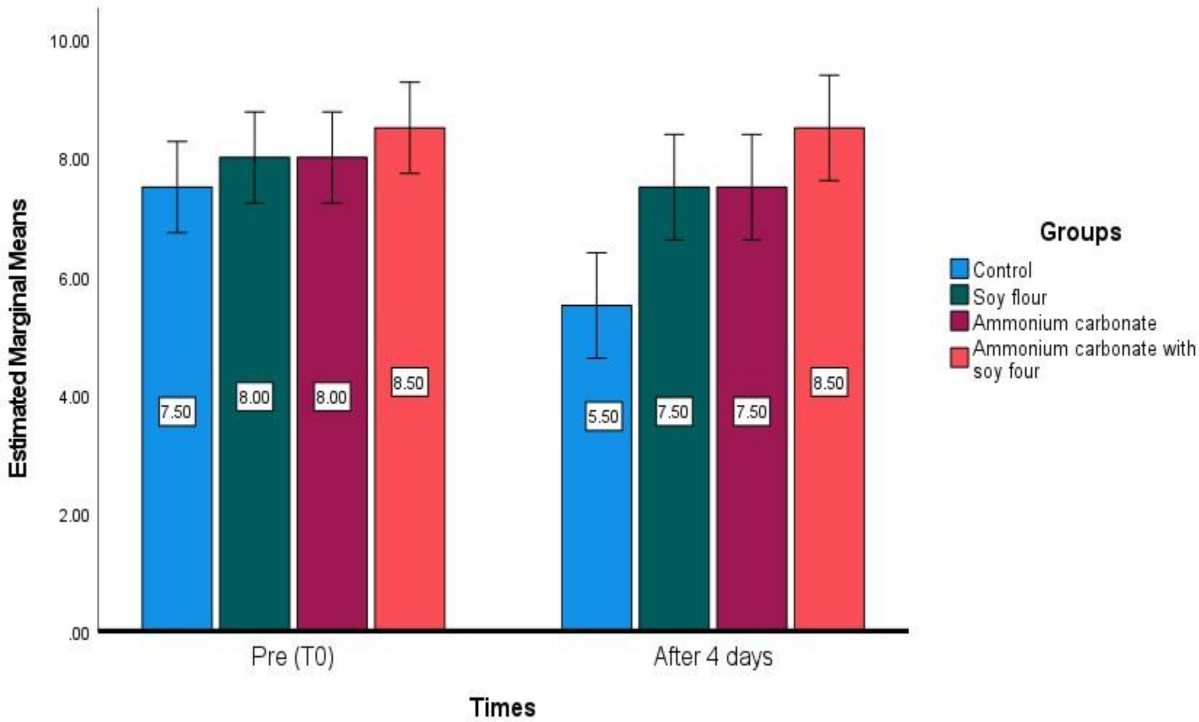

Figure 2 Shock test sensory evaluation after exposure to various conditions (heat and cold).

Figure 3 Produced wafer biscuit without soybean flour and ammonium carbonate.

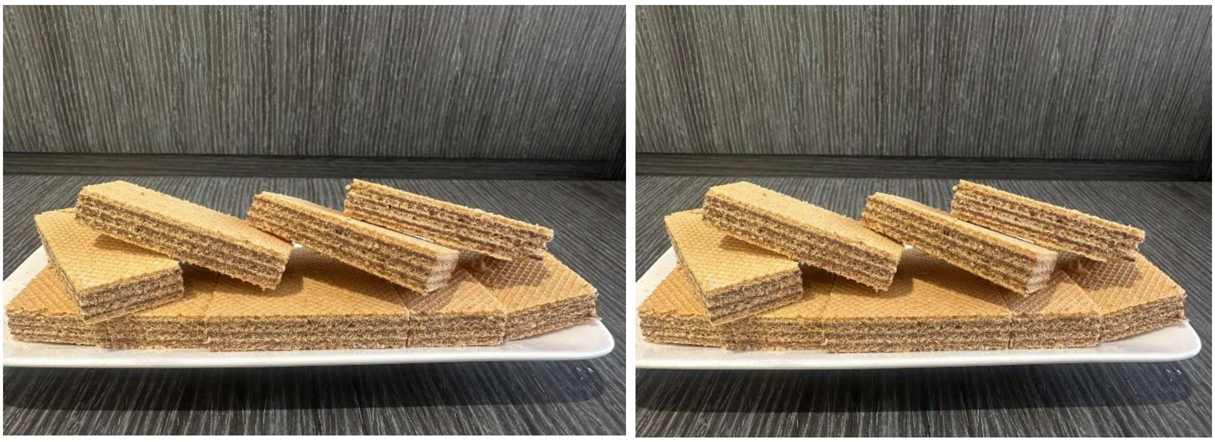

Figure 4 Produced wafer biscuit with say bean flour and ammonium carbonate.

CONCLUSION

The sensory evaluation showed that the wafer biscuit was manufactured by replacing 15% wheat flour with soy flour (9 kg soy flour and 51 kg wheat flour.). With the addition of 150 g, the highest sensory evaluation scores.was 8.80 ± 0.41. The results show that adding ratios and quantities specific to soy flour and ammonium carbonate can extend the product's shelf life and enhance its quality parameters. It can also improve the nutritional value, colour, texture, and sensory properties and reduce the crispness and fragility of the wafer. It was also noted that the wafer was made with partial replacement of wheat flour with soy flour and was characterised by increased hardness compared to the control group. Meanwhile, the control wheat flour had the lowest value of 2556.43. It has been noted that adding 15% soy flour to the biscuits caused an increase in the nutritional compositions (proteins, ash, and fibre content). The result showed a significant increase in the percentage of protein and fat from 6.56±0.30 to 12.19± 0.35 and from 11.56±0.l to 19.64±0.55, respectively. Moisture content was higher in the control group. The carbohydrates in the control sample were higher than those in other treatments. Texture and colour were improved compared with the control. Wafer biscuits with high nutritional value content and high-quality properties can be prepared by replacing wheat flour with 15% soy flour and adding 150 g of ammonium carbonate.

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