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EFFECT OF SUBSTITUTION OF WHEAT FLOUR WITH OAT AND BARLEY MEAL ON THE FUNCTIONAL, RHEOLOGICAL AND SENSORY PROPERTIES OF TARHANA

[42]

Salma, M. Ismail, Rizk, I.R.S., Nagwa, M.H. Rasmy and Samar, M. Mahdy

Food Sci., Dept., Fac. of Agric., Ain Shams Univ., P.O. Box 68-Hadyek Shoubra 11241, Cairo, Egypt

***Corresponding author:** smismail92@yahoo.

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ABSTRACT

Addition of whole cereal grains' meal as a source of dietary fibers for the development of tarhana as a value-added functional food was the aim of this study. The effect of substituting wheat flour 72% (WF) with different ratios of whole wheat meal (WWM), oat flakes meal (OFM), whole barley meal (WBM) and mixed-cereal meal (OFM& WBM) on functional, rheological, color and sensorial properties of tarhana samples was determined. Whole cereal grains' meal showed higher contents of protein, lipids, ash, crude fibers and total phenolic compounds in comparison to wheat flour (72%). pH values of tarhana samples were reduced from 5.22-5.89 to 4.81-5.09 after 72 h. of fermentation.

The flow behavior index of tarhana soup samples ranged between 0.11-0.19, indicating the pseudoplasticity of tarhana samples. The higher value of consistency coefficient was recorded for OFM 50% sample followed by WWM 100% sample. Fermentation loss values of tarhana samples ranged between 7.12% for OFM 25% sample and 12.61% for mixed-cereal 50% sample. Substitution of WF in tarhana formulations with whole cereal grains' meal reduced the yellowness of tarhana samples. Addition of different whole cereal grains' meal significantly ($p<0.05$) improved water and oil absorption capacity of tarhana samples. Also, partial substitution of WF with OFM and mixed-cereal meal at ratio of 50% in tarhana recipe has significantly ($p<0.05$) increased foaming capacity and stability of the final product.

The highest values of sensory parameters were observed in Tarhana soups prepared with OFM at ratios of 25& 50%, mixed-cereal meal at 50% and the control sample. According to the results of this study, it is possible to partially substitute wheat flour with whole cereal grains' meal in tarhana production in attempt to have a product combining the nutritional value of whole cereal grains and the health benefits of lactic acid bacteria.

Keywords: Tarhana, Whole Cereal grains, Functional foods, Dietary fibers, Rheology, Functional properties, Lactic acid bacteria

INTRODUCTION

Tarhana is a traditional Turkish fermented food and considered as a main part of their diet. It mainly consists of wheat flour (72%), yoghurt, yeast, some vegetables such as (onions and tomatoes) and spices (salt and paprika). The mixture is fermented for 1-7 days; after that, it is dried and then ground to obtain tarhana powder ready to be reconstituted and it is mainly consumed hot in the form of thick soup. Tarhana is prepared and consumed intensively in turkey and in many other countries around the world. It is like Thanu in Hungary, Tarhanas in Greece, Talkuna in Finland and Kishk in Egypt, Syria and Jordan. Each country has its own method for tarhana production according to habits and preferences **(Daglioglu, 2000)**.

Lactic acid fermentation lowers the pH of tarhana mixture to 3.8-4.2 due to the formation of organic acids, making the media unsuitable for pathogens and spoilage microorganisms. Low moisture content of dried tarhana (6-10%) preserves tarhana from deterioration and elongates its shelf life as it can be stored for 1-2 years. Tarhana is a good source of minerals, organic acids and amino acids in addition to vitamins such as thiamine and riboflavin **(Ibanoglu and Ibanoglu, 1997)**. Changing of tarhana ingredients and ratios affects the nutritional and sensory properties of tarhana **(Erbas et al 2005)**. The interaction between lactic acid bacteria and yeast during fermentation of tarhana enhance its functional properties, taste and flavor **(Mensah, 1997)**.

Whole cereal grains are important source of many nutrients such as dietary fibers, resistant starch, minerals, vitamins and antioxidants **(Slavin, 2004)**. Increased consumption of whole grain-based foods has been related to a reduced risk of developing diabetes and heart disease. Whole wheat meal has more fibers and minerals than wheat flour (72%) which increased its importance as a nutritional and functional ingredient for human diet and health as it helps reducing some diseases risk such as cardiovascular and obesity **(Liu, 2002)**. Oats and barley are among the richest and most economical sources of soluble dietary fiber; oats beta-glucan considered a functional food ingredient, because it may reduce total blood and low-density lipoprotein cholesterol levels **(Berg et al 2003)**. Whole oats can supply up to 3 gm. of soluble dietary fibers. Moreover, it is allowed by the FDA to claim health benefits for oats products when 0.75 g of B-glucan is consumed in a serving portion **(FDA, 1997)**. Barley is a good source of bioactive compounds that reduce the risk of certain diseases such as chronic heart disease **(Sullivan et al 2013)**. It has been proven that soluble fibers found in barley and oats have an effective role in reducing cardiovascular risk by reducing serum cholesterol through regular consumption. **(FDA, 2006)**.

Traditional tarhana can be modified and formulated with different ingredients to improve its properties. It was prepared with lentil and chickpea **(Türker and Elgün, 1995)**, barley **(Erkan et al 2006)**, corn **(Tarakci et al 2004)** and whole wheat & chickpea flours **(Kumral, 2015)**. This study aimed to determine the functional, rheological and sensorial properties of tarhana prepared with different substitution ratios of whole cereal grains' (wheat, oat flakes and barley) meal.

MATERIAL AND METHODS

Materials

Wheat grains (Shandaweel 1) and barley grains (Giza 136) were obtained from Crops Research Institute, Agricultural Research Centre, Giza, Egypt. Commercial wheat flour (72% extraction), oat flakes (Dobeles dzirnavnieks, Dobele, Latvia), full fat yoghurt (Al-Marai) made from cow milk, tomato paste (Heinz, 21% TS), chopped onions, paprika, salt and active dry yeast (DCL instant yeast); used in tarhana preparation were purchased from local market in Cairo, Egypt.

Methods

Preparation of cereal grains' meal

Wheat grains, barley grains (free from foreign materials) and oat flakes were milled using Perten laboratory mill 3100 to obtain whole meal.

Production of tarhana

Control tarhana sample was prepared according to **Bilgicli et al (2006)**: Wheat flour (400.0 g), yoghurt (160.0 g), tomato paste (40.0 g), chopped onions (20.0 g), paprika (8.0 g), table salt (4.0 g) and active dry yeast (10.0 g) were mixed together using Moulinex stand mixer (France) at the highest speed for 5 min. to form dough, then placed in glass bowls provided with covers and incubated at 30℃ for 72 h. During fermentation, the mixture was mixed manually every 12-hour intervals. pH of tarhana samples was determined during fermentation at 0, 24, 48 & 72 hr. After fermentation, samples were shaped into small pieces and then dried at 55 ℃ for 48 h in an air convection oven (Binder, Germany). Dried samples were ground and sieved using 1 mm opening sieve and stored in polyethylene bags in a dry place until analysis.

Eight different formulas were used for preparation of tarhana samples **(Table 1)** by substituting of wheat flour (72%) with different ratios of barley, oat flakes and mixed-cereals whole meal.

Chemical analysis

Proximate chemical composition: Moisture, Protein, Lipids, Ash and Crude fibers contents of different cereal grains' meal was determined according to **AOAC (2012)**, carbohydrate (Nitrogen Free Extract, NFE) was calculated by difference. Amount of total phenolic compounds, as gallic acid, of meal samples was determined according to **Jayaprakasha et al (2001).**

Physical analysis

pH of tarhana dough was measured during fermentation using a digital pH meter (HANNA, HI 2211), after mixing 5 g sample with 100 ml distilled water **(Bilgicli et al 2014)**.

Table 1. Substitution ratios of whole cereal grains' meal used in tarhana production

*Cereal	Treatments (%)							
	1	2	3	4	5	6	7	8
WF (72%)	100	-	75	50	75	50	75	50
WWM	-	100	-	-	-	-	-	-
OFM	-	-	25	50	-	-	12.5	25
WBM	-	-	-	-	25	50	12.5	25

***WF:** Wheat flour (72%)**, WWM:** Whole wheat meal**, OFM:** Oat flakes meal and **WBM:** Whole barley meal

Rheological properties of tarhana soup samples were measured according to **Hayta et al (2002)** using a coaxial rotational viscometer (*Rheotest* 2.2, *Medingen*, Germany). 10 g of tarhana powder was mixed with 100 mL distilled water and cooked over medium heat for 12 min. with constant stirring. The rotational speeds (6, 7, 8, 9, 19, 11, and 12) were converted to shear rate values (S^{-1}) and the corresponding stress was measured in Dynes/cm2 **(Steffe, 1996).**

Fermentation loss

Fermentation loss percent of tarhana samples was calculated using equation (1), according to **Bilgicli (2009):**

$$\text{Fermentation loss (\%)} = \frac{100\ x\ (axb) - (c\ x\ d)}{(a \times b)} \quad \textbf{(1)}$$

Where:

a = weight of tarhana dough before fermentation (g), b = dry matter ratio of tarhana dough before fermentation (%), c = total weight of ground dry tarhana (g) and d = dry matter ratio of ground dry tarhana (%).

Color measurements

Color of tarhana powder samples was measured using Spectrophotometer (MOM, 100 D, Hungary). Three replicates were performed for each sample. The attributes of color that correlate with the Hue angle, Chroma and Total color index are represented in a three-dimensional colour space, X, Y and Z known as CIELAB, from which the Hunter color parameters L*, a* and b* were calculated according to the equations 2, 3 and 4 provided by the manufacturer of the spectrophotometer, while Hue angle, Chroma and Total color index were calculated according to the equations 5, 6 and 7 **(Pathare et al 2013)**.

$$L* = 116\ (Y/100)^{1/3} - 16 \quad \textbf{(2)}$$

$$a* = 500\ [(X/98.07)^{\frac{1}{3}} - (Y/100)]^{1/3} \quad \textbf{(3)}$$

$$b* = 200[(Y/100)^{1/3} - (Z/118.22)]^{1/3} \quad \textbf{(4)}$$

$$Chroma = \sqrt{a*^2 + b*^2} \quad \textbf{(5)}$$

$$Hue\ angle = \tan^{-1}(\frac{b*}{a*}) \quad \textbf{(6)}$$

$$\Delta E = \sqrt{\Delta a*^2 + \Delta b*^2 + \Delta L*^2} \quad \textbf{(7)}$$

where L* is the measurement of luminosity ranged between black (0) and white (100), parameter a* takes positive values for reddish colors and negative values for the greenish ones, whereas b* takes positive values for yellowish colors and negative values for the bluish ones **(Granato and Masson, 2010)**.

Determination of functional properties of tarhana

Water and Oil absorption capacity (WAC & OAC) of samples were determined according to **Hayta et al (2002)**, 5 grams of tarhana powder was mixed with 25 ml distilled water or sunflower oil, and the mixture was stirred and centrifuged (4000 rpm for 20 min.). Water and oil absorption capacity values were expressed as grams of water or oil absorbed per gram of tarhana.

Foaming capacity (FC) of tarhana samples was measured according to **Hayta et al (2002)**, 10 grams of tarhana powder mixed with 25 ml distilled water and then stirred and centrifuged (4000 rpm for 20 min.). Resultant supernatant was whipped for 2 min at the highest speed using (Moulinex blender, France), and the volume of the foam was recorded after 10 s. Foaming capacity was expressed as the volume (mL) of gas incorporated per mL of solution. Foam stability (FS) was recorded as the time passed until half of the original foam volume had disappeared.

Emulsification activity (EA) was determined according to **Hayta et al (2002)**, 10 grams of tarhana powder were mixed with 25 ml distilled water and stirred for 20 min. and then centrifuged (4000 rpm for 20 min.). The resultant supernatants were mixed with equal volumes of sunflower oil and homogenized in a Waring blender. The emulsified layer was calculated with a measuring cylinder. Emulsifying activity was expressed as percent volume of the emulsified layer in total volume of the mixture.

Sensory properties

The method of **Hayta et al (2002)**, with some modifications, was applied to determine sensory properties of tarhana soup. 10 grams of tarhana powder was mixed with 100 ml of vegetables broth and cooked over medium heat for 12 min. Samples were served at 50˚C in disposable cups and evaluated by ten panelists (6 females and 4 males). The method of **Bilgicli, (2009)**, with some modifications, was applied for sensory evaluation; Taste, Color, flavor, consistency, sourness and overall acceptability of tarhana soup samples were evaluated using a 9-point scale with 1 being 'dislike extremely', 5 being 'Neither like nor dislike' and 9 being 'like extremely'.

Statistical analysis

Resulted data were analyzed using one-way analysis of variance (one-*way ANOVA*) and Duncan's test was performed for measuring specific differences between means. Statistical analysis was done using the **SAS (2000)** Software system for windows V8.

RESULTS AND DISCUSSION

Cereal grains' meal chemical composition

The proximate chemical composition of commercial wheat flour (72%), whole wheat meal, oat flakes meal and whole barley meal used in tarhana preparation are presented in **Table (2)**. Results showed a significant difference (P<0.05) between samples in terms of protein, lipids, ash, crude fibers and carbohydrates. Oat flakes meal had the highest amount of lipids, ash and crude fibers in comparison to the other samples where, whole barley meal had the highest amount of crude protein. Oat flakes meal had 12, 575, 630 and 483 % of crude protein, lipids, ash and crude fibers respectively higher than wheat flour. However, wheat flour (72%) had 17% NFE higher than oat flakes meal. These results agree with **Pastuszka et al (2012)** as they reported that, oat contents of protein are higher than wheat flour. Also, **El-Taeb (2018)** reported that, lipids, ash and crude fibers contents of barley and oat were higher than that of wheat flour.

Table 2. Proximate chemical composition of wheat flour (72%), whole wheat, oat flakes and barley meal.

Sample	Moisture	*Crude protein	Lipids	Ash	Crude fibers	**NFE	Total phenolic compounds (μg/g)
	% (% on dry weight basis)						
Wheat flour (72%)	13.4^{a}	12.20^{d}	1.20^{d}	0.57^{d}	0.65^{d}	85.44^{a}	1621.18^{c}
Whole wheat meal	11.42^{b}	12.88^{c}	1.80^{c}	1.95^{c}	2.10^{c}	81.29^{b}	2217.30^{b}
Oat flakes meal	9.57^{d}	13.65^{b}	8.25^{a}	4.10^{a}	3.70^{a}	70.71^{d}	1551.30^{d}
Whole barley meal	9.75^{c}	13.75^{a}	4.40^{b}	2.96^{b}	3.20^{b}	75.63^{c}	2726.53^{a}

Means with same letter within column are not significantly different (P<0.05).
*protein factor= 5.7, **NFE= Nitrogen Free Extract, calculated by difference.

Results of total phenolic compounds of samples indicates that, whole barley and wheat meal significantly ($p < 0.05$) had higher amount of phenolic compounds 2726.53 and 2217.30μg/g respectively than wheat flour (72%) 1621.18μg/g.

Physical properties of tarhana samples

pH values of tarhana samples

It is important to determine pH values of food products for determining its suitability for consumers as relatively low pH inhibit pathogens and spoilage microorganisms which increase the shelf-life of food products **(Ibanoglu et al 1995)**. Changes in pH values of different tarhana samples **(Figure 1)** were observed during fermentation period at 0, 24, 48 & 72 hr. Long fermentation time (72 h) significantly ($P<0.05$) decreased the pH values of tarhana samples from 5.22-5.89 to 4.81-5.09. Sample of WWM 100% showed the highest pH value of 5.09 at the end of fermentation and that because of its high content of bran which increased the pH value and that agrees with the results reported by **Bilgicli et al (2006)**, while control sample achieved the lowest pH value of 4.81.

pH values were affected by fermentation time as they decreased by time and that reduction of pH was due to the production of organic acids during fermentation by yeast and lactic acid bacteria of yoghurt and that agrees with **Ibanoglu and Ibanoglu (1999), Erbas et al (2005) and Gabrial et al (2010).**

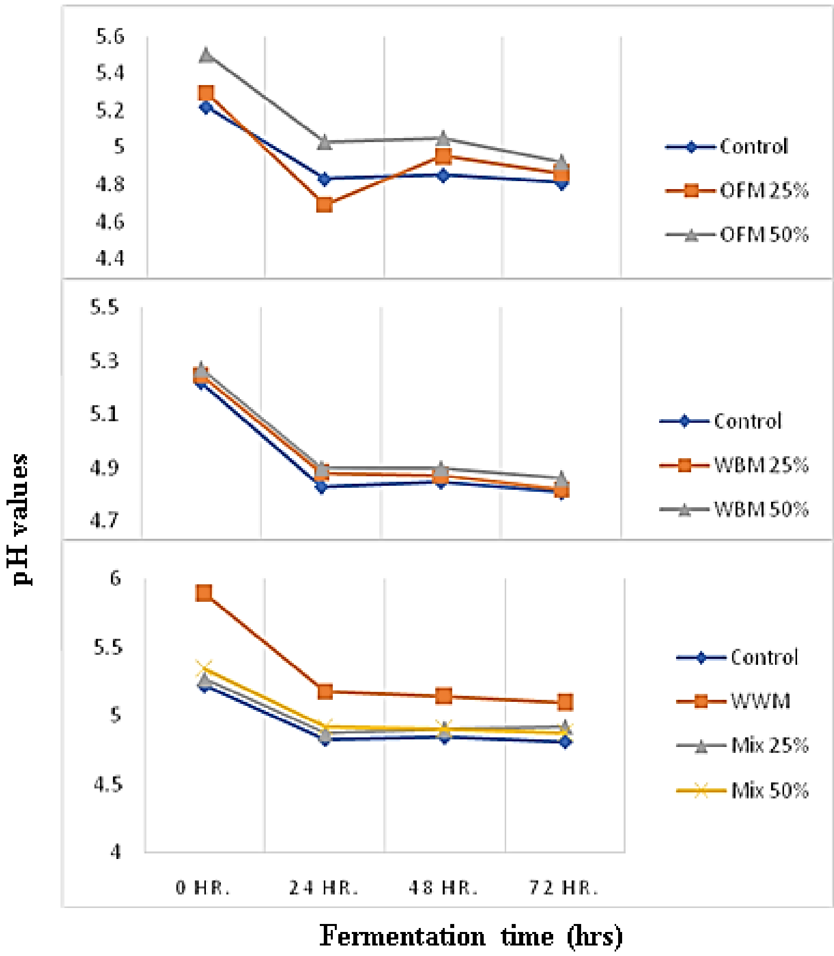

Fig. 1. Changes in pH values of tarhana samples during fermentation (72h).

Rheological properties of tarhana soup

Rheograms of the tested samples are presented in **Figure (2)**. The flow curves are non-linear indicating a non-Newtonian behavior of all tested samples. OFM 50% Sample, showed the highest shear stress response values indicating a thick consistency character for this sample. Meanwhile, control and barley 50% samples showed the lowest shear stress values indicating the fluidity of these samples. Flow curves given in **Figure (1)** were analyzed according to the general power law of non-Newtonian fluids (equation 8) as described by **Steffe, (1996)**:

$$\tau = \mathrm{K} - \gamma^{n} \qquad \textbf{(8)}$$

where: τ = shear stress (dynes/cm^2), γ = shear rate (S^{-1}), K = Consistency coefficient (dynes. S ^{n}/cm^2) and N = Flow behavior index (-).

Results given in **Table (3)** showed that, all R^2 values (coefficient of determination) were close to or higher than 0.9 indicating the suitability of the power low model to represent the shear rate / shear stress values of the samples. The flow behavior index of the samples ranged between 0.11 to 0.19 indicating the pseudo-plastic pattern of the tested samples. The values of consistency coefficient ranged between 120 to 186 Dynes. S^n/cm2, where the highest value was recorded for OFM 50% sample and this could be due to oats' content of beta-glucan and fat which forms highly viscous solutions **(Doublier and Wood, 1995)**, while the lowest value was that for control sample (wheat flour 72% extraction).

From these results, it is obvious that replacing wheat flour (72%) with different ratios of whole grains' meal led to an increase of samples thickness and consistency, which may increase the palatability and mouthfeel of the obtained tarhana samples.

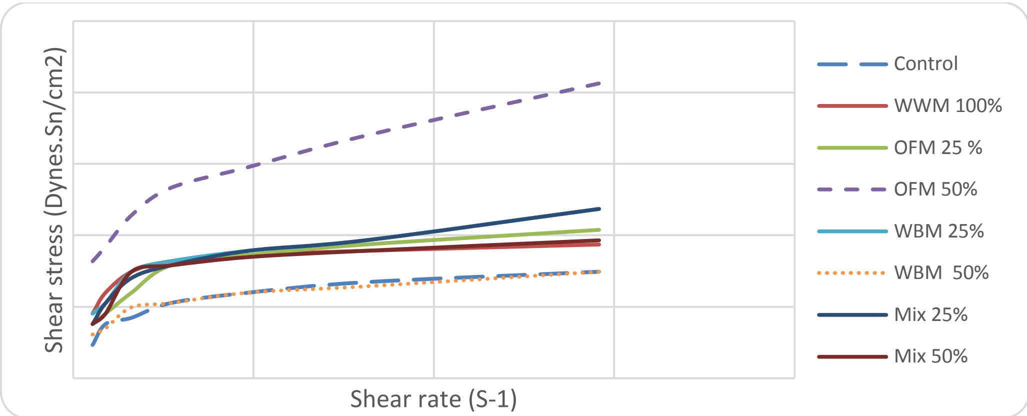

Fig. 2. Flow curves of the tested tarhana soup samples.

Table 3. Flow behavior index, Consistency coefficient and R^2 values of tarhana soup samples

Sample	Flow behavior independent (n)	Consistency coefficient (k)	R^2
Control	0.1519	120.42	0.9621
WWM 100%	0.1165	169.4	0.8708
OFM 25%	0.1764	133.59	0.9622
OFM 50%	0.1986	186.9	0.9941
WBM 25%	0.1651	147.58	0.9638
WBM50%	0.13	131.61	0.968
Mix 25%	0.1828	136.4	0.9692
Mix 50%	0.1542	144.51	0.8659

Fermentation loss values

Fermentation loss values of tarhana samples are presented in **Table (4)**. They ranged between 7.12% and 12.61%. Optimal fermentation is important in terms of functional and sensorial properties of tarhana for consumer acceptability. Long fermentation process of tarhana by lactic acid bacteria and baker's yeast is the main reason for fermentation losses. Over-fermentation of tarhana causes dry matter loss up to 25% and a decrease in functionality **(Türker and Elgün, 1995)**. Highest values of fermentation loss were recorded for tarhana samples formulated with high substitution ratios of whole cereal grains' meal. As shown in

Table 4, fermentation loss values were 12.61, 10.26% for mix 50%, OFM 50% and WWM 100% samples respectively, compared with 9.38% for control sample.

Sample	Fermentation loss (%)
Control	9.38^{f}
WWM 100%	10.26^{c}
OFM 25%	7.12^{g}
OFM 50%	12.23^{b}
WBM 25%	9.85^{e}
WBM 50%	10.18^{d}
Mix 25%	9.77^{e}
Mix 50%	12.61^{a}

*Means with same letter within column are not significantly different (P<0.05)

Optimal fermentation affects the functional and sensory properties of tarhana for consumer acceptability. Long fermentation process (72 h) during tarhana preparation by lactic acid bacteria and baker's yeast was responsible for fermentation losses (**Bilgiçli and Elgün, 2005 and Bilgiçli, 2009)**.

Color values of tarhana powder

Color of food products has a great effect on sensory properties and consumer acceptance. According to the color results presented in **Table (5)**, L* values ranged between 73.51-68.2. OFM 25% sample showed the highest L*-value followed by the control sample, while WWM100% sample showed the lowest L*-value because of whole cereal grains' meal used. Concerning a*, WBM 50% sample achieved the highest value of 2.88 and that may be due to the distribution of anthocyanin pigment in the outer layer of barley grains (**Abdel Aal et al 2006)**, while oat flakes meal (OFM) 50% & mix 50% samples showed the lowest a*-values of 1.58 & 1.45, respectively. Substitution of wheat flour (72%) in tarhana formulation with whole cereal grains' meal reduced the yellowness of other samples which led the control sample to be the most yellowish sample among other samples and that agrees with **Celik et al (2010)**. Similar trend was found for Chroma and Color index-values. The Hue-angle of the tested samples ranged between 82.41° and 86.24°, where the lowest value (yellow-orange) was that of whole barley meal (WBM) 50%, while the highest value (yellow) was that of mix 50% sample.

Table 5. Color values, Chroma, Hue angle and color index of tarhana powder.

Sample	L*	a*	b*	Chroma	Hue angle	Color index
Control	73.1^{b}	2.74^{ab}	28.37^{a}	28.5^{a}	84.46^{abc}	78.49^{a}
WWM 100%	68.23^{h}	2.81^{ab}	27.68^{b}	27.81^{b}	84.19^{abc}	73.68^{e}
OFM 25%	73.51^{a}	2.26^{c}	27.42^{c}	27.51^{c}	85.27^{ab}	78.49^{a}
OFM 50%	72.93^{c}	1.58^{d}	25.85^{d}	25.89^{d}	84.5^{abc}	77.39^{b}
WBM 25%	72.42^{d}	2.61^{abc}	22.85^{f}	23.00^{f}	83.47^{bc}	75.98^{c}
WBM 50%	68.5^{g}	2.88^{a}	21.65^{h}	21.83^{h}	82.41^{c}	71.89^{g}
Mix 25%	70.98^{e}	2.48^{bc}	25.24^{e}	25.35^{e}	84.38^{abc}	75.37^{d}
Mix 50%	70.11^{f}	1.45^{d}	22.12^{g}	22.16^{g}	86.24^{a}	73.52^{f}

*Means with same letter within column are not significantly different (P<0.05)

Functional properties of tarhana

Functional properties of tarhana are of great importance for processing and manufacturing of the product. Ingredients of tarhana affect the functional properties of the final product. **(Celik et al 2005 and Hayta et al 2002)**.

Functional properties of tarhana samples are presented in **Table (6).** Substitution of wheat flour (72%) with different ratios of whole cereal grains' meal has significantly (p <0.05) increased water and oil absorption capacity of tarhana product and that's may be due to the high content of fibers found in whole grains **(Zhang and Moore, 1997)**. Tarhana sample with WBM 50% recorded the highest value of 1.03 ml/g for WAC, where those with OFM 50% recorded the highest value of OAC of 1.00 ml/g in comparison to 0.71 and 0.62 ml/g, respectively for control sample.

Supplementation of tarhana samples with whole grains' meal significantly increased (p <0.05) the foaming capacity and stability of final tarhana. Sample with mixed-cereal 50% achieved the highest value of foaming capacity of 0.91 (ml/ml), while

WWM 100% was the lowest value of 0.52 (ml/ml). Statistical analysis of emulsification activity results showed that there is no significant difference between tarhana samples as they ranged between 96.2-96.7% except for WWM 100% sample which scored the lowest value of 93.1%.

Table 6. Functional properties of tarhana samples

Sample	WAC (ml/gm.)	OAC (ml/gm.)	FC (ml/ml)	FS (min)	EA (%)
Control	0.71^{g}	0.62^{f}	0.60^{g}	0.08^{c}	96.5^{a}
WWM100%	0.83^{e}	0.75^{e}	0.52^{h}	0.07^{d}	93.1^{b}
OFM 25%	0.79^{f}	0.79^{d}	0.70^{c}	0.08^{c}	96.7^{a}
OFM 50%	0.93^{c}	1.00^{a}	0.84^{b}	0.11^{b}	96.2^{a}
WBM 25%	0.88^{d}	0.80^{d}	0.69^{d}	0.08^{c}	96.2^{a}
WBM 50%	1.03^{a}	0.90^{b}	0.68^{e}	0.08^{c}	96.0^{a}
Mix 25%	0.82^{ef}	0.75^{e}	0.67^{f}	0.08^{c}	96.5^{a}
Mix 50%	1.00^{b}	0.83^{c}	0.91^{a}	0.18^{a}	96.5^{a}

*Means with same letter within column are not significantly different (P<0.05).

Sensory properties of tarhana soup

Results of sensory properties of tarhana samples **(Table 7)** showed that, substitution of wheat flour 72% with OFM 50% has improved the taste of traditional tarhana and scored the highest value superior to the control sample (which agree with the rheological tests given in the present work). Concerning the color, tarhana soup samples supplemented with OFM 25 and 50% were the most liked samples scoring 8.2 and 8.5, respectively (which agree with the L-values given in table (5) in the present work). Control soup recorded the highest flavor score of 8.5. Substitution with whole cereal grains' meal has increased the consistency and thickness of samples which negatively affected their score in comparison to the control sample. However, the taste of these samples was the highest. Concerning sourness, no significant difference (p<0.05) was observed among samples. Tarhana soup with OFM 25% had the highest score in overall acceptability than control sample. The overall sensory analysis results indicated that, utilization of whole cereal grains' meal in tarhana production resulted in acceptable soup properties concerning most of the sensory properties.

Table 7. Sensory properties scores of tarhana soup samples

Sample	Taste	Color	Flavour	Consistency	Sourness	Overall acceptability
Control	7.0^{ab}	7.7^{ab}	8.5^{a}	9.0^{a}	7.7^{a}	8.2^{ab}
WWM 100%	7.5^{ab}	5.7^{d}	6.2^{bc}	6.7^{b}	7.5^{a}	6.5^{bc}
OFM 25%	7.2^{ab}	8.2^{a}	7.7^{ab}	7.7^{ab}	8.0^{a}	8.5^{a}
OFM 50%	8.5^{a}	8.5^{a}	7.2^{ab}	7.2^{b}	7.7^{a}	7.7^{abc}
WBM 25%	6.2^{b}	6.2^{cd}	7.5^{ab}	7.5^{ab}	7.2^{a}	6.5^{bc}
WBM 50%	6.5^{ab}	7.0^{abc}	7.2^{ab}	7.0^{b}	7.5^{a}	7.0^{abc}
Mix 25%	7.5^{ab}	6.7^{cd}	6.0^{c}	6.5^{b}	7.2^{a}	6.7^{c}
Mix 50%	6.2^{b}	6.5^{bcd}	7.0^{abc}	7.0^{b}	7.7^{a}	7.7^{abc}

*Means with same letter within column are not significantly different (P<0.05)

CONCLUSION

Consumption of whole cereal grains is related to lower risk of many diseases and considered a nutritious source of minerals, vitamins, dietary fibres and antioxidants. Substitution of wheat flour (72%) with different ratios of whole cereal grains' meal had positively affected the functional and sensory properties of traditional tarhana. Supplementation of tarhana samples with whole cereal grains' meal improved oil& water absorption capacity properties. It also increased foaming capacity and stability of samples compared with control.

Tarhana samples supplemented with OFM at ratios of 25% and 50% achieved the highest scores concerning taste and colour and resulted in acceptable soup compared with control sample. Substitution of wheat flour (72%) with 50% of whole cereal grains' meal increased thickness of tarhana soup samples which didn't appeal to the panellists. Such food products can be greatly improved and developed by using different raw materials or additives in the production of fermented products combining the nutritional value of whole grains and the health benefits of lactic acid bacteria.

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تأثير إستبدال دقيق القمح بمطحون الشوفان والشعير علي الخواص الوظيفية، الريولوجية والحسية للترهانا

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سلمى محمد إسماعيل- إبراهيم رزق سيد أحمد رزق- نجوى موسى حسن رسمي- سمر محمد مهدي
قسم علوم الأغذية- كلية الزراعة- جامعة عين شمس- ص.ب 68 حدائق شبرا 11241- القاهرة- مصر

*Corresponding author: smismail92@yahoo.

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الموجـــــــز

يهدف هذا البحث إلي إستخدام مطحون الحبوب الكاملة (القمح، الشوفان والشعير) في تصنيع الترهانا من أجل الحصول علي منتج وظيفي ذو قيمة غذائية مضافة. تم تقدير تأثير إستبدال دقيق القمح (72%) بنسب مختلفة من دقيق الحبوب الكاملة مثل القمح، رقائق الشوفان، الشعير وخليط من هذه الحبوب علي الخواص الوظيفية، الريولوجية والحسية للمنتج النهائي. أوضحت نتائج التركيب الكيميائي للحبوب سابقة الذكر زيادة في محتواها من البروتين، الدهون، الرماد، الألياف الخام والمواد الفينولية مقارنة بدقيق القمح (72%)؛ كما أظهرت النتائج إنخفاض قيم pH عينات الترهانا من 5.22-5.89 إلي 4.81-5.09 بنهاية فترة التخمير(72 ساعة). تم تقدير الخواص الريولوجية لعينات حساء الترهانا. أوضحت النتائج أن جميع العينات تتبع السوائل غير النيوتينية و قد حققت عينة الترهانا المحضرة بدقيق رقائق الشوفان (50%) أعلي قيمة.تم تقدير نسبة الفقد في المكونات الجافة لعينات الترهانا اثناء عملية التخمير وتراوحت من 7.12% لعينة الترهانا المحضرة بدقيق رقائق الشوفان (25%) إلي 12.61%لعينة الترهانا المحضرة من خليط من الحبوب (50%). أظهرت نتائج تقدير اللون حدوث إنخفاض في درجة إصفرار العينات.

أدي إستخدام مطحون هذه الحبوب إلي تحسن في قدرة العينات علي إمتصاص الماء والزيت، كما أظهرت تحسن معنوي في قدرتها علي تكوين الرغوة وثباتها. حققت عينات كل من المقارنة وعينات دقيق رقائق الشوفان (25&50%) أعلي قيم للقبول الحسي. بناء علي النتائج السابقة، نخلص إلي إمكانية الإستفادة من الحبوب الكاملة في إنتاج أغذية وظيفية متخمرة تجمع بين القيمة الغذائية للحبوب الكاملة والفوائد الصحية لبكتريا حمض اللاكتيك.

الكلمات الدالة: الترهانا، الحبوب الكاملة، الأغذية الوظيفية، الألياف الغذائية، الخصائص الريولوجية، الخصائص الوظيفية، بكتريا حمض اللاكتيك

تحكيم: ا.د يحيى عبدالرازق هيكل
ا.د علاء الدين محمد سلامة