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Research Article

Quality Characteristics of Pan bread Fortified by *Moringa Oleifera* Powder of Leaves and Seeds

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Abstract

The present study was aimed to produce an acceptable pan bread using moringa (*Moringa Oleifera)* leaves and seeds powder (MLP, MSP) and mix of both (MLP + MSP) with replacing of levels (2.5, 5.0 and 7.5%), (5.0, 10.0 and 15.0%) and (2.5 + 2.5, 2.5 + 5.0 and 5.0 + 5.0 %), respectively from the wheat flour (72%). The effects of these replacement levels on the chemical composition, rheological prop-erties of dough, physical, staling and sensory characteristics of pan bread were studied. The obtained results indicated that MLP con-tained higher amounts of protein, crude fibers, ash, minerals and dietary fibers, while MSP was characterized by higher lipids, dietary fibers, protein and minerals contents. Also, M LP and MSP were found to possess higher amounts of amino acids. The results also showed an increase in all nutrients in the produced pan bread, including protein, lipids, dietary fibers, ash, amino acids and minerals contents. While carbohydrates content decreased compared with control sample. Rheological properties showed that increasing the substitution ratio of MLP, MSP and a mix of MLP + MSP increased the farinograph water absorption and degree of softening. Mean-while, dough stability, resistance to extension and dough energy gradually decreased. As physical properties, MLP, MSP and a mix of (MLP + MSP) supplementation also caused a gradual increase in weight of bread loaf. While pan bread loaf and specific volume were gradually decreased by increasing amount of substitution in compared to control sample. The staling rate results showed gradual increments in the freshness of all processed pan bread up to 4 days of storage compared to the control sample. In conclusion, it could be producing pan bread with acceptable quality using MLP, MSP and mix of (MLP + MSP) with ratios of (5.0%) MLP, (10.0%) MSP and (2.5 + 5.0%) mix of (MLP + MSP) to take advantage of the active compounds found in both of them and enhance health benefits.

Keywords: Pan bread; Moringa leaves powder; Moringa seeds powder; Chemical and Physical properties; Rheological properties; Bakery products quality

Introduction

A large number of people suffer from poverty and poor health due to inadequate food supply. This leads to a higher index of mal-nutrition and consequent diseases. Therefore, the cultivation of medicinal plants, which have greatest potential for benefitting hu-man's health and availability to a wide extent of population will help to overcome the malnutrition problem [22].

Moringa Oleifera is well known as 'the miracle tree' for its nu-tritional benefits that reflect the presence of vitamin C seven times more than in oranges, vitamin A ten times more than carrots, sev-enteen times more calcium than milk, nine times more protein than yoghurt, twenty-five times more iron than spinach and fifteen times more potassium than bananas [19]. Its also characterized by its abundance of bioactive compounds represented in all parts of the plant, including phenolics, carotenoids, phytosterols, terpenoids, tocopherols, flavonoids and alkaloids that contribute to its wide range of functional properties as an antioxidant, anti-inflammatory, antimicrobial and antidiabetic agent [10]. Moringa leaves powder is supposed to be a good source of nutrition, which containing 143 bioactive compounds, involving β-carotene, flavonoids (myrecytin, quercetin and kaempferol), saponins, phenolics, tannins, vitamins (A, B and C), calcium, iron, potassium, magnesium and a balance of all essential amino acids [6,15]. Moringa leaves can be cooked and eaten like spinach. Moreover, the dried powder from the leaves is added to soups and sprinkled over other food to increase their nutritional value. It is used as a dietary supplement or mixed with cold or hot drinks like in tea [3]. Moringa seeds powder contains a full punch of fatty acids, phenolics (especially gallic acid), fibers, vitamins, flavonoids, glycosides, proteins, minerals and amino acids [13,24]. Moringa seeds can be boiled like peas, fried and eaten like peanuts or the oil can be refined and consumed as edible oil [29]. It is not only rich in nutritional content but also has some medicinal properties. It is important to treat various diseases such as cardiovascular disease, Crohn's disease, anemia, arthritis, gout, allergies, cramps, epilepsy and sexually transmitted diseases [2].

Bakery products are important sources of nutrients, such as energy, protein, iron, calcium and several vitamins. Most bakery products can be fortified to meet the needs of the object groups and vulnerable parts of the population who are undernourished. Bread is a common example of a bakery product that is a high-energy food rich in carbohydrates and fat; therefore, bread can easily qualify as a functional food [35]. [26] indicated that substituting wheat flour with 10% MSP in pan bread increased the protein, iron, and calcium content, while decreasing the loaf volume and specific loaf volume without changing the sensory properties. Also, [14] reported that it was possible to produce acceptable pan bread with 10% MLP, which increased the protein, ash, Mg, Ca and Fe content. As for the rheological properties of dough, the results revealed that an increased amount of MLP, decreased the extensiblity, water absorption, dough stability, dough development time and dough energy.

So, the aim of the current study was to measure the effects of moringa leaves and seeds powder on the rheological, physical-chemical and sensory properties of pan bread.

Materials and Methods

Materials

Moringa (*Moringa Oleifera)* leaves powder (MLP) and moringa seeds were obtained from National Research Centre (NRC), Dokki, Giza, Egypt.

Strong wheat flour (72% extraction rate), instant active dry yeast, shortening, sugar, skin milk powder, salt and corn oil materials were obtained from local market (Fathalla Hypermarket), El-Mansoura city, El-Dakahlia Governorate, Egypt.

All chemicals used in this study for analysis were of analytical grade and were obtained from Al Gomhouria Company, El-Mansoura city, El-Dakahlia Governorate, Egypt.

Methods

Technical methods

Preparation of moringa seeds powder

Matured moringa seeds were manually removed from the seed kernels and dried using an air circulation dryer (GARBUIO - Treviso) at 50°C for 19 hr at the Food Industries Department, Faculty of Agriculture, Mansoura University. The dried seeds were ground using a clean Marlex blender. The moringa seeds powder was sieved using a sieve of 50 mesh size to obtain a fine powder and stored in polyethylene bags until use, as mentioned by [7].

Preparation of flour blends

Different flour blends were prepared by partially substituting wheat flour (72% ext.) with moringa leaves and seeds powder and a mix of (MLP + MSP) according to the ratios as follows

Treatments	Substitution levels %	Wheat flour (72% ext.) %
Control sample	0	100
MLP	2.5	97.5
	5.0	95
	7.5	92.5
MSP	5.0	95
	10.0	90
	15.0	85
Mixed of MLP + MSP	(2.5 + 2.5)	95
	(2.5 + 5.0)	92.5
	(5.0 + 5.0)	90

Table 1: Formulation of pan bread supplemented with MLP, MSP and mix of (MLP + MSP).

MLP: *Moringa Oleifera* leaves powder; MSP: *Moringa Oleifera* seeds powder

Preparation of Pan bread

Pan bread samples were prepared from flour blends, as mentioned in Table (1) beside the control sample, according to [1] with slight modifications at Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt. The pan bread formula was 100 g wheat flour, 4 g Fat, 4 g sugar, 1.5 g salt, 2 g active dry yeast and 2 g skim milk powder were weighed accurately. Pan bread making involved mixing all the ingredients with water, which was added according to the farinograph water absorption. The resulted dough were let to rest for 20 min at 30 ± 2°C (first proofing), and then the dough was divided into three pieces, 500 g for each piece, hand loaded, and placed into metal pans for final proofing at 30 ± 2°C and 80-85% relative humidity in a fermentation cabinet for 60 min. Then, dough was baked in an electrically heated oven (with steam added during baking) at 210- 220°C for 15- 20 min. After baking, the obtained loaves were cooled at room temperature and packed in airtight polythene bags until use.

Analytical methods

Chemical analysis

Moisture, ash, crude fibers, lipids and nitrogen contents were determined according to the method described in [4].

Total carbohydrates were calculated by difference from the sum of the protein, fat, ash and crude fibers content.

Amino acids were determined according to [4] using the amino acid analyzer Eppendorf LC3000, Germany. EZ Chrom at Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt. While amino acid scores were calculated according to FAO/ WHO Ref.

Mineral samples were prepared according to [9]. The total quantities of iron, zinc, magnesium, sodium, calcium and potassium were determined by atomic absorption spectrophotometry using Sens AA ″GBC scientific equipment″ model ″Sens AA Dual″ made in Dandenong, Victoria, Australia. Whereas phosphorus was determined by spectrophotometer according to the method of [5] at the Micro-Analysis unit, Faculty of Science, Mansoura University, El-Dakahlia Governorate, Egypt.

Total dietary fibers were measured according to [4]. Soluble and insoluble dietary fibers were determined according to [27] at the Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt.

Rheological Characteristic

Farinograph test

Farinograph instrument (Brabender Duis Bur G, type 810105001 No. 941026 made in West Germany) according to [1] at the Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt.

Extensograph test

The extensograph test was carried out according to the method described in the [1] using the Extensograph (Barabender Duis Bur G type 860001 No. 946003 made in West Germany) at the Food Tech. Res. Institute, Agric. Res. Center, El- Giza, Egypt.

Physical properties

The weights of pan bread loaves were determined after cooling for one hour. Bread loaf volume was measured by the rape seeds displacement method at Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt. Specific volume of bread was calculated by dividing the volume of the loaves (cm^3) by their weights (g) [1].

Determination of pan bread staling

The staling rates of the pan bread samples were determined by the alkaline water retention capacity method described by [21] at the Food Tech. Res. Institute, Agric. Res. Center, El-Giza, Egypt.

Sensory evaluation

Pan bread was left to cool at room temperature for an hour after baking, then cut with a sharp knife and subjected to seven panelists from the Food Science Dept., Faculty of Agric., Mansoura University. Organoleptic evaluation of crust color, crumb color, texture, taste, flavor, general appearance and overall acceptability was determined by the method as described by [16].

Statistical analysis

The obtained data were statistically analyzed using the producer of the SAS software system program [31]. Analysis of variance was conducted using General Liner Model (GLM) procedure [32]. Means were separated using Duncan's test at a degree of significance ($P \leq 0.05$).

Results and Discussion

Proximate chemical composition of raw materials

Proximate chemical compositions of wheat flour (72% ext.), *Moringa Oleifera* leaves powder (MLP) and *Moringa Oleifera* seeds powder (MSP) are presented in Table (2). The obtained results detected that, MSP had the highest crude protein and lipids followed by MLP than wheat flour (72% ext.). Meanwhile, the highest values of ash and crude fibers were recorded for MLP(6.52%) and (17.86%), respectively followed by MSP(4.97%) and (5.26%), respectively. These results are in agreement with those of [18], who found that MSP contains higher percentage of lipids content than MLP.

Also, results presented in the above mentioned Table, it could be observed that, MLP and MSP have higher contents of K, Ca compared with those of wheat flour. Also, MLP and MSP contain higher amounts of micro-elements (Fe and Zn) than wheat flour, which in MLP were (28.76 and 1.98 mg/100g), while in MSP were (13.73 and 2.62 mg/100g), respectively. These results are in accordance with those obtained by [20], they mentioned that the minerals contents of MLP were 1652.18, 464.10, 712.99 and 20.65 (mg/100g) for K, Mg, P and Fe, respectively.

Concerning the dietary fibers content presented in the same Table (2), the highest values of total, soluble and insoluble dietary fibers were recorded for MLP (39.48, 5.92 and 33.56 g/ 100 g dry weight basis) and MSP (24.35, 7.88 and 16.47 g/ 100 g dry weight basis), respectively. Alternatively, wheat flour (72% ext.) showed the lowest dietary fibers content (4.52g/ 100 g dry weight basis). These results are in accordance with those obtained by [23], who found that the total dietary fibers, soluble dietary fibers and insoluble dietary fibers of MLP were (39.9, 5.0 and 34.9 g/100 g), respectively.

Amino acids composition of raw materials

Amino acid contents of raw materials are presented in Table (3), the amounts of total essential amino acids of MLP and MSP were relatively high, which were recorded (48.54 and 34.96 g / 100 g protein), respectively compared to wheat flour (72% ext.) (34.28g / 100 g protein). Also, MLP and MSP had higher contents of leucine, isoleucine and lysine than those in wheat flour (72% ext.). Also, valine, threonine and phenylalanine were also higher in MLP compared to the others raw materials. On the other hand, the amount of total non-essential amino acids of MSP was higher than those of MLP and wheat flour. Also, glutamic acid, proline and arginine were higher in MSP compared to wheat flour (72% ext.). Similarly, the highest percentage of total amino acids content for MSP and MLP being (98.08 and 95.27 g/100g protein), respectively as

	Wheat flour (72% extraction)	MLP	MSP
Chemical composition (%)			
Moisture	12.60	7.86	4.30
Crude protein	12.25	27.60	31.90
Lipids	0.70	2.58	28.69
Ash	0.63	6.52	4.97
Crude fibers	0.64	17.86	5.26
Total carbohydrates	85.78	45.44	29.18
Minerals content (mg/100g dry weight basis)			
Potassium(K)	153.65	1341.29	3831.37
Calcium (Ca)	11.15	809.32	164.17
Magnesium (Mg)	35.2	146.96	561.57
Sodium (Na)	42.15	271.89	594.25
Phosphorus (P)	98.24	208.27	428.65
Iron (Fe)	0.95	28.76	13.73
Zinc (Zn)	0.48	1.98	2.62
Dietary fibers (g/100g dry weight basis)			
Total dietary fibers (TDF)	4.52	39.48	24.35
Soluble dietary fibers (SDF)	1.57	5.92	7.88
Insoluble dietary fibers (IDF)	2.95	33.56	16.47

Table 2: Proximate chemical composition of raw materials.

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

compared to wheat flour (91.27 g/100g protein). These results are in agreement with [30] they found that MLP has a well-balanced nutritional profile of essential amino acids, specifically; MLP is rich in lysine, which is considered the first limiting essential amino acid in cereals.

Chemical composition of pan bread samples

The proximate chemical composition of pan bread samples produced by using 100% wheat flour (72% ext.) as a control sample and the other pan bread samples are presented in Table (4). Data indicated that, pan bread prepared from wheat flour substituted by increasing levels of MLP, MSP and mix of (MLP + MSP) resulted in parallel increases of moisture and crude protein in all produced pan bread, which reached (36.75 and 15.67 %) for 7.5 % MLP, (37.05and 17.28 %) for 15 % MSP and (38.42 and 16.21 %) for 5.0 + 5.0 mix of (MLP + MSP), respectively compared with the control sample (31.42 and 14.70 %), respectively. This behavior is due to the fact that MLP and MSP are rich in fibers content, which increases their water absorption and water-holding capacity (Table 2).

Also, lipids, ash and crude fibers contents were increased, which amounted (2.79, 2.26 and 2.63 %) for 7.5 % MLP, (6.85, 2.47 and 2.03 %) for 15 % MSP and (4.18, 2.33 and 2.69%) for 5.0 + 5.0% mix of (MLP + MSP), respectively compared with control sample (2.65, 1.82 and 1.34 %), respectively. This increase may be ascribed to the higher protein, lipid, ash, and crude fiber contents in both MLP and MSP (Table 2). In contrast, total carbohydrates decreased progressively when the MLP, MSP and MLP + MSP ratios increased in all pan bread samples. These results are in accordance with those observed by [14] they found that substitution of pan bread flour by 5.0 % MLP increased the protein and ash content recorded 17.72 and 3.52 %, respectively while carbohydrates content decreased.

Amino acids	Wheat flour (72% extraction)	MLP	MSP
Essential amino acids			
Leucine	6.69	18.90	15.20
Isoleucine	3.35	10.50	8.90
Lysine	2.04	12.80	4.60
Methionine	1.55	5.50	0.77
Cystine	2.04	4.30	1.47
Phenylalanine	5.22	14.50	1.16
Tyrosine	4.41	9.10	0.52
Therionine	2.53	10.00	0.70
Histadine	2.45	5.70	0.66
Valine	4.00	14.30	0.98
Total essential amino acids	34.28	48.54	34.96
Non- essential amino acids			
Alanine	3.02	1.61	1.18
Aspartic acid	4.08	2.38	1.09
Glutamic acid	28.33	26.50	38.90
Glycine	3.51	1.09	1.29
Proline	10.29	12.70	15.70
Serine	4.00	0.96	0.83
Arginine	3.76	1.49	4.13
Total non-essential amino acids	56.99	46.73	63.12
Total amino acids	91.27	95.27	98.08

Table 3: Amino acids composition of different raw materials (g/100g protein).

MLP: *Moringa Oleifera* leaves powder; MSP: *Moringa Oleifera* seeds powder

Minerals play a crucial role in maintaining a healthy life, serving important functions such as maintaining water balance, promoting bone health, preventing fatigue and heart function, as well as for oxygen transport in the body [34]. As shown in Table (4), the minerals content gradually increased in all pan bread samples with increasing levels of substitution with MLP where K, Mg, P and Zn reached to (202.37, 76.38, 72.23 and 0.45 mg/100g) for 7.5% MLP, respectively in compared with control sample (110.02, 70.68, 61.20 and 0.32 mg/100g), respectively. Also, the partial substitution of wheat flour with MSP increased the minerals content. While K content for 15.0 % MSP was increased by 6 folds (668.23 mg/100g) compared to the control sample (110.02 mg/100g). Whereas, Ca, Mg, P, Fe and Zn contents for 15.0 % MSP were increased two folds as compared to control sample. [26, 7] they found that the partial replacement of pan bread flour with 5% MSP resulted in an increase the minerals content such as Ca, K and Zn, which was recorded (27.17, 272 and 0.33 mg/100g), respectively.

In the meantime, the increasing of substitution levels with MLP + MSP was accompanied by a gradual increase in minerals content (K, Ca, Mg, Na, P, Fe and Zn) for all pan bread samples, which reached to (357.65, 65.84, 99.04, 316.57, 86.93, 3.74 and 0.51 mg/100g), for 5.0 + 5.0 % mix of (MLP + MSP) respectively as compared to control sample. However, the pan bread sample with 15% MSP recorded the highest values of minerals content (K, Mg, Na, P and Zn) as compared to the control sample and all the other pan bread samples.

Also, results given in the above mentioned Table (4), it could be indicated that, the dietary fibers content of all pan bread samples increased with increasing in the substitution levels of MLP, MSP and a mix of (MLP + MSP) which reached to (8.64, 3.28 and 5.36 g/100g) at 7.5 % of MLP, (8.87, 3.32 and 5.55 g/100g) at 15 % of MSP and (8.72, 3.28 and 5.44 g/100g) at 5.0 + 5.0 % mix of (MLP + MSP) on dry weight basis , respectively in compared with the control sample (6.14, 2.43 and 3.71 g/100g on a dry weight basis), for total, soluble and insoluble fibers respectively. This increase might be attributed to the higher fibers content in both MLP and MSP (Table, 2), which can improve the dietary fibers content in wheat bread. These results are in agreement with the findings of a previous study [28], who reported that MLP is a good source of dietary fibers.

Chemical composition	Pan bread samples									
	Substitution levels %									
	Control sample	MLP %			MSP %			Mix of (MLP + MSP) %		
	100 %	2.5	5.0	7.5	5.0	10.0	15.0	2.5 + 2.5	2.5 + 5.0	5.0 + 5.0
Chemical composition (%)										
Moisture	31.42	33.35	35.22	36.75	34.59	36.12	37.05	32.84	36.35	38.42
Crude protein	14.70	15.02	15.34	15.67	15.56	16.42	17.28	15.45	15.88	16.21
Lipids	2.65	2.70	2.74	2.79	4.06	5.45	6.85	3.40	4.10	4.18
Ash	1.82	1.97	2.12	2.26	2.04	2.25	2.47	2.08	2.19	2.33
Crude fibers	1.34	1.77	2.20	2.63	1.57	1.80	2.03	1.95	2.00	2.69
Total carbohydrates	79.49	78.54	77.60	76.65	76.77	74.08	71.37	77.12	75.83	74.59
Minerals content (mg/100g dry weight basis)										
Potassium(K)	110.02	140.80	171.58	202.37	296.09	482.16	668.23	233.65	326.87	357.65
Calcium (Ca)	21.69	42.38	60.72	78.25	28.81	35.94	42.62	44.97	48.51	65.84
Magnesium (Mg)	70.68	72.55	74.49	76.38	95.23	117.69	143.26	81.36	94.58	99.04
Sodium (Na)	293.88	293.30	292.78	292.23	308.92	323.46	337.89	300.74	307.18	316.57
Phosphorus (P)	61.20	64.86	68.54	72.23	79.57	98.45	116.31	74.06	83.25	86.93
Iron (Fe)	1.79	2.46	3.15	3.82	2.39	2.94	3.58	2.76	3.07	3.74
Zinc (Zn)	0.32	0.36	0.40	0.45	0.43	0.55	0.67	0.42	0.48	0.51
Dietary fibers (g/100g dry weight basis)										
Total dietary fibers (TDF)	6.14	6.97	7.81	8.64	7.05	7.96	8.87	7.43	7.88	8.72
Soluble dietary fibers (SDF)	2.43	2.72	3.00	3.28	2.73	3.06	3.32	2.89	3.12	3.28
Insoluble dietary fibers (IDF)	3.71	4.25	4.81	5.36	4.32	4.90	5.55	4.54	4.76	5.44

Table 4: Proximate chemical composition of pan bread samples (on dry weight basis).

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

Amino acids composition of pan bread samples

Amino acids are essential nutrients required for life. They serve as the fundamental building blocks of proteins and play a crucial role in transporting nutrients, building and repairing muscles and biosynthesis. Additionally, they are important for ensuring food quality [11]. Amino acids content of pan bread samples is presented in Table (5), the total amino acids content was gradually increased by increasing levels of substitution of MSP and mix of (MLP + MSP), while the addition of MLP recorded a slight decrease in pan bread samples compared with the control sample.

Among all the essential amino acids contents, leucine, isoleucine and lysine were found to be of the highest values by increasing the substitution levels up to 7.5 % MLP, 15 % MSP and 5.0 + 5.0 % mix of (MLP + MSP) in pan bread samples recorded (7.72, 3.94 and 2.72 g/100g protein), (8.06, 4.23 and 3.54 g/100g protein) and (7.83, 4.03 and 2.58g/100g protein), respectively compared with control sample (6.80, 3.40 and 1.90 g/100g protein), for the same amino acids respectively.

On the other hand, the amounts of non-essential amino acids analyzed, the proline acid recorded slight differences by increasing of substitution levels up to 7.5 % MLP, 15.0 %MSP and 5.0 + 5.0 % mix of (MLP + MSP) in pan bread samples compared with control sample. Also, glutamic acid content noted simple differences between control sample being (29.70 g/100g protein) and by increasing of substitution levels up to 15.0 %MSP and 5.0 + 5.0 % mix of (MLP + MSP) in pan bread samples being (30.75 and 30.12 g/100g protein), respectively.

The increase in amino acid content of the produced pan bread samples was significant due to the higher amino acid content in moringa leaves and seed powder (Table 3).

Finally, it may be concluded that the addition of moringa leaves and seeds powder to pan bread flour improves its nutritional value as amino acids content of wheat bread. These results are accordance with [17,20] they found that moringa leaves and seeds

Amino Acids	Pan bread samples									
	Substitution levels %									
	Control sample	MLP %			MSP %			Mix of (MLP+MSP) %		
	100 %	2.5	5.0	7.5	5.0	10.0	15.0	2.5+2.5	2.5+5.0	5.0+5.0
A) Essential amino acids										
Leucine	6.80	7.10	7.41	7.72	7.22	7.64	8.06	7.31	7.52	7.83
Isoleucine	3.40	3.58	3.76	3.94	3.68	3.95	4.23	3.72	3.85	4.03
Lysine	1.90	2.17	2.45	2.72	2.44	3.00	3.54	2.24	2.31	2.58
Methionine	2.00	1.98	1.97	1.95	1.98	1.88	1.86	1.97	1.86	1.87
Cystine	2.80	2.74	2.68	2.62	2.73	2.67	2.60	2.71	2.67	2.62
Phenylalanine	5.0	4.91	4.82	4.73	4.81	4.62	4.43	4.82	4.71	4.63
Tyrosine	3.40	3.34	3.28	3.21	3.26	3.11	2.97	3.27	3.19	3.13
Therionine	3.00	2.95	2.90	2.85	2.89	2.77	2.66	2.89	2.84	2.79
Histadine	2.20	2.16	2.12	2.08	2.12	2.05	1.97	2.12	2.08	2.04
Valine	5.40	5.30	5.21	5.10	5.18	4.96	4.74	5.19	5.08	4.98
Total essential amino acids	35.90	36.23	36.60	36.92	36.31	36.65	37.06	36.24	36.11	36.50
B) Non-essential amino acids										
Alanine	3.90	3.84	3.79	3.73	3.76	3.63	3.49	3.78	3.71	3.65
Aspartic acid	4.60	4.55	4.49	4.26	4.43	4.25	4.07	4.46	4.26	4.31
Glutamic acid	29.70	29.62	29.54	29.46	30.16	30.49	30.75	29.85	30.08	30.12
Glycine	3.80	3.73	3.67	3.60	3.68	3.55	3.42	3.67	3.61	3.54
Proline	11.10	11.14	11.18	11.22	11.34	12.08	12.79	11.26	11.37	12.41
Serine	4.70	4.61	4.50	4.42	4.51	4.29	4.12	4.50	4.43	4.32
Arginine	4.00	3.94	3.88	3.81	4.00	4.01	4.02	3.94	3.95	3.88
Total non-essential amino acids	61.80	61.43	61.05	60.50	61.88	62.30	62.66	61.46	61.41	62.23
Total amino acids	97.70	97.66	97.65	97.42	98.19	98.95	99.72	97.70	97.52	98.73

Table 5: Amino acids composition of pan bread samples (g/100g protein).

powder had a well-balanced complement of essential and non-essential amino acids, which were rich in lysine, isoleucine, leucine, valine, proline and glutamic acid.

Farinograph parameters for dough samples of pan bread:

Table (6) presented farinograph parameters of wheat flour and flour blends with MLP or MSP. The water absorption was gradually increased as the level of substitution with MLP, MSP and the mix of (MLP + MSP) increased, which reached to (66.4, 65.5 and 67.2 %) for substitution level of 7.5 % MLP, 15.0 % MSP and (5.0 + 5.0%) mix of (MLP + MSP), respectively in compared to (60.8%) for the control dough. This increment in dough water absorption is probably due to the higher protein and fiber contents of MLP, and MSP than wheat flour as reported by [33] they stated the addition of fiber sources to wheat flour caused an increase in water absorption of the produced dough.

Also, from the same Table (6), it could be revealed that the arrival time and dough development time were gradually increased with the increasing of replacement levels with MLP, MSP and a mix of (MLP + MSP) in compared to the control sample (100% wheat flour).

Dough stability time were decreased from (11.0 min) for control sample to (3.5, 4.5 and 5.5 min) for wheat flour replaced by 7.5% MLP, (5.0 + 5.0%) mix of (MLP + MSP) and 15.0 % MSP, respectively. The decrement in stability time indicates the weakness of dough strength due to using MLP, MSP, and a mix of (MLP + MSP), which reduced the wheat gluten content (dilution effect) in the blends. These results are approximately similar to those of [12], they reported that the dough development time increased with increasing substitution levels of moringa leaves powder to wheat flour, while the dough stability time decreased compared to the control sample.

Concerning the degree of softening, the samples that exhibited a decrease in dough stability showed an increase in softening values. So, the degree of softening values was gradually increased with increasing replacement levels of MLP, MSP and the mix of (MLP + MSP).

Dough blends			*Water absorption (%)	Arrival time (min)	Development time (min)	Dough stability (min)	Degree of softening (BU)
Control sample			60.8	1.5	2.5	11.0	40
Substitution levels %	MLP %	2.5	64.7	2.0	3.0	10.5	50
		5.0	65.2	2.5	4.5	7.0	100
		7.5	66.4	3.5	4.5	3.5	140
	MSP %	5.0	63.8	2.0	2.5	8.0	90
		10.0	64.6	2.5	3.5	6.0	110
		15.0	65.5	2.5	4.0	5.5	120
	Mix of (MLP + MSP) %	2.5 + 2.5	63.4	2.0	3.0	7.5	100
		2.5 + 5.0	65.9	2.5	3.5	6.5	120
		5.0 + 5.0	67.2	3.0	4.5	4.5	130

Table 6: Farinograph parameters for dough samples of pan bread.

*Expressed on 14% moisture basis. BU = Brabender unit.

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

Extensograph parameters for dough samples of pan bread

Data presented in Table (7) show the effect of substitution of wheat flour with MLP, MSP and a mix of (MLP + MSP) on extensibility, resistance to extension, proportional number and energy of dough. Furthermore, values presented in the same table indicated that the values of resistance to extension were decreased as a result of increased substitution levels with MLP, MSP and mix of (MLP + MSP) from (740 BU) for control sample to (260, 350 and 310 BU) in blends 7.5 % MLP, 15.0% MSP and (5.0 + 5.0%) mix of (MLP + MSP), respectively. This may be attributed to the dilution of wheat gluten as a result of the addition.

From the obtained data (Table, 7), it could be showed that the extensibility of the dough were decreased as a result of increased substitution levels of wheat flour with MLP, MSP and mix of (MLP + MSP), it recorded (100, 85and 80 mm) in blends 7.5 % MLP, 15.0% MSP and (5.0 + 5.0%) mix of (MLP + MSP), respectively, in compared with 175 mm for wheat flour dough of the control sample.

Concerning to proportional number, it was detected that when adding MLP and mix of (MLP + MSP) caused a gradual decrease in the proportional number, being (2.60) in blend 7.5 % MLP and (3.88) in blend (5.0 + 5.0%) mix of (MLP + MSP) while, addition of MSP recorded a slight decreased, being (4.11) in blend 15.0% MSP in compared with control sample (4.23). For energy, the control sample achieved the highest value being 168 cm^2, whereas the other blended samples had lower energy values. Result were recorded (46, 54 and 50 cm^2) for wheat flour replaced with 7.5 % MLP, 15.0% MSP and (5.0 + 5.0%) mix of (MLP + MSP), respectively. These results are in approximately similar with [14], who found a gradual decrease in maximum resistance to extension with the substitution of wheat flour dough with MLP. Also, [20] reported that the energy and proportional number decreased with increasing substitution levels of MLP. Also, the maximum resistance to extension, extensibility and energy decreased with the addition of MSP, while the proportional number recorded different values.

Dough blends			Maximum resistance to extension "R" (BU)	Extensibility "E" (mm)	Proportional number (R/E)	Energy (Cm^2)
Control sample			740	175	4.23	168
Substitution levels %	MLP %	2.5	700	170	4.12	155
		5.0	450	135	3.33	78
		7.5	260	100	2.60	46
	MSP %	5.0	640	125	5.12	135
		10.0	480	102	4.71	92
		15.0	350	85	4.11	54
	Mix of (MLP + MSP) %	2.5 + 2.5	610	120	5.08	123
		2.5 + 5.0	520	115	4.52	98
		5.0 + 5.0	310	80	3.88	50

Table 7: Extensograph parameters for dough samples of pan bread.

BU= Brabender unit. mm= Millimeter. R/E= resistance/ Extensibility.

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

Physical measurements of pan bread samples

Results presented in Table (8) and illustrated in Figure (1) showed that, the partial substitution of wheat flour (72% ext.) with MLP, MSP, and a mix of (MLP + MSP) increased the weight of bread loaves gradually in parallel with increasing the level of substitution. The increase in bread weight when fiber was added may be because of the high water-holding capacity of fibers [25].

Pan bread samples			Physical measurements		
			Loaf Weight (g)	Loaf Volume (Cm^3)	Specific volume (Cm^3/g)
Control sample			582.70^{c}	1663.65^{a}	2.86^{a}
Substitution levels %	MLP %	2.5	588.50b^{c}	1582.40^{ab}	2.69^{ab}
		5.0	594.10^{b}	1387.15^{b}	2.34^{b}
		7.5	594.20^{b}	1155.00^{d}	1.94^{c}
	MSP %	5.0	592.20b^{c}	1579.85^{ab}	2.67^{ab}
		10.0	596.80^{ab}	1463.56^{b}	2.45^{b}
		15.0	599.60ab	1304.35^{c}	2.18^{bc}
	Mix of (MLP + MSP)%	2.5 + 2.5	586.30b^{c}	1498.45^{b}	2.56^{ab}
		2.5 + 5.0	597.50^{ab}	1367.32^{bc}	2.29^{b}
		5.0 + 5.0	617.40^{a}	1258.57^{c}	2.04^{bc}

Table 8: Physical measurements of pan bread samples.

Means followed by different letters in the same column are significantly different by Duncan's multiple test ($p < 0.05$).

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

On the other side, this replacement caused a gradual decrease in bread volume and specific volume with increasing level of substitution compared to the control sample. The reason for this result is due to the amount of the fibers which are found in higher concentrations in the moringa leaves and seeds powder. These results are in agreement with those of [8], they found that the addition of MLP to pan bread samples decreased the loaf volume and specific loaf volume.

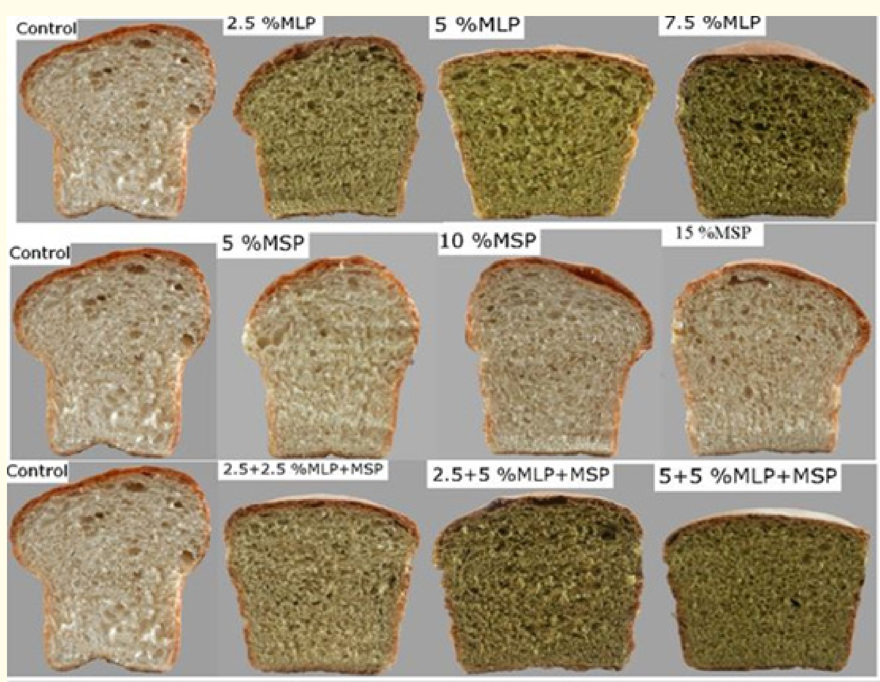

Figure 1: Physical measurements of pan bread samples prepared by partial replacement of wheat flour by MLP, MSP and mixed of (MLP + MSP).

Staling rate of pan bread samples

The staling rate of pan bread produced by using 100% wheat flour (72% ext.) as control or substituted with MLP, MSP and a mix of (MLP + MSP) stored for 72 hours at room temperature (25 ± 2°C) are presented in Figure (2). The data showed that, the freshness of all pan bread samples produced gradually increased during the storage period. Furthermore, the results show that the ability to retain alkaline water gradually decreased in all bread samples during the storage period as the degree of substitution increased. This observation is probably due to the gradual increase in moisture content of the pan bread samples, which makes the bread more tender, improves the freshness of the pan bread and causes higher alkaline water retention capacity values, as previously reported by [14].

Figure 2: Staling rate of pan bread samples as measured by alkaline water retention capacity.

Sensory evaluation of fresh pan bread samples

Sensory evaluation is considered a critical indicator of potential consumer preferences. Despite its limitations, it remains the most important quality indicator. From date data presented in Table (9), it could be observed that, there were significant differences between the control sample and the pan bread samples prepared from (2.5, 5.0 and 7.5 %) of MLP across all sensory attributes. A significant decrease ($p<0.05$) in crust and crumb color scores could be attributed to the green color of the pan bread imparted by the chlorophyll content of MLP which negatively affects consumer perception. The reduction in flavor scores for the MLP-enriched pan bread samples could be ascribed to the herbal flavor of MLP. Overall acceptability of the pan bread samples decreased as the level of MLP supplementation increased. However, acceptable quality was maintained with MLP incorporation up to 5.0 % in pan bread samples. These findings are consistent with those reported by [8], who found that substitution of MLP in bread samples caused a relatively greenish and darker crust and crumb.

Concerning to the substitution of wheat flour by MSP in pan bread samples, no significant differences were observed in crumb color, taste, flavor and overall acceptability between the control sample and pan bread samples (5.0 and 10.0%) of MSP, while significant differences were recorded for 15.0% MSP which was bitter and unacceptable. There were no significant differences in texture and general appearance between the control sample and pan bread samples with (5.0, 10.0 and 15.0%) MSP. This may be attributed to the higher lipids content of MSP (Table, 2), which improve color and increases food palatability. On the other hand, there were no significant differences between the control sample and pan bread samples with 10.0% MSP for crust color, but there was a significant difference for pan bread with (5.0 and 15.0%) MSP. Acceptable quality could be obtained by incorporating MSP up to 10.0% in pan bread samples. [7], reported that the addition of MSP to pan bread improved its palatability due to the higher lipids content of MSP.

Furthermore, substitution of wheat flour by a mix of (MLP + MSP) produced pan bread with no significant differences in texture, flavor, general appearance and overall acceptability for (2.5 + 2.5 %) mix of (MLP + MSP). Also, there were no significant differences in taste for (2.5 + 2.5 and 2.5 + 5.0%) mix of (MLP + MSP). This may be due to higher lipids content of MSP (Table, 2), which enhances the food palatability. However, a significant difference in taste was observed for (5.0 + 5.0%) mix of (MLP + MSP). On the other hand, significant differences were detected between the control sample and pan bread with (2.5 + 2.5, 2.5 + 5.0 and 5.0 + 5.0%) mix of (MLP + MSP) for crust and crumb color. This change may be due to the green color of the pan bread resulting from the addition of MLP. Acceptable quality can be achieved by incorporating a mix of (MLP + MSP) up to 2.5 + 5.0% in pan bread samples.

Pan bread Samples			Crust color (10)	Crumb color (10)	Texture (20)	Taste (20)	Flavour (20)	General appearance (20)	Overall acceptability (100)
Control sample			9.57 ± 0.53[a]	9.57 ± 0.53[a]	19.14 ± 0.69[a]	19.00 ± 1.00[a]	19.14 ± 0.90[a]	18.86 ± 1.21[a]	95.29 ± 2.81[a]
Substitution levels %	MLP %	2.5	8.00 ± 1.00[b]	8.29 ± 0.49[b]	16.14 ± 3.02[b]	15.43 ± 2.76[b]	16.00 ± 2.94[b]	16.29 ± 1.25[b]	80.14 ± 8.49[b]
		5.0	6.57 ± 1.27[c]	6.57 ± 0.98[c]	15.71 ± 1.50[b]	14.43 ± 2.30[b]	14.43 ± 2.76[b]	14.57 ± 1.90[b]	72.29 ± 8.44[c]
		7.5	4.57 ± 1.51[d]	4.57 ± 1.90[d]	12.57 ± 2.57[c]	11.29 ± 2.14[c]	11.29 ± 3.15[c]	11.71 ± 2.50[c]	56.00 ± 11.15[d]
	MSP %	5.0	8.86 ± 0.38[b]	9.29 ± 0.49[ab]	19.00 ± 1.15[a]	18.43 ± 1.72[a]	18.29 ± 1.25[a]	18.29 ± 0.76[a]	92.14 ± 4.49[a]
		10.0	9.57 ± 0.53[a]	9.43 ± 0.79[ab]	19.00 ± 1.00[a]	17.29 ± 2.69[ab]	17.43 ± 2.57[a]	18.57 ± 1.40[a]	91.29 ± 7.52[a]
		15.0	8.86 ± 0.69[b]	8.86 ± 1.07[b]	18.43 ± 1.27[a]	15.43 ± 3.78[b]	13.86 ± 4.38[b]	18.14 ± 1.95[a]	83.57 ± 11.76[b]
	Mix of (MLP + MSP)%	2.5 + 2.5	8.14 ± 0.38[b]	8.43 ± 0.53[b]	17.57 ± 0.79[ab]	17.71 ± 0.76[a]	17.71 ± 0.76[ab]	17.86 ± 0.38[ab]	87.43 ± 1.81[ab]
		2.5 + 5.0	7.86 ± 1.07[b]	8.14 ± 1.35[b]	17.43 ± 1.40[b]	17.71 ± 1.38[a]	17.43 ± 1.13[b]	17.00 ± 1.41[b]	85.57 ± 6.50[b]
		5.0 + 5.0	5.86 ± 1.07[c]	5.57 ± 1.72[c]	15.14 ± 2.73[c]	14.14 ± 3.44[b]	13.29 ± 3.64[c]	14.00 ± 4.00[c]	75.14 ± 14.38[c]

Table 9: Sensory characteristics of pan bread samples.

Means followed by different letters in the same column are significantly different by Duncan's multiple test ($p < 0.05$).

MLP: *Moringa Oleifera* leaves powder. MSP: *Moringa Oleifera* seeds powder.

Conclusion

Moringa Olifera play a critical role in fortifying a series of food products such as bread, cookies, cakes, meat, biscuits, yoghurt and beverages by augmenting their nutritional quality, bioactive compounds content and shelf life, thus satisfying the nutritional needs of consumers. Importantly, no toxicological effects have been reported from the consumption of these products, which are therefore considered safe and hypoallergenic. The results of the present study concluded that *Moringa Oleifera* leaves and seeds powder could be used in the production of pan bread as a rich source of nutritional values because of its diversity of nutrients (dietary fibers, minerals (Fe, Ca, K and Zn), protein, fat and essential and non-essential amino acids) in pan bread production, have health-promoting effects and strengthen immune functions to fight infectious diseases. Generally, it could be said that the substitution level up to 5.0 % for MLP, 10.0 % for MSP and 2.5 + 5.0 % for a mix of (MLP + MSP) from the wheat flour could produce pan bread without remarkable effect on its physical, staling and sensory properties.

Bibliography

1. AACC. "American Association of Cereal Chemists. Approved Methods of the A.A.C.C. Published by the American Association of Cereal Chemists, 10th Edition., St. Paul, MN. USA (2010).

2. Abe A., *et al.* "Alleviating the physical discomfort in healthy individuals with Moringa seed extract: a randomized, double-blind, placebo-controlled, parallel-group trial". *Functional Foods in Health and Disease* 13.10 (2023): 459-475.

3. Adebayo FO and Abdus-Salaam RB. "Comparative assessment of dried moringa leaves of Nigerian ecotype". *African Journal of Food, Agriculture, Nutrition and Development* 22.6 (2022): 20721-20736.

4. AOAC. "Official Methods of Analysis, 17th Ed., Association of Official Analytical Chemists International. Gaithersburg, Maryland, USA (2010).

5. Astm S. "Annual book of American society of testing materials standard water". Part 31 Dsis-72-Philadelphia, PA (1975).

6. Azra WNF., *et al.* "Extraction of Bioactive Compounds in Moringa Leaves (*Moringa Oleifera* Lam.) using Modified Sonication Technique". *BIO Web of Conferences* 12.3 (2024): 1-8.

7. Bolarinwa IF., *et al.* "Nutritive value and acceptability of bread fortified with moringa seed powder". *Journal of the Saudi Society of Agricultural Sciences* 18.2 (2017): 195-200.

8. Bourekoua H., *et al.* "Evaluation of physical, sensorial, and antioxidant properties of gluten-free bread enriched with *Moringa Oleifera* leaf powder". *European Food Research and Technology* 244.2 (2018): 189-195.

9. Chapman HD and Pratt PF. "Methods of analysis for soils, plants and waters". Univ. California, Div. Agric. Sci., Priced publication (1978): 4034.

10. Chiş A., *et al.* "Bioactive compounds in Moringa oleifera: mechanisms of action, focus on their anti-inflammatory properties". *Plants* 13.1 (2023): 20-29.

11. Church DD., *et al.* "Essential amino acids and protein synthesis: insights into maximizing the muscle and whole-body response to feeding". *Nutrients* 12.12 (2020): 3717.

12. Dachana KB., *et al.* "Effect of dried moringa (*Moringa Oleifera* lam) leaves on rheological, microstructural, nutritional, textural and organoleptic characteristics of cookies". *Journal of Food Quality* 33.5 (2010): 660-677.

13. Dzuvor CK., *et al.* "Bioactive components from *Moringa Oleifera* seeds: production, functionalities and applications–a critical review". *Critical Reviews in Biotechnology* 42.2 (2022): 271-293.

14. El-Gammal RE., *et al.* "Effect of moringa leaves powder (*Moringa Oleifera*) on some chemical and physical properties of pan bread". *Journal of Food and Dairy Sciences* 7.7 (2016): 307-314.

15. Fejér J., *et al.* "First report on evaluation of basic nutritional and antioxidant properties of *Moringa Oleifera* Lam. from Caribbean Island of Saint Lucia". *Plants* 8.12 (2019): 537-346.

16. Gelinas P and Lachance O. "Development of fermented dairy ingredients as flavor enhancers for bread". *Cereal Chemistry* 72.1 (1995): 17-21.

17. Ijarotimi OS. "Macronutrient composition, amino acid profiles and acceptability of maize-based complementary foods enriched with defatted white melon seed and *Moringa Oleifera* leaf powder". *Croatian Journal of Food Science and Technology* 14.1 (2022): 63-73.

18. Ilyas M., *et al.* "Antioxidant potential and nutritional comparison of Moringa leaf and seed powders and their tea infusions". *Journal of Animal and Plant Sciences* 25.1 (2015): 226-233.

19. Islam Z., *et al.* "*Moringa Oleifera* is a prominent source of nutrients with potential health benefits". *International Journal of Food Science* 2021.1 (2021): 6627265.

20. Khalaf AR., *et al.* "Evaluation of wheat flour blended with different ratios of *Moringa Oleifera* leaves and seeds". *Arab Universities Journal of Agricultural Sciences* 26.2 (2018): 1895-1906.

21. Kitterman S and Rubanthaler GL. "Assessing the quality of orally generation wheat selection with the micro AWRC test". *Cereal Science Today* 16.2 (1971): 313-320.

22. Mahaveerchand H and Abdul Salam AA. "Environmental, industrial, and health benefits of *Moringa Oleifera"*. *Phytochemistry Reviews* 23.5 (2024): 1497-1556.

23. Mallillin AC., *et al.* "Mineral availability and dietary fiber characteristics of *Moringa Oleifera"*. *Food Public Health* 4.5 (2014): 242-246.

24. Nour AAM., *et al.* "Changes in protein nutritional quality as affected by processing of millet supplemented with Moringa seed flour". *Journal of the Saudi Society of Agricultural Sciences* 17.3 (2018): 275-281.

25. Nudel A., *et al.* "Developing a nutrient-rich and functional wheat bread by incorporating *Moringa Oleifera* leaf powder and gluten". *LWT* 187.2 (2023): 115343- 115350.

26. Ogunsina BS., *et al.* "Quality characteristics of bread and cookies enriched with debittered *Moringa Oleifera* seed flour". *International Journal of Food Sciences and Nutrition* 62.2 (2011): 185-194.

27. Prosky L., *et al.* "Determination of insoluble, soluble, and total dietary fiber in foods and food products: inter laboratory study". *Journal of the Association of the Official Analytical Chemists* 71.5 (1988): 1017-1023.

28. Rajput H., *et al.* "Chemical and Phytochemical Properties of Fresh and Dried *Moringa Oleifera* (PKM-1) Leaf Powder". *Chemical Science Review and Letters* 6.22 (2017): 1004-1009.

29. Saa RW., *et al.* "Treatments and uses of *Moringa Oleifera* seeds in human nutrition: A review". *Food Science and Nutrition* 7.6 (2019): 1911-1919.

30. Salama MA., *et al.* "Biological, physiochemical and sensory evaluation of hard biscuit enriched with a powder of moringa leaves (*Moringa Oleifera* L.)". *Archives of Agriculture Sciences Journal* 5.3 (2022): 62-83.

31. SAS. "Statistical Analysis System. User's Guide: Statistics, SAS Institute Inc, Gary, Nc., USA.

32. Sendecor GW and Cochran WG. "Statistical Methods; 7th Edition. Oxford and J; B.H. Publishing Co 6.2 (1997): 240:285.

33. Verbeke C., *et al.* "Technological evaluation of fiber effects in wheat-based dough and bread". *Foods* 13.16 (2024): 2582-2592.

34. Weyh C., *et al.* "The role of minerals in the optimal functioning of the immune system". *Nutrients* 14.3 (2022): 644-659.

35. Zain MZ., *et al.* "Potential functional food ingredients in bread and their health benefits". *Biointerface Research in Applied Chemistry* 12.5 (2022): 6533-6542.