Evaluation of untraditional Macaroni Formulated by Using Different Grain Meals and Their Mixtures

.

ABSTRACT

Aims: wheat, Barley and millet meals are having superior nutritional qualities and health benefits; they can be used for supplementation of macaroni. Its effect on physiochemical, rheological, color parameters, cooking quality, nutritional value and sensory evaluation.
Place and Duration of Study: Regional Center for Food and Feed, Agriculture Research Center, Giza, Egypt.
Methodology: Macaroni was prepared using wheat, barley, millet and composite meals mix (1), mix (2) and mix (3). Proximate chemical composition, rheological, color parameters, cooking quality and sensory evaluation were measured of wheat, barley, millet and composite meals macaroni.
Results: Results show that the level of millet replacement led to increasing the fat, ash and total fiber in the products. B-glucan content in barely represented the superiority (3.90%) as compared with other samples. Substitution of wheat, barley and millet meals (mixed) macaroni have significantly increasing in the water absorption while they have significantly decreasing the cooking time. The highest value of water absorption (54.60 %) was found for wheat and the lowest value (35.0%) was obtained for millet. Color characteristics indicate that an increasing proportion of millet had signed negative effect on lightness and overall acceptability. While barley addition showed significant positive effect on lightness and overall acceptability. Sensory evaluation scores indicated non-significant difference among of the samples control and barley products were overall acceptance, then mixed (1) and millet was the lowest value of overall acceptance.
Conclusion: It can be concluded that the possibility of producing macaroni relatively higher in fiber and β-glucan without considerable of less density effects on its cooking quality and sensory evaluation and has many benefits for health of diabetes, high cholesterol and heart diseases patients.

Keywords: Wheat, barley, millet meal and mixtures; properties of macaroni.

1. INTRODUCTION

At present, dietary guidelines recommend an increase in the consumption of whole grain cereal products due to their role in reducing the risk of degenerative chronic diseases. Whole grains contain all parts of the grain viz., the endosperm, germ, bran and rich in nutrients and photochemical with known health benefits [1].Other protective compounds in whole grains include phytate, phyto-oestrogens such as lignans, plant stanols and sterols, and vitamins and minerals. Several epidemiological studies have shown that consumption of whole grain cereals is associated with reduced incidence of diabetes [2; 3], cardiovascular diseases and certain cancers [4; 5].
Traditionally, pasta products are made from wheat semolina, although more recently other cereals have been used to partially replace it [6].

Hull-less barley being a cereal grain is suitable for cereal pasta. The nutritional value of whole-grain barley to be low in fat content, higher in total dietary fiber and essential amino acid therefore has a positive health profile. Beta-glucans from barley have been found to reduce blood glucose and insulin levels with hypo-cholesterolemic effects [7]. The Food and Drug Administration (FDA) has indicated that dietary intake of 3 g /day of barley β-glucan helps to decrease total cholesterol in both the serum and the low-density lipoprotein [8].
Finger millet *(Eleusinecoracana)* also known as ragi is one of the important millet consumed without dehulling.It has good source of methionine, cysteine, lysine and high levels of calcium, iron, zinc, lipids then it has high concentrations of threonine and tryptophan along with less leucine than other cereals [9].
Millets have nutraceutical properties of antioxidants which play many roles in the body immune system, such as lowering blood pressure, risk of heart disease, prevention of cancer and cardiovascular diseases, diabetes, decreasing tumor cases etc. [10].Millet is easily available cheap in cost and gluten-free food, which can be a substitute for celiac patients.
Bread and Pasta are the major processed cereal products that are part of the daily diets of the most people in large number of countries and especially the Mediterranean as in Egypt. While these products are low in fat and good sources of complex carbohydrates, they are usually not good sources of dietary and, in particular, soluble fiber [11].
Pasta's versatility, long shelf life in dry form, availability in numerous shapes and sizes, high digestibility, good nutrition, and relatively low cost are attractive to the consumer. It has become more popular due to its nutritional properties and being regarded as a product with low glycemic index [12].Pasta with a mixture of durum wheat and beta-glucan enriched barley flour (BF) (60/40%, w/w) and found it to have a final content of 5% β-glucan.Quality parameters, cooking loss and dry matter did not vary substantially from the control, suggest in high potential for consumer acceptance [13].The addition of millet flours to the pasta will improve the dietary fiber content [14].Therefore the present study was aimed to evolution the macaroni formulations by wheat, barley, millet meal and their mixed and its effect on physiochemical, rheological, color parameters, cooking quality, nutritional value of macaroni and sensory analysis.

2. MATERIAL AND METHODS

2.1 Materials

Wheat *(Triticum durum),* barley *(Hordeumdistychum)* and millet *(Pennisetum Spp.)* grains cultivar was obtained from Egypt. Wheat, barley and millet which was obtained from Corp Intensification Research Department - Field Crops Research Institute - Agriculture Research Center during 2018.

2.1.1 Preparation of meal grains

A ten kg of wheat, barley and millet sample used in this investigation was stored at temperature 25°C and relative humidity less than 62 % according to the methods of USDA [15]. Wheat, barley and millet sample was cleaned mechanically to remove dirt, dockage, imparters and other strange grains by Carter Dockage Tester according to the methods described [16].The extraction rate of flour sample was adjusted to recurred rate (100 % extraction) which had milled by laboratory mill 3100 Perten according to the methods described for meal flour [17].

2.1.2 Analysis of Raw Materials

2.1.2.1 Physical properties

Cleanliness, dockage, shrunken and broken, foreign materials, total damaged kernels and total defects were separated and determined manually (hand picking). Test weight pound per bushel, Test weight P/B = (Kg ⁄ Hectoliter) ÷ 1.278 according to methods of USDA [15]. A thousand kernel weights were determined by counting the kernels (wheat, barley and millet) in a 10 g sample [18]. Gluten and falling number were determined to wheat, barley, millet meals and their mixtures according to AOAC [19].

2.1.2.2 Determination of color of raw materials and produced macaroni

Colour was evaluated by a colorimeter CR-400 (Konica Minolta, Japan) in the CIE LAB colour space: Commission International de l'Eclairage (CIE) tristimulus L* a* b* parameters were determined using colour meter (Colour Tec PCMTM Color Tec Associates, Inc., Clinton, NJ, USA), according to the method outlined AACC. 2 [18].

2.1.2.3 Chemical properties

Moisture, crude protein, ash, crude fiber, fat, mineral, vitamins and aflatoxin were determined to wheat, barley , millet meals and their mixtures according to methods of AOAC [19] and USDA [15].The nitrogen free extract (NFE) was calculated by difference. Beta-glucan was determined according to Pérez-Vendrell *et al.*, [20].

2.1.2.4 Rheological properties

All mixtures of flours were tested by Alveograph, consistograph while amylograph was used to determine the maximum viscosity, temperature at the maximum viscosity and the transition point according to the methods described in Regional Center for Food and Feed, Agri. Res. Center, Cairo, Egypt) [17]. To determine the rheological properties of the different types of meal grains and their mixtures according to the methods described on AACC.1 [17].

2.2 Methods:

2.2.1 Marconi processing was processed into flour, using the method of fresh pasta dough according to the methods described in Regional Center for Food and Feed, Agri. Res. Center; Cairo, Egypt [17]. All macaroni was used in this formula to produce macaroni by six formulas:

1-Wheat 100%
2-Barley 100%
3-Millet 100%
4-Mix1= (12.5% barley, 12.5% millet and 75% wheat)
5-Mix 2= (25.0% barley, 25.0% millet and 50% wheat)
6-Mix 3= (37.5% barley, 37.5% millet and 25% wheat)

2.2.2 Evaluation of cooking quality of produced macaroni

Cooking quality, increase in volume, cooking loss and optimal cooking time was carried out according to the method outlined AACC. 2 [18].

2.2.3 Sensory evaluation

The sensory characteristics of macaroni were evaluated according to Fany and Khan [21]. Sensory attributes like appearance, flavor, taste, colour, mouth feeling and overall acceptability for all the samples were assessed.

2.2.4 Statistical analysis

Data of three replicates were determined by Duncan's multiple range test at (P>0.05) level was used to compare between means using SAS programs [22].

3. RESULTS AND DISCUSSION

3.1 Proximate analysis for wheat, barley, millet meals and their mixtures

The proximate composition of the samples, including moisture, protein, fat, ash, fiber, nitrogen free extract and total caloric values is shown in Table 1 in the present study. The results revealed that the moisture content were no significant effect for both wheat, mix 1 and mix 2 meals (10.50, 10.50 and 10.20 %, respectively).The average protein content of wheat meal and barley ranged between 13.4 % - 9.8 %, respectively, these agreements with work by Hatcher, *et al.[*23]. The high fat content of meal was millet and lowest value was recorded in mix 3 (1.21 %). And Mandge *et al. [*24] reported that 1.58 per cent fat in wheat and 35.5 per cent fat in flaxseed, per cent fat content of oat, maize, pearl millet and mung bean was(4.42, 4.74, 5.47 and 1.85 %), respectively**.** The ash content of meal ranged between 1.80 % to 1.06 % millet and barley respectively**,** Abdalla *et al.,* [25] reported 1.53 % ash content of pearl millet which agreement with us. The ash content indicated a rough estimation of the mineral value of the product. The high fiber content was millet 8.5% and the lowest was mix 3 meals 1.30%. Our results are in conformity with Mandge *et al.* [24].

Nitrogen free extracts (NFE) % ranged between 65.8- 77.55 % for millet and mix 3, these results are lower than results by Hejazi [26].The calorific value of samples was ranged between 345-363.6 %. Barley had hi ghest calorific value when compared to other treatments. Millets contain 60-70 % carbohydrates, 7-11 % proteins, 1.5-5 % fat, and 2-7 % crude fiber [10]. While β-glucan content in barely flour represented the superiority (3.90 mg/g) as compared with its content in millet flour (0.75 mg/g) and wheat flour (0.70 mg). This agrees with the findings of Dahab [27].

Table 1: proximate analysis for wheat, barley, millet mealsand their mixtures

Analysis	Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Moisture content %	10.5 ^{a}	7.6 ^{c}	8.7 ^{b}	10.5 ^{a}	10.2 ^{a}	8.2 ^{b}
Protein content %	13.4 ^{a}	9.8 ^{d}	11.0 ^{c}	12.1 ^{b}	11.7 ^{b}	10.6 ^{c}
Fat content %	1.43 ^{c}	1.75 ^{b}	4.2 ^{a}	1.27 ^{d}	1.24 ^{d}	1.21 ^{d}
Ash content %	1.45 ^{ab}	1.06 ^{c}	1.8 ^{a}	1.27 ^{bc}	1.22 ^{bc}	1.14 ^{bc}
Fiber content %	1.52 ^{c}	2.64 ^{b}	8.5 ^{a}	1.35 ^{c}	1.32 ^{c}	1.30 ^{c}
Nitrogen free extracts %	71.7 ^{c}	77.2 ^{a}	65.8 ^{d}	73.91 ^{b}	73.92 ^{b}	77.55 ^{a}
Total caloric values %	353.3 ^{b}	363.6 ^{a}	345.0 ^{c}	353.9 ^{b}	355.2 ^{b}	363.2 ^{a}
β-glucan	0.70 ^{e}	3.90 ^{a}	0.75 ^{e}	1.12 ^{d}	1.50 ^{c}	1.91 ^{b}

*a,b,…Means with the same letter in the same row are not significantly different at (*P>0.05*).*

3.2 Minerals for wheat, barley, millet meals and their mixtures

Minerals for wheat, barley, millet meals and their mixtures were presented on Table 2. It showed that millet was the low significant effect of calcium (8.0 mg) for all samples. Pearl millet accompanying grains of other types have oxalic acid which by forming a complex, which is insoluble, with calcium results in reduction of bioavailability of this mineral [28]. The concentration of calcium in pearl millet is very less and if oxalate is present then the condition will become worse. Iron value ranged between 3.19- 2.50 mg wheat and barley respectively, millet is also a good source of other dietary minerals like manganese, phosphorus and iron [10].The high value of Magnesium (Mg) was 126.0 mg on wheat meal and the lowest value was 79.0 mg barley meal. And the high values manganese and phosphorus was wheat meal (3.99 mg and 288 mg). The highest potassium value was wheat 363.0 mg and the lowest value was millet 195.0 mg. Selenium (Se) value in all samples ranged between 0.003 -0.071 mg. Wheat meal sample was high in zinc value compared to all samples and low value was millet samples. Minerals are located in the germ; therefore, we may expect that they are not completely lost during the refining process. Total content of minerals is 2.3 mg per 100 g which is more in quantity in comparison too their cereals consumed commonly. It is a rich source of potassium, B-vitamin, phosphorous, copper, magnesium, zinc, iron, manganese [29].

Table 2: Minerals for wheat, barley, millet meals and their mixtures.

Minerals mg	Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Calcium (Ca)	29.0 ^{a}	29.0 ^{a}	8.0 ^{b}	25.7 ^{a}	25.2 ^{a}	24.70 ^{a}
Iron (Fe)	3.19 ^{a}	2.50 ^{a}	3.0 ^{a}	2.82 ^{a}	2.77 ^{a}	2.71 ^{a}
Magnesium (Mg)	126.0 ^{a}	79.0 ^{c}	114.0 ^{b}	111.5 ^{b}	109.5 ^{b}	107.4 ^{b}
Manganese (Mn)	3.99 ^{a}	1.32 ^{b}	1.60 ^{b}	3.53 ^{a}	3.47 ^{a}	3.40 ^{a}
Phosphorus (P)	288.0 ^{a}	2.21 ^{c}	285.0 ^{a}	255.0 ^{b}	250.2 ^{b}	245.5 ^{b}
Potassium (K)	363.0 ^{a}	280.0 ^{e}	195.0 ^{f}	321.0 ^{b}	315.4 ^{c}	309.4 ^{d}
Selenium (Se)	0.071 ^{a}	0.040 ^{a}	0.003 ^{a}	0.063 ^{a}	0.062 ^{a}	0.061 ^{a}
Zinc (Zn)	2.65 ^{a}	2.13 ^{c}	1.70 ^{d}	2.35 ^{b}	2.30 ^{b}	2.26 ^{bc}

*a,b,…Means with the same letter in the same row are not significantly different at (*P>0.05*).*

3.3 Vitamins for wheat, barley, millet meals and their mixtures

Millets are excellent source of vitamin B. In Table 3 millet was the high level of vitamin C 2.0 % in all samples. Wheat meal was the high value of vitamin E in all samples 7.00 %.Vitamin K ranged between 1.00-2.00 % in all samples. Matured and dried kernels do not have vitamin C but vitamin B is present in sufficient amount in aleurone layer and the germs. Decortications used for removing hull results in reduced levels of niacin, riboflavin and thiamine to an extent of 50 % in flour. In cereals, niacin is present in both bound and free form and is mainly synthesized by using tryptophan [30]. Quantity of niacin is enough even in hulled form of millet.

Table 3: Vitamins for wheat, barley, millet meals and their mixtures

Vitamins %	Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Thiamine(B1)	33.0 ^{a}	17.0 ^{c}	Non ^{d}	29.2 ^{ab}	28.7 ^{b}	28.1 ^{b}
Riboflavin(B2)	10.0 ^{d}	10.0 ^{d}	24.0 ^{a}	20.3 ^{c}	20.9 ^{bc}	21.5 ^{b}
Niacin (B3)	36.0 ^{a}	31.0 ^{bc}	31.0 ^{bc}	31.8 ^{b}	31.3 ^{bc}	30.7 ^{c}
Pantothenic acid (B5)	19.0 ^{a}	6.0 ^{c}	17.0 ^{b}	16.8 ^{b}	16.5 ^{b}	16.2 ^{b}
Pyridoxine(B6)	23.0 ^{c}	20.0 ^{d}	29.0 ^{a}	20.4 ^{d}	24.7 ^{b}	25.2 ^{b}
Folic Acid (B9)	10.0 ^{d}	6.0 ^{e}	21.0 ^{a}	11.2 ^{c}	17.9 ^{b}	18.2 ^{b}
Vitamin C	Non ^{c}	Non ^{c}	2.0 ^{a}	0.5 ^{c}	1.1 ^{b}	1.7 ^{a}
Vitamin E	7.0 ^{a}	Non ^{e}	Non ^{e}	5.0 ^{b}	3.4 ^{c}	1.7 ^{d}
Vitamin K	2.0 ^{a}	2.0 ^{a}	1.0 ^{b}	1.85 ^{a}	1.93 ^{a}	1.96 ^{a}

a,b,…Means with the same letter in the same row are not significantly different at ($P>0.05$*).*

3.4 Mycotoxins content for wheat, barley and millet grains

Results in Table 4 show that Mycotoxin content in wheat, barley and millet grains. It can be noticed that the sample before storing had under detection limit (0.5 ppb) for aflatoxin, ochratoxin, zearalenone, fumonisin. More ever it can be concluded that the sample wheat, barley and millet were under detection limit (0.5 ppb) of the stander Egyptian maximum (B1=10 ppb and total aflatoxin =20 ppb). Aflatoxin content was valet within the safe limit 50 ml/kg recommended by FAO [31].

Table 4: Mycotoxins content for wheat, barley and millet grain

Mycotoxins		Wheat	Barley	Millet
Mycotoxins		*	*	*
Ochratoxin ppb		*	*	*
Zearalenone ppb		*	*	*
Fumonisinppb		*	*	*
Aflatoxin ppb	B1	*	*	*
	B2	*	*	*
	G1	*	*	*
	G2)	*	*	*
	Total	*	*	*

***=** Under detection limit (0.50 ppb).

3.5 Physical properties of wheat, barley and millet kernels cultivars

Mean values of physical properties of wheat, barley and millet were presented in Table 5. It can be concluded that the test weight for all samples which ranged from 43.1 pound per bushel for millet to 60.1 pound per bushel for wheat. Percentage of shrunken and broken of wheat was (1.10 %) while thin and sound of barley was highest percentage (2.80 %- 95.46 %). For damage kernels which contest of heat damage and total damage, especially wheat have highest total damage kernels percentage (1.5 %) while barley and millet were lowest percentage of total damage kernels (0.83 %). It can be noticed that the wheat, barley and millet haven't heat damage. More over from the same table noticed that all sample are free from insect and OK odor. Results in Table 5 showed that weight per 1000 of kernels wheat, barley and millet have highest value (60.0 gm), barley 49.50 gm while wheat has lowest value (33.50 gm). For addition the kernel colour in wheat sample is red whereas barley is white and millets green. These results are in agreement with thus obtained by the Egyptian stander no. 1601/1986 and it's modification on 23/4/2002 [32] has obligation that the dockage % (first separated from sample) not exceed 1 %, foreign material % not exceed 1 %, total damage kernels % (heat damage ,sprout damage, insect damage and mould damage kernels) not exceed than 4 %. However that difference between wheat samples, all wheat samples had graded one [15].

Table 5: physical properties of wheat, barley and millet kernels cultivars

Parameters		Wheat	Barley	Millet
Moisture Content	(M.C) %	10.4 ^{a}	10.2 ^{a}	8.70 ^{b}
Test weight	(T.W) p/b	60.10 ^{a}	49.0 ^{b}	43.10 ^{c}
Broken kernels & Foreign Material (BNFM) %		0.20 ^{b}	1.0 ^{a}	0.77 ^{a}
Sh.&B.N %		1.10 ^{a}	0.33 ^{b}	0.45 ^{b}
Thin		-	2.80	-
Sound		-	95.46	-
Damage Kernels (D.K) %	Heat Damage (H.D) %	0.0	0.0	0.0
	Total Damage (T.D) %	1.50 ^{a}	0.83 ^{b}	0.83 ^{b}
Odor		Ok	Ok	Ok
Insect		Free	Free	Free
Weigh per 1000 kernels gm		33.50 ^{c}	49.50 ^{b}	60.0 ^{a}
Hardness %		61.0 ^{b}	50.0 ^{c}	75.0 ^{a}
Colour		Red	White	Green

a,b,…Means with the same letter in the same row are not significantly different at (P>0.05).

p/b= Pound per Bushel (American unit),

3.6 Physicochemical properties of wheat, barley, millet mealsand their mixtures

The data in Table 6 showed that the highest starch damage was in barley meal (11.20 %) while mix 3 meal was the lowest (2.75 %). It could be noticed from that the wet and dry gluten of control sample was 25.60 % and 7.70 % respectively, with a gluten index of 61.41. Upon substituting wheat with 25 % (barley and millet meal), wet and dry gluten contents were 20.10 % and 5.9 %, respectively, with a gluten index of 62.80, and also, increasing the level of barley and millet meal, the gluten content (either wet or dry) and the gluten index decreased. Gluten is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten reflects protein content and is a common flour specification required by end-users in the food industry and the results are in concordance with previous study [33]. From Table 6 it can be concluded that the percentage of protein sediment ranged from 10% for wheat to 28 % for barley meals and reviewed that the falling number values were ranged from 240 to 512 sec., and wheat meal had the highest value 512.0 sec. while mix 3 meal had lower values 240.0 sec.,. It can observe that addition of barley and millet at different level to wheat meal decrease the value of falling number and developed for enzyme activity of Alfa amylase and rheological properties of dough. Generally, a falling number value of 350 seconds or longer indicates low enzyme activity and very sound wheat. As the amount of enzyme activity increases, the falling number decreases. Economic European community recommended that the falling number of flour should exceed than 230 sec [34]. Also, for durum wheat has obligation that protein content of durum wheat not less than 10.5 % and ash content not exceed than 1.3 % [35]. At the end of the Table 6 it showed that the barley had the highest value of whiteness color 32.5 % and the lowest values of yellow color 14.53 %, then the millet meal which is less whiteness 2.96 % and highest value of yellow color 23.32 %. Flour color often affects the color of the finished product and is therefore one of many flour specifications required by end-users. Generally speaking, bright white color flour is more desirable for many products and the results are in concordance with D'Appolonia and Emeritus [36].

Table 6: physicochemical properties of wheat, barley, millet meals and their mixtures

Parameters		Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Starch damage %		7.00^{b}	11.20^{a}	7.05^{b}	4.70^{c}	4.75^{c}	2.75^{d}
Gluten quantity	Wet %	25.6^{a}	Free	Free	20.1^{b}	Free	Free
	Dry %	7.7^{a}	Free	Free	5.90^{b}	Free	Free
	Hydration ratio%	17.9^{a}	Free	Free	14.20^{b}	Free	Free
	Index %	61.4^{b}	Free	Free	62.80^{a}	Free	Free
Protein sediment %		10.0^{e}	28.0^{a}	25.0^{b}	18.00^{d}	20.00^{c}	24.00^{b}
Falling number sec.		512.0^{a}	431.0^{b}	254.0^{e}	349.0^{c}	290.0^{d}	240.0^{f}
flour colour %	White	11.5^{e}	32.7^{a}	2.96^{f}	16.24^{d}	19.58^{c}	20.30^{b}
	Yellow	20.63^{b}	14.53^{f}	23.32^{a}	18.74^{c}	17.40^{d}	16.98^{e}

a,b,…Means with the same letter in the same row are not significantly different at ($P>0.05$*)*

Free= free of wheat gluten.

3.7 Rheological properties of wheat, barley, millet meals and their mixtures

Water absorption (WA) is a parameter indicated as the amount of water needed to develop the standard dough at the peak of the curve. Consistographe parameters of the macaroni flours resulted from different grain meals and their mixtures showed that water absorption (WA %) decreased from 54.6 % for the control sample made from wheat to 35.0 % for millet in Table 7. Higher water absorption is required for good bread characteristics which remain soft for a longer time. The gradual decrease in WA % was found to be due to decreasing the level of barley and millet from 25 to 75 %. This decrease can be attributed to lower gluten-starch network formation which is responsible for water absorption, as the ratio of wheat in blends. Those results were agreement with Young, *et al.,* who said that the presence of damaged starch tends to increase water absorption [37 and Sanz-Penella *et al.* [38] reported that the inclusion of a higher amount of bran in the dough formulation usually resulted in increased dough water absorption due to the higher levels of pentosans present in bran. The alveograph determines the gluten strength of dough by measuring the force required to blow and break a bubble of dough. The Tenacity (P) was (156 mm H2O) for wheat to (19.0 mm H2O) for mix 2 Table 7. So that wheat flour was the high significant effect value (15 mm, 8.60 ml) of Expandability and Swelling (G) while mix 2 was the low significant effect (9.00 mm, 6.70 ml). The P/L value is high significant effect in mix 1 (14.70 %) and the low significant effect was mix 2 (6.70 ml). Baking strength (W) was the high significant effect in wheat (108.0 jol). W is the most widely used characteristic because it summaries all the others. The very different shapes of the curves from 'extreme' individuals indicate the great variation in dough strength and extensibility present in the core collection. Also**,** table 7 showed the transition point, maximum viscosity and temperature at maximum viscosity as measured by amylograph. The data revealed that transition point (°C) of wheat was 68.45°C followed by mix1 (63.91 °C). The maximum viscosity was arranged in the descending order as follows: barley (511.40 B.U.) > wheat (342.10 B.U.) which in parallel with the temperature of 94.0 °C and 92.0 °C, respectively. Our results are in agreement by Lee, *et al*.[39] how reported that amylograph parameters indicated that hull-less barley had lower gelatinization temperature and higher maximum viscosity than the hull-barley as a result of the presence of beta-glucan with a higher ratio in hull-less barley and Symons and Brennan suggested that a reduction in maximum viscosity of hull-barley may be associated with a reduced enthalpy of starch gelatinization, and retention of the integrity of the starch granule [40].

Table 7: Rheological properties of wheat, barley, millet meals and their mixtures

	Parameters	Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Consist graph	Water absorption %	54.60^{a}	47.2^{d}	35.0^{e}	52.40^{b}	49.5^{c}	47.3^{d}
Alveograph test	Tenacity mmH2O (P)	156.00^{a}	-	-	133.00^{a}	19.0^{b}	-
	Expandability mm (L)	15.00^{a}	-	-	10.00^{ab}	9.00^{b}	-
	Swelling ml (G)	8.60^{a}	-	-	7.00^{b}	6.70^{b}	-
	Baking strength Jol (W)	108.00^{a}	-	-	61.00^{b}	9.0^{c}	-
	Confiiguration rate % (p/L)	10.40^{b}	-	-	14.78^{a}	1.9^{c}	-
Amylograph	Transition point (Cº)	68.45^{a}	55.21^{d}	45.32^{f}	63.91^{b}	59.35^{c}	54.82^{e}
	Maximum viscosity (B.U.)	342.1^{f}	511.4^{a}	501.9^{b}	383.2^{e}	424.1^{d}	465.4^{c}
	Temperature at maximum viscosity (Cº)	92^{a}	94^{a}	96^{a}	91^{a}	93^{a}	94^{a}

*a,b,…Means with the same letter in the same row are not significantly different at (*P>0.05*).*

3.8 Chemical composition of macaroni obtained from wheat, barley, millet meals and their mixtures

The chemical composition of macaroni produced from the different levels of wheat, barley, millet meals was reported in Table 8. The data revealed that no significant effect of the moisture content for macaroni meal. Protein content decreased from 13.10 gm/100 gm for control to 9.60 gm/100 gm for barley. These findings were in close range with Salem [33]. Fat content increased from 1.11 gm/100 gm for wheat macaroni to 3.3 gm/100 gm for millet which agreement with result has been reported by Sawsan*, et al.* [41]. Ash content increased from1.00 gm/100 gm for barley macaroni to 1.5 gm/100 gm for millet macaroni. The increase in ash content may be due to the higher ash content of millet (1.80 gm/100 gm). As for crude fiber, the content increased from1.30 gm/100 gm for wheat macaroni to 7.20 gm/100 gm for millet; this may be due to the high fiber content of millet compared with wheat. Total carbohydrates decreased from 74.9 (for barley) to 66.10 gm/100 gm (for millet). Total caloric values increased from 337.3 to 351.5 gm/100 gm for millet and barley, respectively and these results are parallel with the results obtained by Salem [33].

Table 8: Chemical composition of macaroni obtained from wheat, barley, millet meals and their mixtures

Chemical composition	Wheat	Barley	Millet	Mix 1	Mix 2	Mix 3
Moisture content %	12.5^{a}	10.8^{a}	11.1^{a}	12.1^{a}	11.7^{a}	11.3^{a}
Protein content %	13.1^{a}	9.6^{c}	10.8^{bc}	12.5^{ab}	11.9^{ab}	11.3^{bc}
Fat content %	1.11^{b}	1.5^{b}	3.3^{a}	1.43^{b}	1.8^{b}	2.1^{ab}
Ash content %	1.22^{ab}	1.0^{b}	1.5^{a}	1.22^{ab}	1.23^{ab}	1.24^{ab}
Fiber content %	1.3^{d}	2.2^{cd}	7.2^{a}	2.15^{cd}	3.0^{bc}	3.85^{b}
Carbohydrates %	70.77^{b}	74.9^{a}	66.1^{c}	70.6^{b}	70.37^{b}	70.21^{b}
Total caloric values%	345.47^{b}	351.5^{a}	337.3^{c}	345.27^{b}	345.28^{b}	344.94^{b}

*a,b,…Means with the same letter in the same row are not significantly different at (*P>0.05*).*

3.9 Effect of macaroni obtained from wheat, barley, millet meals and their mixtures on the cooking quality

Cooking performance is an important factor in a consumer's judgment of macaroni quality. Table 9 revealed that macaroni cooking time decreased from control to mix 3 (10.00 to 5.5 min) with increased level of mixed. Addition of mixed meal to the macaroni resulted in lower cooking time for complete gelatinization of starch as compared to control. The data revealed that no difference significant in macaroni weight. Similar trend was found regarding volume. While explained such trend be the high levels of total dietary fiber and β-glucan in barley and as a result increasing the water holding capacity of macaroni [42]. The cooking loss was increased by substitution with barley 10.34 % compared to wheat macaroni 4.35 %, then after increased level of mixed. The cooking loss is an indicator of the capability of the starch-protein matrix to retain its physical integrity during cooking [43], and only values lower than 7 % are acceptable for a good quality pasta [44]. Generally, non-starch polysaccharide addition increased the cooking loss [45 and Makhlouf [46] explained that increased amount of barley present in the semolina matrix had disrupted the protein-starch network, causing starches to leach out during the cooking, and consequently resulting in a decrease in pasta cooking quality.

Table 9: Effect of macaroni obtained from wheat, barley, millet meals and their mixtures on the cooking quality

	Treatments	Cooking time (minutes)	Weight increase (%)	Volume increase (%)	Cooking loss (%)
Macaroni meal	Wheat	10.0^{a}	180^{a}	190^{a}	4.35^{d}
	Barley	7.7^{b}	196^{a}	205^{a}	10.3^{a}
	Millet	5.9^{c}	192^{a}	200^{a}	5.5^{c}
	Mix 1	6.5^{bc}	181^{a}	188^{a}	4.52^{d}
	Mix 2	6.2^{bc}	190^{a}	200^{a}	5.25^{c}
	Mix 3	5.5^{c}	192^{a}	200^{a}	8.15^{b}

a,b,…Means with the same letter in the same row are not significantly different at (P>0.05).

3.10 The change in density as affected by cooking of macaroni made from wheat, barley, millet meals and their mixtures

To confirm the rheological data, density of macaroni was determined before and after cooking Table 10. The data revealed that no difference significant in macaroni volume before cooking, but after cooking millet was highest values 28.0 cm^2 and wheat was the lowest values of volume 23.0 cm^2. So that revealed that no difference significant in macaroni's weight and density before cooking but millet macaroni was the highest value for weight of macaroni after cooking. Mix 2 was highest values of density after cooking. These findings are in agreement with previous study of Salem [33]. This decrease may be due to the amount of water absorbed during cooking.

Table 10: The change in density as affected by cooking of macaroni made from wheat, barley, millet and their mixtures before and after cooking

	Treatments	Volume (cm^2)		Weight (gm)		Density (gm/ cm^2)	
		(Before)	(After)	(Before)	(After)	(Before)	(After)
Macaroni meal	Wheat	7.25^{a}	10.0^{a}	10.01^{a}	29.08^{c}	1.38^{a}	1.26^{ab}
	Barley	7.25^{a}	7.7^{b}	10.0^{a}	30.71^{a}	1.38^{a}	1.13^{b}
	Millet	7.26^{a}	5.9^{c}	10.05^{a}	31.0^{a}	1.38^{a}	1.11^{b}
	Mix 1	7.23^{a}	6.5^{bc}	10.03^{a}	29.85^{b}	1.38^{a}	1.25^{ab}
	Mix 2	7.21^{a}	6.2^{bc}	10.01^{a}	30.02^{b}	1.38^{a}	1.33^{a}
	Mix 3	7.24^{a}	5.5^{c}	10.0^{a}	30.26^{b}	1.38^{a}	1.16^{b}

a,b,…Means with the same letter in the samecolum are not significantly different at (P>0.05).

3.11 Effect of adding different wheat, barley, millet meals and their mixtures on color parameters of macaroni product

Color plays a major role in consumer's perception and acceptability of the product. The observed color value of cooked macaroni with different combinations of the ingredients varied from L=92, a=-0.91 and b=10.41 for wheat while for millet flour the values were 52.0, -0.51 and -5.88 for L, a and b respectively, as shown in Table 11. And in this table represents change in lightness (L*) value of macaroni millet significantly decreased the lightness (L*) value of prepared macaroni. As the level of mixed meal (barley and millet) increased, the lightness (L* value) and redness (a* value) decreased, but the brightness (b* value) increased, this increase may be due to presence of barley and millet which gives macaroni a yellow tint, as they are rich sources of carotenoids. This may be due to the brick red color of finger millet seed coat and grey color of pearl millet flour [47] and Rathi, *et al.* [48]observed that L* value of pasta prepared from native pearl millet was lower than the pasta prepared from depigmented pearl millet flour. This difference in color of millet flours is due to the polyphenolic pigments present in pericarp, aleuronic layer and in endosperm region [49].

Table 11: Effect of adding different wheat, barley, millet meals and their mixtures on color parameters of macaroni product

Treatments		Brightness "L"	Redness"a"	Yellowness "b"
		L*	a*	b*
Macaroni meal	Wheat	92.0 ^{a}	-0.91 ^{e}	10.41 ^{a}
	Barley	86.5^{ab}	-0.61^{bc}	8.97 ^{c}
	Millet	52.0 ^{d}	-0.51 ^{b}	-5.88 ^{d}
	Mix 1	86.31^{ab}	-0.18 ^{a}	9.66 ^{b}
	Mix 2	80.63^{bc}	-0.65 ^{cd}	-8.17 ^{e}
	Mix 3	74.94 ^{c}	-0.74 ^{d}	-8.92 ^{f}

*a,b,c,d…Means with the same letter in the same colum are not significantly different at (*P>0.05*).*

3.12 Sensory evaluation of macaroni made from wheat, barley, millet mealsand their mixtures

Table 12 revealed that a high significant differences in appearance at wheat and barley then mix 3 macaroni (17.14, 17.0 and 16.35 %), respectively. Meanwhile, a highly significant decrease was found as a result of millet macaroni (10.30 %). A similar observation has been agreement with results reported by Salem [33]. Flavor showed significant decrease in millet macaroni but all produced macaroni showed that a non-significant differences in flavor. Taste showed high significant difference at wheat macaroni then barley then mix1 (17.14, 16.28, 14.21 %), respectively. The texture of macaroni was found maximum with barley + mix1 and lowest was found with millet. Color showed high significant difference at mix 2 and low significant difference in millet (8.78- 5.57 %). It could be noticed that the overall quality values of tested macaroni were found to be high acceptable and scores ranged between 85.19, 84.91 % for barley and control then after that mix (1) 78.29 % but the lowest was for millet 51.88 %. Sensory evaluation is most reliable test as it allows overall characteristics of cooked macaroni. The overall acceptability of cooked macaroni within the combinations varied from 51.88 to 85.19. It was shown decreased overall acceptability by increasing the proportion of barley and pearl millet meals. This may be due to unattractive dark color of finger millet and grey to yellow color of millet which limits the wider acceptability of its food products.

Table 12: Sensory evaluation of macaroni made from wheat, barley, millet meals and their mixtures

Macaroni	Appearance 20%	Flavour 20%	Taste 20%	Texture 10%	Colour 10%	Mouth feeling 20%	Overall 100%
Wheat	17.14 ^{a}	17.0 ^{a}	17.14 ^{a}	8.07 ^{b}	7.92 ^{c}	17.64 ^{b}	84.91 ^{a}
Barley	17.0 ^{a}	16.85 ^{a}	16.28 ^{b}	8.50 ^{a}	8.64 ^{ab}	17.92 ^{a}	85.19 ^{a}
Millet	10.28 ^{e}	10.30 ^{b}	10.13 ^{f}	5.10 ^{d}	5.57 ^{e}	10.50 ^{d}	51.88 ^{d}
Mix 1	15.78 ^{c}	14.35 ^{a}	14.21 ^{c}	8.39 ^{a}	8.60 ^{b}	16.96 ^{c}	78.29 ^{b}
Mix 2	15.28 ^{d}	14.0 ^{a}	12.84 ^{e}	8.07 ^{b}	8.78 ^{a}	17.59 ^{b}	76.56 ^{c}
Mix 3	16.35 ^{b}	14.07 ^{a}	14.07 ^{d}	7.82 ^{c}	7.28 ^{d}	16.82 ^{c}	76.36 ^{c}

a,b,…Means with the same letter in the same colum are not significantly different at ($P>0.05$*).*

4. CONCLUSION

It can be concluded that the present study was found that the wheat, barley and millet meals fortified macaroni offer a broader spectrum for people opinion to improve the nutritional quality of their diet. Barley and millet were highest nutritious which were rich in health promoting photochemical and dietary fiber. The mixed macaroni was slightly darker in appearance. Macaroni made of mixed meal grains showed lower water absorption and higher volume. The results showed that macaroni with good nutritional and functional properties can be obtained from barley then mix 1, mix 2, and mix 3, respectively. Mixed meal grains could be effectively utilized for high quality macaroni which will increase the meal grain consumption and likely to reduce the risk of degenerative diseases.

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