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EVALUATION OF WHEAT FLOUR BLENDED WITH DIFFERENT RATIOS OF *MORINGA OLEIFERA* LEAVES AND SEEDS

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Khalaf[2] A.R., El-kalyoubi[1] M.H., Khallaf[1] M.F., Hussein[2] A.S. and Helmy[2] I.F.

1- Food Sci. Dept., Fac. of Agric., Ain Shams Univ., P.O. Box 68 Hadayek Shoubra 11241, Cairo, Egypt
2- Food Technology Dept., National Research Centre, Giza, Egypt

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ABSTRACT

Chemical composition, minerals content, amino acids, fiber fractions, fatty acids profile, total phenols, total flavonoids and antioxidant activity were determined in wheat flour (WF) 72%, moringa leaves powder (MLP), defatted moringa seeds powder (DMSP) and moringa seeds (MS). Pasting profile and rheological properties of blends supplemented with MLP at levels of 3, 6, 9 and 12% or DMSP at levels of 5, 10, 15 and 20% were also studied. The highest moisture and carbohydrate contents were found in WF (12.60 and 85.05%), respectively. MLP had higher ash and fiber contents (8.87 and 7.91%), respectively, while, protein and fat contents were higher in DMSP and in MS. Mineral content (Ca, K, Mg, P, Na and Fe) in MLP was the highest, while DMSP was higher in Zn content than that of other samples. Fiber fractions of WF were lower than that of both MLP and DMSP. Total essential amino acids of DMSP was higher (19.25%) than that of MLP and WF (12.45 and 4.16%), respectively. Oleic acid was the predominant fatty acid (66.85%) in moringa seeds oil. MLP had the highest value of total phenolic, total flavonoid and antioxidant activity (11.97, 8.02 and 15.87 mg/g), respectively. Color measurements showed that all of MLP, DMSP and WF blends decreased in L*, a*,however, they increased in b*, saturation, hue and ΔE values.

Supplementation with MLP and DMSP at all levels decreased the peak viscosity, trough, breakdown, final and setback viscosities. While, it increased water absorption, dough development time, mixing tolerance index and dough weakening. On contrary, arrival time and dough stability were decreased. Also, MLP and DMSP decreased the extensibility, resistance to extension, maximum resistance to extension energy of dough and the proportional number.

INTRODUCTION

Moringa oleifera belongs to family Moringaceae is the most cultivated species of a monogeneric family, that is native to the sub-Himalayan lands of India, Pakistan, Bangladesh and Afghanistan. This fast-growing plant, also, it is universally referred as the miracle plant or the tree of life. The moringa plant derives this name based on its uses, particularly with regard to medicine and nutrition **(Sharma et al 2011).** It is considered one of the most useful trees in the world because almost all parts of this plant can be used as food **(Khalafalla & Abdel-latef, 2010).** In numerous parts of the world including Africa, the utilization of *M. oleifera* as a food fortificant is on the increase. For instance, both fresh and dried moringa leaves are included in meals in African countries **(Agbogidi and Ilondu, 2012).**

The chemical composition of moringa leaves showed that the percentages of protein, moisture, ash, fat, fiber, and carbohydrates were 31.01, 7.51, 4.01, 3.19, 18.02, and 36.10%, respectively **(Dachana et al 2010; Yameogo et al 2011; Okolo et al 2012 and El-Massry et al 2013).** The seeds

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of *Moringa oleifera* are good source for oil (44.78%), crude protein (25.97%) , ash(5.22%) and also crude fibers(4.87%). Also, the different parts of moringa are considered as rich sources for natural antioxidants and total antioxidant activity. Finally, it is recommended investigation that moringa crop is suitable for both cultivation and food processing in Egypt **(El-Massry et al 2013)**. The moringa seed cake had higher values in the ash (10%), crude fiber (12.96%) and protein (50.80%). The undefatted moringa seed flour had higher fat content (45.84%). The defatted cake could be used in fortification of other food materials. The proximate composition of the nutrients in *Moringa olifera* seed 5.01% moisture, 3.89% ash, 42.01% fat, 2.97% fiber, 39.61% protein and 16.01%carbohydrate **(Okolo et al 2012 and Abiodun et al 2012).** The most concentrated amino acids in the *M. oleifera* leaves and seed meals were glutamic acid, aspartic acid and leucine. Moringa seed kernel contain significant amount of oil. The protein content of M. oleifera leaves and seed meals was higher **(Al Juhaimi et al 2017)**. *Moringa oleifera* leaves contained high amount of other amino acids, mostly essential amino acids such as, methionine, valine, phenylalanine, leucine, lysine and tryptophan **(El-Massry et al 2013)**. Moringa seed oil can be used as an edible oil in human nutrition due to its high content of unsaturated fatty acids (61.53%) as **Goja (2013)**. **Aly et al (2016)** found that, the moringa oil contains high level of unsaturated fatty acids, mostly omega-9(oleic)fatty acid (up to 76.29 %). Also, the dominant saturated acids were palmitic, stearic acid and arachidic. **Singh, et al (2013)** fractionated and identified ten phenolic compounds (gallic acid, p-coumaric acid, ferulic acid, caffeic acid, protocatechuic acid, cinnamic acid, catechin, epicatechin, vanillin and quercetin) in both free and bound phenolic extracts of DMF.

Addition of high amount of DML increased water absorption and arrival time. The stability value decreased with the addition of DML. Mixing tolerance index was also increased with the addition of DML, owing to dilution and disruption of continuity of gluten **(Dachana et al 2010)**. Use of increasing amount of DBMS flour increased mixing tolerance of the blends but a decrease was observed in water absorption, dough development time, and dough stability. The decrease in the strength of the dough with the addition DBMS is due to dilution of gluten **(Ogunsina et al 2011)**. Substitution of germinated tigernut moringa flour and germinated moringa flour decreased the peak viscosity, trough, breakdown, final and setback viscosity of WF. The decrease in these RVA parameters could be ascribed to amylase activity in germinated moringa flour **(Dachana et al 2010 and Chinma et al 2014a and b).**

Thus, this work aims to evaluate the nutritional value and rheological properties of moringa leaves and seeds and their blends with wheat flour at different ratios, as well as the fatty acids composition and phytochemical compounds to providing the possible utilization of Moringa supplementation in some food products.

MATERIALS AND METHODS

Materials

Wheat flour (WF) 72% extraction was obtained from South Cairo Mill Company, Giza, Egypt. The fresh leaves and seeds of moringa (*Moringa oleifera*) were obtained from National Research Centre (NRC), Dokki, Giza, Egypt. 1,1-diphenyl-2-picrylhydrazyl (DPPH) was purchased from Sigma Chemical Co. (St. Louis, Mo, USA).

Methods

Preparation of moringa leaves powder (MLP)

The fresh leaves appropriated has been dried in an air oven at 45 ± 2°C for overnight, then milling and passed through 40 mesh sieve.

Debittering of moringa seeds powder (DMSP)

The seeds were dehulled and debittered by ordinary boiling in clean water for 35 min using a 1:30 w/v ratio. The debittered seeds were oven-dried at 80°C for 8h according to **Ogunsina and Radha, 2010** method**.** The debittered seeds were defatted by using screw press device to obtain the cold pressed crude oil then milled, passed through 40 mesh sieves.

Preparation of blends from wheat flour, MLP and DMSP

Blends were prepared from wheat flour and MLP (100:0, 97:3, 94:6, 91:9 and 88:12 w/w) and DMSP (100:0, 95:5, 90:10, 85:15 and 80:20 w/w).

Analytical methods

Chemical composition

Moisture, protein, Fat, ash and crude fiber contents were determined according to **AOAC (2005).** Carbohydrates were calculated by difference.

Minerals content

Minerals content (Na, Ca, P and K) were determined in the diluted solution of ash samples by using emission flame photometer and spectrophotometer **(Chapman & Pratt 1961).** Fe, Zn and Mg were spectrophotometerically determined using atomic absorption **(Jackson 1973)**.

Amino acids

Amino acids of Moringa leaves, seeds powder and wheat flour 72% were determined at Central Lab of Food and Feed, Agricultural Research Center. The samples were hydrolyzed and determined according to **AOAC. (2005)** using amino acid analyzer Eppendorf LC3000, Germany. EZ Chrom Manual Software 2004 was used for data collection and processing. While amino acid score were calculated according to FAO/ WHO Ref**.**

Fiber Fractions

The content of fibers, hemicellulose, cellulose, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and lignin were determined as **Van Soest & Robertson (1979)** method.

Determination of fatty acid profile

The fatty acids of lipid were estimated for selected isolates as methyl esters according to **Luddy et al (1960)** using gas chromatography: (Perkin Elmer Auto System XL).

Color measurements

The color of blended was measured using a Spectro-Colorimeter (Tristimulus color machine) with CIE lab color scale (Hunter, Lab Scan XE, Reston VA.) calibrated with a white standard tile of Hunter Lab color standard (LXNO. 16379): X= 77.26, Y= 81.94 and Z= 88.14. Color difference (ΔE) was calculated from a,b and L parameters, using Hunter-Scotfield's equation **(Hunter, 1975)** as follows:

$$\Delta E = (\Delta a^2 + \Delta b^2 + \Delta L^2)^{1/2}$$

Where $a=a-a_0$, $b=b-b_0$ and $L=L-L_0$
Subscript "O" indicates color of control. The Hue angle (tg^{-1} b/a) and saturation index ($\sqrt{a^2+b^2}$) were calculated.

Total phenolic content

The total phenolic content was determined according to the Folin-Ciocalteu procedure as metioned by **Hagerman et al (2000).** As gallic acid equivalent (mg/g)

Determination of total flavonoids content

The total flavonoids content was determined according to **Zhishen et al (1999)** using aluminum chloride ($AlCl_3$) colorimetric assay. As catachine equivalent (mg/g)

Determination of radical DPPH scavenging activity

Free radical scavenging capacity of extracts was determined using the stable DPPH according to **Cheung et al (2003).** As trolox equivalent (mg/g)

Rheological properties of dough

Rheological properties of the different resulted doughs were carried out using Farinograph, Extensograph and Rapid Visco Analyser (Newport Scientific, Australia) according to **AACC (2000).**

Statistical Analysis

The obtained data were subjected to Analysis of Variance ANOVA. **Duncan (1955)** multiple range at 5% level of significance was used to compare between means (triplicate determination).

RESULTS AND DISCUSSION

Chemical composition

The moisture content of WF 72% indicated the highest content (12.60%), followed by MLP (5.28%) while, the Dehulled moringa seed (DMS) and DMSP had 3.79 and 3.74 %, respectively **(Table 1)**. The protein content of raw materials ranged between (13.24- 70.32 %). WF was minimized in lipid (0.95 %). The lipid content of the other raw materials ranged between (6.12 –39.02 %). MLP exhibited the most concentrated source of ash and fibers (8.87 and 7.91 %), respectively. Wheat flour had the maximum value of total carbohydrates. Our findings are in the same line with those obtained by **Sengev et al 2013; Abdel-Samie & Abdulla, 2014 and Amabye & Gebrehiwot, 2015.**

Table 1. Chemical composition of raw materials (dry weight basis)

Components (%)	MLP	DMS	DMSP	WF (72%)	LSD at 5 %
Moisture	5.28^{b}±0.08	3.79^{c}±0.09	3.74^{c}±0.10	12.60^{a}±0.12	0.18
Protein	29.67^{c}±0.02	30.44^{b}±0.14	70.32^{a}±0.09	13.24^{d}±0.12	0.2
Fat	6.12^{c}±0.11	39.02^{a}±0.06	10.44^{b}±0.07	0.95^{d}±0.09	0.17
Ash	8.87^{a}±0.17	3.78^{c}±0.10	6.09^{b}±0.14	0.49^{d}±0.01	0.22
Fiber	7.91^{a}±0.03	3.87^{b}±0.02	2.43^{c}±0.04	0.27^{d}±0.04	0.06
Carbohydrates	47.43^{b}±0.05	22.89^{c}±0.05	10.72^{d}±0.03	85.05^{a}±0.04	0.12

MLP: Moringa leaves powder, DMS: Dehulled moringa seeds, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Values are means ± standard deviation of triplicate determinations, Means in the same row not followed by the same superscript letters are significantly ($p \leq 0.05$) different.

Minerals content

MLP had the highest contents of calcium, potassium, magnesium, phosphorus, sodium and iron contents as compared with other raw materials (1734.79, 1652.18, 464.10, 712.99, 202.39 and 20.65 mg/100g), respectively **(Table 2)**. DMSP exhibited the most concentrated source of dietary zinc (12.36 mg/100g) among all raw materials. These results are in agreement with **Yameogo et al 2011; El-massry et al 2013; Amabye & Gebrehiwot, 2015 and Mouminah 2015.**

Table 2. Mineral contents of raw materials (mg/100g) (dry weight basis)

Mineral mg/100g	MLP	DMSP	WF (72%)
Ca	1734.79	78.60	42.67
K	1652.18	101.89	67.37
Mg	464.10	458.09	23.53
P	712.99	84.67	42.63
Na	202.39	66.27	65.19
Fe	20.65	6.16	3.74
Zn	1.46	12.36	-

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Amino acids composition

Amino acid profiles of WF, MLP and DMSP are presented in **Table (3).** WF, MLP and DMSP contained 17 amino acids. The concentration of all essential amino acids in MLP and DMSP were higher than those of WF 72%. DMSP contained high amount of essential amino acids e.g. hisitidine, isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine and valine which were 1.63, 2.29, 4.00, 0.99, 1.28, 3.05, 1.40 and 3.00%, respectively. The MLP contain also the same essential amino acids. The MLP and DMSP proteins have good amount of essential amino acids and these may have nutritional interest and could be a good protein supplement to bakery products.

On the other hand, DMSP and MLP powders contained other amino acids as glutamic, argnine and proline in defatted seeds protein are the most predominant amino acids. While glutamic and aspartic in moringa leaves protein are the most predominant ones.

Amino acids content of moringa leaves are in agreement with those reported by **Melesse (2011); Moyo et al (2011) and El-Massry et al (2013).** Methionine, lysine and leucine were the first, second and third limiting amino acids in the moringa leaves powder, respectively. Hisitidine, lysine and therionine were the first, second and third limiting

Table 3. Amino acids composition of raw materials (%) (dry weight basis)

Amino acids %	Amino acids %			FAO/ WHO Ref*	Amino acids scores %		
	MLP	DMSP	WF		MLP	DMSP	WF
Essential amino acid							
Hisitidine	0.71	1.63	0.27	1.9	59.66	2.73	9.88
Isoleucine	1.28	2.29	0.51	2.8	45.71	5.01	10.18
Leucine	2.30	4.00	0.88	6.6	34.85	11.48	7.67
Lysine	1.60	0.99	0.29	5.8	27.59	3.59	8.08
Methionine	0.54	1.28	0.19	2.2	24.55	5.21	3.64
Phenylalanine	1.81	3.05	0.69	2.8	64.64	4.72	14.62
Therionine	1.22	1.61	0.34	3.4	35.88	4.49	7.58
Tyrosine	1.22	1.40	0.45				
Valine	1.77	3.00	0.54	3.5	50.57	5.93	9.10
Total E. A. A.	**12.45**	**19.25**	**4.16**				
Non-essential amino acid							
Aspartic	2.49	3.00	0.53				
Serine	1.20	1.78	0.57				
Glutamic	4.11	13.05	3.64				
Proline	1.37	4.37	1.29				
Glycine	1.26	2.94	0.48				
Alanine	1.96	3.70	0.50				
Argnine	1.77	9.51	0.46				
Cystine	0.62	2.59	0.26				
Total N.E. A. A.	**14.78**	**40.94**	**7.73**				

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

amino acids in the defatted seeds powder, respectively, while methionine, therionine and lysine were the first, second and third limiting amino acids in the wheat flour 72% respectively **(Ijarotimi et al 2013).**

Fiber fractions

Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were the highest in MLP to 19.16% and 15.38%, respectively **(Table 4)**. The defatted seeds powder (DMSP) contained high values of Acid detergent lignin (ADL) and lignin. The contents of cellulose and hemicelluloses in MLP were 8.18% and 7.27% respectively and higher than the same fiber fractions present in defatted seeds powder and wheat flour 72%. (**Moyo et al 2011 and Soliva et al 2005)**.

Table 4. Fiber fractions of MLP, DMSP and WF (72%) (as percentage on dry weight basis)

Parameters DM	MLP	DMSP	WF (72%)
NDF	19.16	11.55	1.98
ADF	15.38	8.01	0.01
ADL	1.36	2.29	-
Lignin	1.88	2.57	-
Cellulose	8.18	4.63	0.01
Hemicelluloses	7.27	5.69	1.97

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Fatty acids composition

Palmitic**,** stearic**,** arachidic and behenic acids in the *M. oleifera* seed oil were 6.25, 6.53**,** 4.14 and 7.01%, respectively **(Table 5)**. Therefore, the total saturated fatty acids were 23.93%, the major saturated fatty acid was behenic acid. The oil was found to contain a high level of unsaturated fatty acids up to 76.07%. Oleic ($C_{18:1}$ ω-9) was the predominant fatty acid, which accounted for 66.85% of the total unsaturated fatty acids, and this percent was slightly lower than the reported percent which ranged from 67.79 to 76.00% **(Anwar et al 2006, Anwar & Rashid 2007 and Gibriel et al 2015).**

Table 5. Fatty acids composition of *Moringa oleifera* seed oil

Fatty acids	%
Saturated fatty acid	
Palmitic acid ($C_{16:0}$)	6.25
Stearic acid ($C_{18:0}$)	6.53
Arachidic acid ($C_{20:0}$)	4.14
Behenic acid ($C_{22:0}$)	7.01
Unsaturated fatty acid	
Palmitoleic acid ($C_{16:1}$)	1.33
Oleic acid ($C_{18:1}$)	66.85
Linoleic acid ($C_{18:2}$)	5.79
Linolenic acid ($C_{18:3}$)	-
Eicosanic acid ($C_{20:1}$)	2.10
Unsaturated fatty acids	76.07
Saturated fatty acids	23.93

The high percentage of oleic acid in the oil makes it desirable in terms of nutrition and high stability cooking and frying oil. Many circumstances have focused attention on high-oleic vegetable oils. In addition, high-oleic oils have low saturated fatty acids levels. Therefore, high-oleic oils can viewed as a healthy alternative to partially hydrogenated vegetable oils **(Abdulkarim et al 2005).**

Total phenols, total flavonoids and antioxidants activity

Total phenols, total flavonoids contents and antioxidants activity (DPPH) were reached to their highest values in MLP (12.64, 8.47 and 16.75 mg/g), respectively, compared to the other samples **(Table 6)**. Dehulled moringa seed (DMS) had 1.65, 0.15 and 0.60 mg/g for total phenols, total flavonoids and antioxidants activity (DPPH), respectively these results were higher than that of DMSP and WF. The lowest content for the last three parameters was found in WF 72% which were 0.17, 0.03 and 0.38 mg/g, respectively. **(Compaoré et al 2011and Ijarotimi et al 2013)**

Color evaluation

Blends of MLP, DMSP and WF were darker than WF at different levels (3, 6, 9, 12 and 5, 10, 15, 20%), respectively **(Table 7**), where L* considerably decreased from 85.41 to 75.41 in case of MLP blends, but DMSP blends quietly decreased from 92.77 to 92.01 (**Abdel-Samie and Abdulla, 2014)** While, MLP blends had negative a* values this may be due to the sharp green color of the moringa leaves, a* values gradually decreased with increasing of MLP. Also, a* slightly decreased in DMSP with increasing of addition. Yellowness values b* increased as the level of MLP and DMSP increased in blends.

The increase in yellowness in MSF-formulated is likely to be due to the presence of carotenoid pigment in MSF **(Siddhuraju & Becker, 2003)**. It was found that all tested materials gradually increased in ΔE value as the levels increased.

Pasting profile

The control sample had high values of peak (2077 CP), trough (1316 CP), breakdown (761 CP), final (2462 CP) and setback (1146 CP) viscosities. Substitution of MLP decreased the peak viscosity, trough, breakdown, final and setback viscosities of wheat flour 72% **(Table 8)**. Also substitution with DMSP to WF decreased the peak viscosity, trough, breakdown, final and setback viscosities of wheat flour 72%.

While, peak time and pasting temperature values were ranged between 5 to 6.40 min and 69.40 to 87.90^{o}C, respectively for both MLP and MSP supplementation percents. (**Chinma et al 2014a, b** and **Dachana et al 2010)**. **Hallen et al (2004)** reported that, the decrease in the pasting parameters could be due to the decrease in the available starch for gelatinization. **Symons and Brennan (2004)** also reported that substitution of wheat starch with 5% barley β-glucan fiber fractions reduced peak viscosity due to the reduction in starch for gelatinization and less water available for initial swelling of starch granule.

Rheological parameters

Farinograph parameters

Water absorption of the control showed a gradual increase in parallel with addition increase, **(Table 9)** this may be due to the high protein and fiber contents in MLP and DMSP, where proteins and fibers tend to bind more water. The arrival time decreased and increased with the supplementation of MLP and DMSP, respectively.

Table 6. Total phenols, total flavonoids and antioxidants activity of MLP, DMSP and WF (72%) (dry weight basis)

Parameters	MLP	DMSP	DMS	WF	LSD at 5 %
Total phenols (mg GAE/g)	12.64^{a}±0.09	0.92^{bc}±0.21	1.65^{b}±0.053	0.17^{c}±0.00	1.17
Total flavonoids (mg CE/g)	8.47^{a}±0.17	0.03^{b}±0.01	0.15^{b}±0.04	0.03^{b}±0.02	0.37
DPPH (mg trolox equivalent /g)	16.75^{a}±0.40	0.54^{b}±0.09	0.60^{b}±0.09	0.38^{b}±0.06	0.86

MLP: Moringa leaves powder, DMS: Dehulled moringa seeds, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Values are means ± standard deviation of triplicate determinations, Means in the same row not followed by the same superscript letters are significantly ($p \leq 0.05$) different.

Table 7. Color attributes of wheat flour blends with MLP and DMSP at different levels

	L*	a*	b*	saturation	Hue	∆E**
Control (WF)	93.15^{a} ± 0.03	0.67^{a} ±0.02	10.92^{g} ±0.02	10.94^{g}±0.20	86.49^{d}±0.05	_
3% MLP	85.41^{f} ±0.01	-2.07^{e}±0.01	16.18^{d} ±0.01	16.31^{d}±0.01	-82.72^{h}±0.02	9.75^{d}±0.01
6% MLP	81.11^{g} ±0.01	-2.91^{f} ±0.01	18.76^{c} ±0.02	18.99^{c}±0.01	-81.18^{g}±0.03	14.81^{c}±0.01
9% MLP	78.13^{h} ±0.01	-3.47^{g} ±0.01	20.75^{b} ±0.02	21.04^{b}±0.02	-80.52^{f}±0.02	18.42^{b}±0.01
12% MLP	75.41^{i} ±0.01	-3.90^{h} ±0.01	22.62^{a} ±0.02	22.95^{a}±0.02	-80.21^{e}±0.01	21.74^{a}±0.01
5% DMSP	92.77^{b} ±0.04	0.54^{b} ±0.02	10.99^{g} ±0.06	11.01^{g}±0.07	87.19^{c}±0.09	0.41^{h}±0.04
10% DMSP	92.53^{c} ±0.02	0.53^{b} ±0.02	11.23^{f} ±0.02	11.24^{f}±0.02	87.31^{c}±0.08	0.71^{g}±0.01
15% DMSP	92.36^{d} ±0.01	0.49^{c} ±0.01	11.30^{f} ±0.01	11.31^{f}±0.01	87.50^{b}±0.03	0.90^{f}±0.01
20% DMSP	92.01^{e} ±0.01	0.46^{d} ±0.01	11.62^{e} ±0.02	11.63^{e}±0.02	87.75^{a}±0.03	1.35^{e} ±0.01
LSD at 0.05	0.05	0.02	0.20	0.20	0.14	0.04

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Values are means ± standard deviation of triplicate determinations, Means in the same columns not followed by the same superscript letters are significantly ($p \leq 0.05$) different.

Table 8. Pasting profile (viscosity) of mixtures of WF, MLP and DMSP

Additives	Peak Viscosity (CP)	Trough1 (CP)	Break down (CP)	Final Vis. (CP)	Setback (CP)	Peak Time (Min)	Pasting Temp (^{0}C)
Control (WF)	2077	1316	761	2462	1146	6.20	69.45
3% MLP	1503	663	840	1325	662	5.80	75.10
6% MLP	1239	362	877	799	437	5.33	69.40
9% MLP	1095	327	768	648	321	5.27	70.90
12% MLP	991	269	722	476	207	5	69.40
5% DMSP	2013	1385	628	2339	954	6.40	70.95
10% DMSP	1706	1123	583	2071	948	6.13	86.35
15% DMSP	1460	979	481	1774	795	6.07	87.90
20% DMSP	1244	834	410	1564	730	5.80	86.35

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Table 9. Farinograph parameters of mixtures of WF, MLP and MSP

Samples	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability (min)	Mixing tolerance index (BU)	Weakening (BU)
Control (WF)	63	1.5	2	14	80	45
3% MLP	66	1.5	5	8	140	130
6% MLP	68	0.5	3.5	8	160	90
9% MLP	70.5	0.5	3.5	7.5	120	80
12% MLP	72.5	1.25	3.5	7.5	140	80
5% DMSP	68	1.25	7.5	15	110	80
10% DMSP	71	1.25	7.25	14.5	150	120
15% DMSP	75	1.5	6	12	150	110
20% DMSP	76	1.75	6.75	13.5	120	90

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Dough development time, mixing tolerance index and weakening of different supplementation samples increased compared to control. Mixing tolerance index increased from 80 to 160 BU with the supplementation of MLP and MSP indicating a decrease in the strength of the bread dough. These data indicate that addition of DML decreased the strength of the dough owing to dilution and disruption of continuity of gluten **(Dachana et al 2010 and Ogunsina et al 2011).**

Extensograph parameters

The supplementation of MLP with increasing proportions from 3% to 12% increased the extensibility except 12%MLP and energy of dough decreased compared to control **(Table 10)**. Also, the same trend of result was observed after supplementation of DMSP from 5 to 20% which decreased the extensibility and energy of dough. The substitution of WF with MLP and DMSP resulted in decreased gluten, so the binding structure of dough became weak. This effect may be due to the presence of fibers and protein fractions that dilute the wheat gluten complex of dough. It is well known that viscoelastic property of wheat dough depends on gluten quality and quantity. Therefore, as gluten content increased the viscoelastic property was improved. Fiber addition caused shortened and low resistance to dough extension, and increased concentration of insoluble and soluble cell wall materials have been shown to partially disrupt the gluten network **(Collar et al 2007).** The decrease of dough extensibility may be attributed to the dilution of gluten proteins. This decrease may be due to the presence of fibers and protein fractions that dilute the wheat gluten complex of dough **(Boz, 2015)**. This decrement may be due to the absence of gluten fractions in MLP and MSP, without the possibility of forming a gluten complex. The proportional number, resistance to extension and maximum resistance to extension were decreased compared with the control.

Table 10. Extensograph parameters for mixtures of wheat flour, Moringa leaves and defatted seeds powder

Samples	Extensibility (E) (cm)	Resistance to extension (R) (BU)	Maximum resistance to extension (BU)	Proportional number (R/E)	Dough energy (cm2)
Control (WF)	15	440	600	2.9	101
3% MLP	19	220	290	1.6	77
6% MLP	18	110	110	0.6	40
9% MLP	15.5	90	90	0.6	46
12% MLP	10	80	110	0.8	20
5% DMSP	10.5	410	425	3.9	58
10% DMSP	9	185	190	2.05	25
15% DMSP	8	440	465	5.5	67
20% DMSP	6	120	470	2	35

MLP: Moringa leaves powder, DMSP: Defatted moringa seeds powder and WF: Wheat flour 72%

Conclusion

Moringa leaves and defatted seeds powder is very rich in many important nutrients to human health which means that moringa plant has an available technological value to utilize moringa leaves and defatted seeds powder in producing bakery products as an untraditional new cultivated crop and worth to be investigated.

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مجلة اتحاد الجامعات العربية
للعلـــوم الزراعيـــة
جامعة عين شمس ، القاهرة
مجلد(26)، عدد (2C)، عدد خاص ، 1895 - 1906، 2018

1906

تقييم دقيق القمح المخلوط بنسب مختلفة من أوراق وبذور المورينجا

[139]

أحمد روبى خلف[2]– ممدوح حلمى القليوبى[1]– محمد فرج خلاف[1] – احمد سعيد حسين[2]– ابراهيم فؤاد حلمى[2]

1- قسم علوم الاغذية – كلية الزراعة- جامعة عين شمس- ص.ب. 68 حدائق شبرا 11241 القاهرة – مصر

2- قسم الصناعات الغذائية- المركز القومى للبحوث- جيزة – مصر

الكلمات الدالة: دقيق القمح، اوراق المورينجا، بذور المورينجا، التركيب الكيماوى، الاحماض الامينية، الاحماض الدهنية، النشاط المضاد للأكسدة، الخواص الريولوجية

الموجـــــــز

تم دراسة التركيب الكيماوي، محتوى المعادن، الأحماض الأمينية، مشتقات الألياف، الأحماض الدهنية، الفينولات الكلية، الفلافونويدات الكلية والنشاط المضاد للأكسدة لدقيق القمح72% ، مسحوق أوراق المورينجا ،مسحوق بذور المورينجا منزوعة الدهن. كما تم دراسة اللزوجة والخصائص الريولوجية للخلطات من دقيق القمح 72% المخلوط بمسحوق أوراق المورينجا عند مستويات 3 ، 6 ، 9 و 12% و مسحوق بذور المورينجا عند مستويات 5 ، 10 ، 15 و 20%.

وأظهرت النتائج ان أعلى نسبة رطوبة وكربوهيدرات كانت في دقيق القمح (12.60 و 85.05%) على التوالي. وتميز مسحوق أوراق المورينجا بإرتفاع محتواه من الرماد والألياف(8.87 و 7.91 %) على التوالي، في حين ارتفع محتوي البروتين والدهن في مسحوق بذور المورينجا منزوعة الدهن وبذور المورينجا الكاملة مقارنة بدقيق القمح. كما ارتفع المحتوي المعدنى لمسحوق اوراق المورينجا من الكالسيوم، المغنيسيوم، البوتاسيوم، الفوسفور، الصوديوم والحديد، بينما كان محتوى مسحوق بذور المورينجا من الزنك اعلى من العينات الأخرى. وكانت مشتقات الالياف لدقيق القمح أقل منها فى مسحوق اوراق المورينجا ومسحوق بذور المورينجا. وكان مجموع الأحماض الأمينية الأساسية في مسحوق بذور المورينجا (19.25%) أعلى من مثيله الموجود في مسحوق اوراق المورينجا ودقيق القمح (12.45 و 4.16%)، على التوالي. كما ظهر حمض الأوليك (66.85%) كحمض دهني سائد فى زيت بذور المورينجا. واوضحت النتائج ان مسحوق اوراق المورينجا أعلى فى محتواه من الفينولات الكلية، الفلافونويدات والنشاط المضاد للأكسدة (11.97، 8.02 و15.87 ملجم/جرام) على التوالي. كما أظهرت نتائج قياس اللون أن جميع الخلطات من مسحوق اوراق المورينجا و مسحوق بذور المورينجا ودقيق القمح ادت الى انخفاض قيم *L ، *a و *b.

كذلك اظهرت النتائج ان استبدال دقيق القمح بمسحوق اوراق المورينجا ومسحوق بذور المورينجا على جميع المستويات أدى إلي انخفاض قيم كل من اللزوجة القصوى، اللزوجة الدنيا، الفرق بين اللزوجة القصوى واللزوجة الدنيا، اللزوجة النهائية والفرق بين اللزوجة الدنيا واللزوجة عند نهاية المنحني لدقيق القمح 72%. كما ادى الى زيادة نسبة امتصاص الماء، زمن تطور العجين، مؤشر الخلط وضعف العجين. وعلى العكس انخفض الزمن اللازم لتكوين العجين وفترة الثبات. وكذلك انخفضت كل من درجة انسيابية العجين، مقاومة العجين للشد، اقصى مقاومة للشد ،طاقة العجن والرقم النسبى مقارنة مع العينة الضابطة.

تحكيم: ا.د محمد مجدى مصطفى

ا.د شاهيناز أحمد حلمي

مجلة اتحاد الجامعات العربية
للعلـــوم الزراعيـــة
جامعة عين شمس ، القاهرة
مجلد(26)، عدد (2C)، عدد خاص ، 1895 - 1906، 2018

تحكيم: ا.د محمد مجدى مصطفى
ا.د شاهيناز أحمد حلمي