Egypt. J. Food. Sci. **Vol. 47,** No. 1, pp. 65- 79 (2019)

Egyptian Journal of Food Science
http://ejfs.journals.ekb.eg/

Utilization of Defatted Mustard and Garden Cress Seeds Flour in The Production of Highly Nutritious Noodles

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DEFATTED yellow mustard and/or garden cress seed flours were incorporated into noodle formulations at levels up to 20% with the aim of producing noodles with higher nutritional benefits. Nutritional value and quality characteristics of noodles were investigated. Macronutrients, mineral content, amino acids profile, protein quality parameters, cooking quality and sensory characteristics of noodles were studied. Results showed that incorporation of defatted seed flours resulted in an increase in protein and fiber contents up to 1.41 and 4.62 times than the control ones, respectively, while carbohydrate and fat contents were decreased. Noodles containing defatted seed flour had considerably higher amounts of minerals (e.g. calcium, iron, phosphorus, magnesium, manganese, and zinc). Improvement in the essential amino acid profile of the produced noodles was observed with higher values of essential amino acid index (EAAI), biological value (BV) and protein efficiency ratio (PER). Cooking quality tests showed that incorporation of defatted mustard and/or garden cress seed flours into noodle formulations led to a higher cooking loss, water uptake, and volume increase. Sensory evaluation indicated that all noodles containing defatted mustard and/or garden cress seed flours were acceptable with regard to color, softness, stickiness, taste, odor and overall acceptability. However, noodles containing defatted garden cress flour had significantly lower, but still acceptable scores.

Keywords: Noodles, Defatted mustard, Garden cress, Supplementation, Nutritional value, Protein quality, Cooking quality, Sensory evaluation.

Introduction

Noodles is one of the staple foods originated and consumed in many Asian countries. Currently, noodles have become internationally recognized and their worldwide consumption is rising (Gulia et al., 2014 and Karim & Sultan, 2015). According to WINA (2018), more than one hundred billion servings of instant noodles were eaten in 2017. This could correspond to as many as 270 million servings are eaten every day. Regardless of the area, age and gender, noodles are being recognized now as "a global food". The main three basic ingredients of wheat-based noodles are: wheat flour, water, and salt. Fine wheat flour is the common flour type that is used in Noodle products (Fu, 2008).

The addition or supplementation with nutritious food ingredients or natural products is an important trend to improve the nutritional quality of noodles (Karim & Sultan, 2015 and Filip & Vidrih, 2015). Fortification with Protein is of current interest because of the increasing awareness of consumers towards nutrition, food quality and their relation to human health. Moreover, international, governmental guidelines and policies across the globe are now focusing

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Received: 8/6/2019; accepted: 2/9/2019
DOI: 10.21608/EJFS.2019.13502.1008

on the improvement of individuals' health and nutritional status (Tyagi et al., 2007; FAO, 2012; Pakhare et al., 2018). However, the fortification of noodles can be optimized by the use of protein and/or fiber rich materials (Kudake et al., 2018 and Pakhare et al., 2018)

The fortification of Instant noodles can be performed either by the fortification of flour used to make noodles like addition of gluten, other flours such as soya, barley, oats, buckwheat (Van hung et al., 2007 and Pakhare et al., 2018), legumes (Bahnassey & Khan, 1986 and Bergman et al., 1994) and other seeds (like those belong to family *Brassicaceae*) or by fortifying the seasoning consumed along with the noodles (Mirdula et al., 2006 and Kaur et al., 2013).

Yellow mustard (*Sinapis alba* L.), synonymous with white mustard, is a spring annual crop of the family *Brassicaceae* with good adaptation ability to hot and dry growing conditions (Brown et al., 2005). The mustard seed is rich in excellent nutritional quality protein, being rich in lysine with adequate amounts of sulfur-containing amino acids, the limiting amino acids in most of the cereals and oilseed proteins (Sadeghi and Bhagya, 2008). Moreover, mustard flour was found to have considerable amounts of fiber and minerals such as calcium, iron, manganese and zinc (Dini et al., 2008). Thus, the use of protein rich full fat and defatted mustard flour shows promise in improving the nutritional quality of the final product as well as optimum utilization of flour (Tyagi et al., 2007).

Garden cress (*Lepidium sativum*) is a fast-growing annual edible herb that also belongs to the family *Brassicaceae* that is native to Egypt and west of Asia, and presently cultivated all over the world. It is related to both watercress and mustard, sharing their, tangy, peppery flavor and aroma (Cassidy and Hall, 2002 and Singh et al., 2015).

Garden cress seeds are reddish brown in color with a small and oval shape, pointed and triangular at one end, with a length of about 3-4, and a width of 1-2 mm (Chaudhary and Gupta, 2017). The inclusion of garden cress seeds in the human diet has been tested over time, and its numerous benefits have been documented and observed throughout different communities and cultures (Juma and Martin, 2011).

Zia-Ul-Haq et al. (2012) reported that garden cress seeds contain appreciable amounts of 24.2, 23.2, 30.7, 11.9, 7.1 and 2.9% of protein, lipids, carbohydrates, fiber, ash, and moisture, respectively. Moreover, data obtained by Chaudhary and Gupta (2017) showed the rich mineral content of whole garden cress seeds, especially of Calcium (391.7 mg/100g), phosphorus (613.2 mg/100g) and potassium (1449.3 mg/100g), that boosts their potential to be used as a good source of minerals. In addition, the usage of garden cress seeds into different foods formulations had a significant impact on the essential amino acid composition and protein nutritional quality (Jain et al., 2016).

Since the available literature on mustard and garden cress fortified noodles products is rather limited, the present investigation was undertaken to study the possibility of using defatted mustard and/or garden cress seed flours as rich sources of protein, minerals and fiber in the production of high nutritional value noodles and their effects on the quality characteristics of the produced noodles.

Materials and Methods

Materials

Wheat flour (72% extraction) was purchased from the local market (El-Doha Co., 10th of Ramadan city, Egypt). Mustard (*Sinapis alba* L.) and garden cress (*Lepidium sativum* L.) seeds were obtained from a local herb and plant seeds provider (Harraz Market , Cairo, Egypt).

Methods

Preparation of defatted mustard and garden cress seeds flour

Defatted yellow mustard seed flour (DYMSF) was prepared according to the method described by Abul-Fadl et al. (2011) with some modifications as follows:

Mustard seeds were cleaned to remove stones and sand by hand and by sieving. For the preparation of flour, mustard seeds were first crushed using a manual mortar and pestle, and soaked overnight in petroleum ether. The crushed seeds were then drained and the remining solvent was evaporated in a forced air oven (60^{o}C to a constant weight). Then the crushed extracted seeds were ground into small particles in Retsch rotor mill (type SK100, Retsch , Germany). The particles were defatted in Soxhlet apparatus using petroleum ether. The obtained defatted mustard meal was dried in a forced air oven at 60^{o}C to a constant weight, and then was milled again to obtain flour passing through a 20 mesh size sieve. The defatted mustard seed flour was then kept in polyethylene bags for further usage.

The same procedure was used for the preparation of defatted garden cress seed flour (DGCSF) except that the seeds were slightly roasted in a forced air oven (at 150 ^{o}C for 5 min.) before grinding to enhance the flavor (Jain et al., 2017).

Preparation of noodles

Wheat flour or wheat-defatted seed flour (*i.e.* DYMSF and/or DGCSF) mixtures (as shown in Table 1) and salt (1% W/W) were mixed together in Pastamatic pasta maker machine (Pastamatic, Simac 1000N, Treviso, Italy). Water (30% V/W) was added gradually while kneading the mixture for 15 minutes. Then, the dough was allowed to press through the die and noodles were cut by a sharp knife to 20 cm length. Afterwards, noodles were dried at 55^{o}C for 14 hr and were kept in polyethylene bags till further tests.

Chemical composition

Proximate chemical composition of raw materials used in this study (*i.e.* wheat flour, DYMSF and DGCSF) and the produced noodles was determined according to the methods outlined in AACC (2010). The methods used to determine moisture, protein, oil, crude fiber and ash were those of numbers (44-15.02), (46-12.01), (30-25.01), (32-10.01) and (08-01.01), respectively.

Total Carbohydrate contents (as nitrogen free extract, NFE) was calculated by difference.

Caloric value of noodles was calculated from the following equation :

Caloric value (Kcal/100g) = (% carbohydrates x 4) + (%protein x 4) + (% fat x 9)

Mineral content determinations

Calcium, iron, manganese, phosphorus, potassium, sodium, zinc and magnesium were determined in raw materials and noodles by using Perkin-Elmer atomic absorption spectrometer 3300 (Perkin-Elmer Ltd., Norwalk, CT, USA) according to the methods numbers 40-70.01 and 40-71.01 of AACC (2010).

Amino acid contents determination

Amino acids were determined using a Mikrotechna AAA881 automatic amino acid analyzer according to the method of Moore and Stein (1963) that was described by Rutherfurd and Gilani (2009) with samples being hydrolyzed in the presence of 6 M HCl at 110^{o}C for 24 h under a nitrogen atmosphere. Sulfur-containing amino acids were determined after performic acid oxidation. The chemical method of Miller (1967) was used to determine Tryptophan.

Protein nutritional quality

The quality of noodles' protein was determined by using different measurements as follows:

Essential Amino Acid Index (EAAI)

Essential Amino Acid Index (EAAI) was calculated using the equation of Oser (1959). Whole egg protein was used as a standard reference protein as follows:

TABLE 1 . Formulations of noodle flour mixtures *.

Flour mixture code	Wheat flour (g)	Defatted yellow mustard seed flour (DYMSF) (g)	Defatted garden cress seed flour (DGCSF) (g)	Salt (g)
Control	100	0	0	1
M10	90	10	0	1
M20	80	20	0	1
G10	90	0	10	1
G20	80	0	20	1
MG10	90	5	5	1
MG20	80	10	10	1

* Control = noodles containing 100% wheat flour , M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF

$$EAAI = \sqrt[n]{\frac{100a \times 100 \ldots .100j \times 100}{av \times bv \ldots jv}}$$

Where: n = number of essential amino acids, a, b …..j = represent the concentration of essential amino acids (lysine, tryptophan, isoleucine, valine, arginine, threonine, leucine, phenylalanine, the sum of methionine and cystine plus histidine) in test sample and av, bv ….. jv = content of the same amino acids in standard protein (%) , respectively.

Biological Value (BV):

Biological value of protein was computed according to the method of Oser (1959) as follows:

BV = 1.09 (EAAI) – 11.7.

Protein Efficiency Ratio (PER):

PER of noodles' protein was calculated according to the equation described by Alsmeyer et al., (1974) as follows :

$PER = 0.06320 [X_{10}] - 0.1539$

Where X_{10} = threonine + valine + methionine + isoleucine + leucine + phenylalanine + lysine + histidine + arginine + tyrosine.

Cooking quality of noodles

Weighed samples (10 g) of control and defatted seed flour supplemented noodles were cooked in 250 ml boiling distilled water. Cooking loss was assessed according to the method 66-50.01 (AACC, 2010) as follows :

Cooked samples were drained for 5 min and immediately weighed. The drained water was collected and the volume was noted. Twenty milliliters of the drained water was transferred to an evaporating dish and dried at 105 ̊C until a constant weight was attained. Cooking loss (%) was calculated based on the dry weight of noodles.

Percent water absorption and volume expansion ratios were calculated from the increase in weight and volume of noodles on cooking for the optimum cooking time as the following

$$\%\ \text{Water absorption} = \frac{\text{Noodles weight after cooking (g)} - 10}{10} \times 100$$

$$\%\ \text{Volume expansion} = \frac{\text{Noodles volume after cooking} - \text{noodles volume before cooking}}{\text{noodles volume before cooking}} \times 100$$

Sensory evaluation of noodles

Sensory evaluation was carried out on the cooked noodles by 10 trained panelist judges in the Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. The panelists were asked to evaluate and score different quality characteristics, including color, softness, stickiness, taste, odor and overall acceptability on a 10-point hedonic scale and the scores were statistically analyzed afterward.

Statistical analysis

Data obtained from different tests of raw materials and noodles were analyzed by Analysis of Variance using General Linear Model (GLM) procedure within a package program of Statistical Analysis System (SAS, 1999). Means were separated using Least Significant Difference (L.S.D) test at a degree of significance ($P< 0.05$).

Results and Discussion

In the present study, the effect of incorporating defatted mustard and/or garden cress seed flours at levels up to 20% (wheat flour basis) on the nutritional value, cooking quality and sensory characteristics of noodles was studied.

Chemical composition of raw materials

Proximate chemical composition of used raw materials (*i.e.* wheat flour, DYMSF and DGCSF) is shown in Table 2. In general, DYMSF and DGCSF were found to have higher protein, crude fiber and ash contents, and lower carbohydrate (determined by difference as nitrogen free extract NFE) contents when compared to wheat flour. In comparison, DYMSF and DGCSF were found to have as much as 2.9 and 2.2 times of the protein content of wheat flour, respectively. The corresponding values with respect to crude fiber were 17.45 and 19, while were 4.7 and 6 times with regard to ash content, respectively.

However, DYMSF was found to contain higher protein content than DGCSF, while DGCSF had higher fiber and ash contents. Carbohydrate contents of DYMSF were lower than that of DGCSF.

These results are close to those obtained by Sarker et al. (2015) who reported that yellow mustard cakes (obtained after the extraction of oil at local oil mills) contains 14.80 % crude fiber and 28.80 % protein. Moreover, Gokavi et al. (2004) found that the whole meal of garden cress seeds contains 22.5, 34.2, 7 and 4.7% of protein, carbohydrate, crude fiber and ash, respectively.

Mineral contents of raw materials

Table 3 shows the mineral (calcium, iron, manganese, phosphorus, potassium, sodium, zinc and magnesium) content of raw materials. In general, DYMSF and DGCSF had very much higher mineral contents than wheat flour. For example, DYMSF and DGCSF had iron contents up to 10 and 9 times as much as of that of wheat flour, respectively. The corresponding values for calcium were 26 and 15 times, 5 times for each of phosphorus, 16 and 9 times for magnesium, respectively.

In comparison between defatted mustard and garden cress seed flours, DYMSF was found to be higher in calcium, iron, manganese, phosphorus and magnesium, while DGCSF was higher in potassium, sodium and zinc.

These results are consistent with those obtained by Özcan (2004), Zia-Ul-Haq et al. (2012), and Chaudhary & Gupta (2017).

Amino acid composition of raw materials

The amino acid composition (expressed as g amino acid/100 g protein) of wheat flour, DYMSF and DGCSF is presented in Table 4. For non-essential amino acids, wheat flour had higher contents of aspartic acid, glutamic acid and proline than both DYMSF and DGCSF. On the other hand, glycine and alanine were higher in both DYMSF and DGCSF. Generally, wheat flour had higher total non-essential amino acids content when compared to test defatted seed flours.

TABLE 2 . Proximate chemical composition of wheat flour, defatted yellow mustard and garden cress seed flours (g/100 g as-is basis).*

	Wheat Flour (72% extraction)	Defatted yellow mustard seed flour	Defatted Garden cress seed flour
Moisture	$11.47^a \pm 0.17$	$7.80^b \pm 0.46$	$6.37^c \pm 0.09$
Crude protein	$11.03^c \pm 0.37$	$32.50^a \pm 1.11$	$24.50^b \pm 0.83$
Oil	$1.82^a \pm 0.05$	$1.19^b \pm 0.15$	$1.63^a \pm 0.06$
Ash	$0.78^c \pm 0.03$	$3.67^b \pm 0.42$	$4.69^a \pm 0.39$
Crude fiber	$0.47^c \pm 0.07$	$8.21^b \pm 0.19$	$8.93^a \pm 0.15$
Carbohydrate (NFE)**	74.44	46.63	53.88

* Results are means ± standard deviation, (n = 3).
Values within the same row with the same letter are not significantly different ($p < 0.05$).
** Nitrogen free extract (NFE) was calculated by difference.

TABLE 3. Mineral content of wheat flour, defatted mustard and garden cress seed flours (mg/100 g dry wight basis).*

	Wheat Flour (72% extraction)	Defatted yellow mustard seed flour	Defatted Garden cress seed flour
Calcium	$16.98^c \pm 1.87$	$442.02^a \pm 3.24$	$250.43^b \pm 2.51$
Iron	$1.11^c \pm 0.12$	$11.66^a \pm 0.66$	$9.58^b \pm 0.47$
Manganese	$0.61^c \pm 0.01$	$5.75^a \pm 0.80$	$1.50^b \pm 0.39$
Phosphorus	$119.03^c \pm 1.53$	$607.12^a \pm 5.27$	$569.59^b \pm 0.84$
Potassium	$93.02^c \pm 2.12$	$835.03^b \pm 5.16$	$1414.13^a \pm 8.43$
Sodium	$4.95^c \pm 0.11$	$8.00^b \pm 1.24$	$15.84^a \pm 2.01$
Zinc	$0.6^c \pm 0.18$	$4.18^b \pm 1.05$	$6.04^a \pm 0.06$
Magnesium	$34.04^c \pm 0.31$	$546.94^a \pm 8.47$	$301.30^b \pm 2.23$

* Results are means ± standard deviation, (n = 3).
Values within the same row with the same letter are not significantly different ($p < 0.05$).

TABLE 4. Amino acids composition of wheat flour, defatted mustard and garden cress seed flours (g/100g protein).

Amino acid	Wheat Flour (72% extraction)	Defatted yellow mustard seed flour	Garden cress seed flour
Aspartic acid	$4.52^{a}\pm0.30$	$2.10^{b}\pm0.27$	$1.94^{b}\pm0.11$
Gultamic acid	$35.50^{a}\pm1.92$	$19.51^{b}\pm0.07$	$17.92^{b}\pm0.10$
Serine	$5.14^{b}\pm0.06$	$5.03^{b}\pm0.24$	$8.64^{a}\pm0.57$
Proline	$11.7^{a}\pm0.63$	$4.34^{b}\pm0.46$	$5.66^{b}\pm0.42$
Glycine	$3.61^{c}\pm0.05$	$5.15^{b}\pm0.34$	$6.31^{a}\pm0.25$
Arginine	$4.20^{b}\pm0.19$	$7.85^{a}\pm0.45$	$6.93^{a}\pm0.09$
Alanine	$3.09^{c}\pm0.42$	$6.02^{b}\pm0.24$	$7.62^{a}\pm0.16$
Histidine**	$2.66^{c}\pm0.16$	$4.49^{a}\pm0.16$	$3.33^{b}\pm0.06$
Valine**	$3.51^{b}\pm0.31$	$6.33^{a}\pm0.12$	$6.05^{a}\pm0.84$
Isoleucine**	$3.95^{a}\pm0.37$	$4.39^{a}\pm0.11$	$4.15^{a}\pm0.12$
Leucine**	$7.01^{a}\pm0.71$	$8.24^{a}\pm0.75$	$7.97^{a}\pm1.58$
Tyrosine	$3.83^{a}\pm0.10$	$4.23^{a}\pm0.24$	$3.99^{a}\pm0.38$
Lysine**	$2.67^{b}\pm0.12$	$6.01^{a}\pm0.30$	$5.51^{a}\pm0.17$
Phenylalanine**	$2.05^{b}\pm0.3$	$4.05^{a}\pm0.23$	$3.41^{a}\pm0.13$
Threonine**	$3.10^{b}\pm0.21$	$5.15^{a}\pm0.32$	$4.38^{a}\pm0.21$
Tryptophan**	$1.14^{b}\pm0.11$	$1.89^{a}\pm0.28$	$1.81^{a}\pm0.14$
Cysteine	$1.26^{b}\pm0.16$	$2.78^{a}\pm0.31$	$2.51^{a}\pm0.21$
Methionine**	$1.22^{c}\pm0.00$	$2.47^{a}\pm0.19$	$1.95^{b}\pm0.08$

* Results are means ± standard deviation, (n =3).
Values within the same row with the same letter are not significantly different ($p < 0.05$).
** Essential amino acids.

Essential amino acids (or indispensable amino acid) are the amino acids that cannot be synthesized by the human body and thus, they must be obtained from diet (WHO/FAO/UNU, 2007). Results indicated that DYMSF and DGCSF had higher contents of essential amino acids than wheat flour. DYMSF had higher valine, isoleucine, leucine, lysine, phenyalanine, therionine, tryptophan and methionine values by 1.8, 1.1, 1.2, 2.3, 2.0, 1.6, 1.7 and 2 times as much as those in wheat flour, respectively. The corresponding values for DGCSF were 1.7, 1.1, 1.1, 2.1, 1.7, 1.9, 1.6 and 1.6 times, respectively.

Mustard seed is known for its rich and excellent nutritional quality protein content. The protein is rich in lysine with adequate amounts of sulfur containing amino acids (Sadeghi and Bhagya, 2008). Additionally, Gokavi et al. (2004) found that the total essential amino acid percentage in garden cress seeds was 47.08% suggesting the potential contribution of this seed to the supply of essential amino acids in the diet.

Chemical composition of noodles

Proximate chemical composition control noodles and those supplemented with levels 10 and 20 % of DYMSF and DGCSF is presented in Table 5. In general, noodles supplemented with DYMSF and/or DGCSF had higher protein contents when compared to the control one. This could be attributed to the significantly higher protein content in those flours when compared to wheat flour. Incorporation of DYMSF and DGCSF at 20% supplementation level led to the production of noodles with higher protein contents by 40.6 and 26 % than the control noodles, respectively. Oil content was slightly decreased with the incorporation of DYMSF and DGCSF, and ranged from 1.71 to 1.9%. As a result of the higher ash contents of DYMSF and DGCSF when compared to wheat flour as previously indicated, noodles containing such two defatted seed flours were found to contain higher ash contents than the control one. One of the advantages observed was the increase in fiber content as noodles containing DYMSF and/or DGCSF were found to have significantly higher fiber content than control noodles.

Noodles supplemented with 20% of DYMSF + DGCSF achieved a higher fiber content up to 4.6 times as that of control ones. The increase in both protein and fiber content was associated with a significant decrease of the calculated carbohydrate content of noodles from 80.23 to 72.77%. Caloric value of noodles was slightly decreased in the supplemented noodles. This could be attributed to the increase in fiber content (Tyagi et al., 2007).

The aforementioned findings of the changes in the chemical composition of resulted noodles agree with those obtained by Mridula et al. (2006), Tyagi et al. (2007), Abul-Fadl et al. (2011), Singh et al. (2015) and Pâucean et al. (2018) with regard to the fortification of noodles and different cereal products with mustard and garden cress seed flours.

Mineral contents of noodles

The mineral content of noodles supplemented with 10 and 20% of DYMSF and DGCSF is presented in Table 6. All tested noodles supplemented with defatted mustard and/or garden cress seed flours had higher mineral contents than control one. Moreover, the content of minerals in noodles was also positively related to seed flour incorporation level. Anyhow, the initial amounts of minerals in defatted seed flours were the determinant factor for the final mineral content in noodles. Calcium was significantly increased by the incorporation of DYMSF and/or DGCSF. The calcium content was increased by 6 and 4 times when DYMSF and DGCSF were added at levels 20%, respectively when compared to control noodles. Iron also was increased by 3 and 2 times for the same 20% DYMSF and DGCSF incorporation levels, respectively. The same trend was observed with other minerals under study (*i.e.* manganese, phosphorus, potassium, zinc and magnesium). With the exception of the sodium content that is mainly attributed to the added salt during noodle processing rather than the incorporation of defatted seed flour, Noodles containing DYMSF had relatively higher contents of calcium, manganese, iron and magnesium than those containing DGCSF.

TABLE 5. Proximate chemical composition of noodles supplemented with defatted yellow mustard and garden cress seed flours (g/100 g)*, **.

	Control	M10	M20	G10	G20	MG10	MG20
Moisture	4.92^{b} ± 0.68	5.41^{ab} ± 0.14	5.58^{a} ± 0.24	5.60^{a} ± 0.11	5.89^{a} ±0.07	5.78^{a} ±0.01	5.66^{a} ±0.24
Crude protein	11.54^{e} ± 0.36	13.78^{cd} ±1.24	16.23^{a} ±1.06	13.14^{d} ± 0.07	14.54^{bc} ±0.11	13.43^{cd} ±0.65	15.67^{ab} ±0.56
Oil	1.90^{a} ± 0.05	1.81^{a} ±0.25	1.76^{a} ±0.14	1.80^{a} ±0.04	1.88^{a} ±0.01	1.71^{a} ±0.00	1.86^{a} ±0.07
Ash	0.89^{d} ± 0.01	1.19^{c} ±0.04	1.41^{b} ± 0.03	1.32^{bc} ±0.02	1.45^{ab} ±0.00	1.36^{bc} ±0.20	1.64^{a} ±0.20
Crude fiber	0.52^{d} ±0.04	1.61^{b} ±0.21	2.23^{a} ±0.01	1.46^{b} ±0.10	2.35^{a} ±0.10	1.28^{c} ±0.06	2.40^{a} ±0.03
Carbohydrate (NFE)***	80.23	76.2	72.79	76.68	73.89	76.44	72.77
Caloric Value (Kcal/100g)	384.18	376.21	371.92	375.48	370.64	374.87	370.50

* Results are means ± standard deviation, (n = 3).
Values within the same row with the same letter are not significantly different (p < 0.05).
** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.
*** Nitrogen free extract (NFE) was calculated by difference.

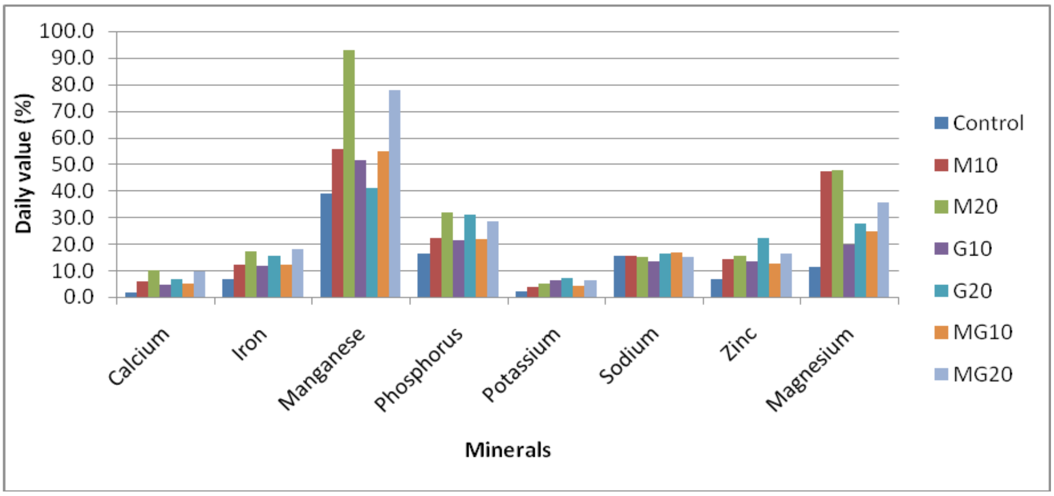
TABLE 6. Mineral content of noodles supplemented with defatted yellow mustard and garden cress seed flours (mg/100 g) * , **.

	Control	M10	M20	G10	G20	MG10	MG20
Calcium	17.6^{f} ±1.98	59.1^{d} ±2.69	100.4^{a} ±4.87	47.7^{e} ±1.05	66.9^{c} ±3.04	50.7^{e} ±0.10	95.4^{b} ±1.00
Iron	1.2^{c} ±0.06	2.2^{b} ±0.14	3.1^{a} ±0.35	2.1^{b} ±0.24	2.8^{a} ±.01	2.2^{b} ±0.52	3.2^{a} ±0.07
Manganese	0.7^{d} ±0.02	1.0^{c} ±0.21	1.7^{a} ±0.00	0.9^{c} ±0.13	0.7^{d} ±0.01	1.0^{c} ±0.07	1.4^{b} ±0.00
Phosphorus	115.4^{d} ± 3.33	155.3^{c} ±1.60	221.9^{a} ± 9.04	150.6^{c} ±0.8	218. 0^{a} ±1.46	152.4^{c} ±1.63	200.2^{b} ±4.52
Potassium	91.2^{f} ±0.45	171.2^{e} ±2.99	234.1^{c} ±2.85	287.3^{b} ±7.13	337.3^{a} ±9.75	204.6^{d} ±2.07	287.4^{b} ±1.03
Sodium	355.0^{b} ± 5.33	355.0^{b} ±5.43	345.8^{b} ±6.24	306.7^{c} ±2.41	377.4^{a} ±1.65	386.3^{a} ±8.20	346.6^{b} ±6.71
Zinc	0.6^{d} ± 0.08	1.1^{c} ±0.09	1.3^{b} ±0.11	1.1^{c} ±0.0.8	1.8^{a} ±0.01	1.0^{c} ±0.00	1.3^{b} ±0.14
Magnesium	35.1^{f} ± 0.68	146.9^{a} ±7.12	148.3^{a} ±4.38	61.0^{e} ±3.04	86.1^{c} ±2.70	76.4^{c} ±0.55	110.6^{b} ±6.66

* Results are means ± standard deviation, (n = 3).
Values within the same row with the same letter are not significantly different (p < 0.05).
** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.

The daily values (DV) of minerals per a 100 g serving of noodles (as % of Dietary Reference Intakes, DRI) of supplemented noodles for both medium aged females and males (age 19-30 years) are illustrated in Fig. 1. An observed increase in the DV was associated with the addition of DYMSF and/or DGCSF. This corresponds to a higher nutritional value. According to USDA (2015), Dietary Reference Intakes (DRI) for medium age adults of calcium, phosphorus, potassium (as adequate intake) and sodium (as tolerable upper intake Level) are 1000, 700, 4700 and 2300 mg/day, respectively. Iron recommended daily intake (RDI) for females was 18 mg/day, while was only 8 mg/day for males. Other RDIs of magnesium, zinc and manganese (as adequate intake) were higher in case of males than in females (2.3 vs. 1.8, 400 vs. 310 and 11 vs. 8 mg/day for males and females, respectively). Control noodles were found to have DV% of 1.8, 6.7, 38.9, 16.5, 1.9, 15.4, 6.9 and 11.3% of calcium, iron, manganese, phosphorus, potassium, sodium, zinc and magnesium, respectively. Incorporation of defatted seed flours led to significant increases in DV % values to be 10.1, 17.1, 92.8, 31.7, 5, 15, 15.6, and 47.8% in case of DYMSF and 6.7, 15.6, 41.1, 31.1, 7.2, 16.4, 22.1 and 27.8% in case of DGCSF for the aforementioned minerals, respectively.

A)



B)

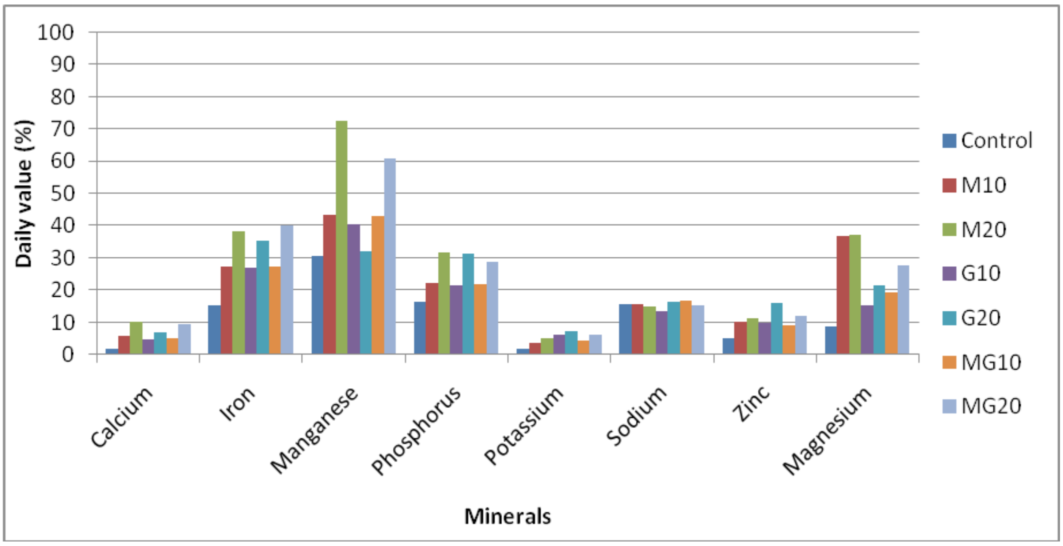


Fig. 1. Percentage daily value (%DV) of minerals provided by 100 g of noodles ("A" is for females and "B" is for males).

Amino acid composition of noodles

The effect of incorporating DYMSF and/or DGCSF on the amino acid composition of noodles is shown in Table 7. Slight variations in most non-essential amino acid contents were observed between control noodles and noodles containing DYMSF and/or DGCSF. An improvement was found in the essential amino acid profile of noodles containing DYMSF and DGCSF as compared to control one. Valine, tryptophan and methionine were increased by 20.2, 15.0 and 23.1% at the incorporation levels of 20% of DYMSF and DGCSF, respectively. Cereals are important sources of protein for human nutrition in many societies; unfortunately, cereal proteins are limitedly utilized by human body because of the lower content of lysine, the first limiting amino acids in cereals (Shewry, 2007). In our study, we found that lysine content of noodles was increased by up to 28% of that of control one at 20% incorporation levels of DYMSF and DGCSF. Furthermore, the second limiting amino acid in cereal products, threonine, was increased by 12.5% at the same incorporation level, which corresponds to better amino acids profile.

TABLE 7. Amino acid composition of noodles supplemented with defatted yellow mustard and garden cress seed flours (g/100 g protein) * .

Amino acid	Control	M10	M20	G10	G20	MG10	MG20
Aspartic	4.85[a] ±0.42	4.45[ab] ±0.43	4.13[b] ±0.18	4.67[ab] ±0.25	4.23[ab] ±0.07	4.46[a] ±0.14	4.23[ab] ±0.21
Gultamic	37.72[a] ±0.15	35.88[ab] ±0.10	34.90[b] ±0.47	35.59[bc] ±1.48	33.67[c] ±1.32	35.65[abc] ±0.30	33. [bc] ±0.17
Serine	5.65[a] ±0.73	5.31[a] ±0.18	5.39[a] ±0.06	5.72[a] ±0.24	6.21[a] ±0.91	5.60[a] ±0.10	5.63[a] ±0.42
Proline	12.38[a] ±0.07	11.34[b] ±0.52	10.86[b] ±0.66	11.67[ab] ±0.38	11.03[b] ±0.28	11.61[b] ±0.30	10.89[ab] ±0.44
Glycine	3.61[c] ±0.24	3.95[bc] ±0.19	4.11[ab] ±0.14	4.06[abc] ±0.23	4.46[a] ±0.21	4.10[ab] ±0.07	4.42[a] ±0.24
Alanine	4.55[b] ±0.34	3.75[a] ±0.44	3.90[a] ±0.44	3.58[a] ±0.23	4.28[a] ±0.24	3.69[a] ±0.07	4.24[a] ±0.88
Argnine	3.41[a] ±0.34	4.7[a] ±0.45	5.11[a] ±0.31	4.65[a] ±0.28	4.94[a] ±0.11	4.66[a] ±0.34	5.00[a] ±0.44
Histidin***	2.47[c] ±0.30	2.9[ab] ±0.14	3.19[a] ±0.01	2.77[bc] ±0.16	2.86[ab] ±0.06	2.88[ab] ±0.06	3.01[ab] ±0.08
Valine***	3.84[c] ±0.17	4.09[abc] ±0.28	4.39[a] ±0.14	3.96[c] ±0.16	4.01[bc] ±0.06	3.91[c] ±0.07	4.34[ab] ±0.10
Isoleucine***	4.51[a] ±0.41	4.16[a] ±0.25	4.31[a] ±0.30	4.13[a] ±0.34	4.13[a] ±0.44	4.20[a] ±0.11	4.15[a] ±0.14
Leucine***	7.66[a] ±0.16	7.58[a] ±0.57	7.64[a] ±0.51	7.53[a] ±0.07	7.58[a] ±0.33	7.54[a] ±0.01	7.61[a] ±0.18
Tyrosine	3.67[b] ±0.52	4.00[ab] ±0.38	4.12[ab] ±0.16	4.02[ab] ±0.04	4.08[ab] ±0.17	4.11[ab] ±0.20	4.35[a] ±0.10
Lysine***	2.90[d] ±0.11	3.15[cd] ±0.07	3.66[a] ±0.20	3.20[bc] ±0.02	3.43[ab] ±0.18	3.14[cd] ±0.00	3.30[bc] ±0.04
Phenylalanine***	2.34[a] ±0.24	2.45[a] ±0.00	2.57[a] ±0.06	2.34[a] ±0.28	2.49[a] ±0.16	2.30[a] ±0.14	2.58[a] ±0.01
Threonine***	3.33[a] ±0.10	3.43[a] ±0.16	3.68[a] ±0.21	3.33[a] ±0.44	3.58[a] ±0.30	3.39[a] ±0.13	3.69[a] ±0.18
Tryptophan***	1.15[a] ±0.23	1.21[a] ±0.08	1.36[a] ±0.18	1.49[a] ±0.20	1.34[a] ±0.18	1.05[a] ±0.28	1.38[a] ±0.43
Cysteine	1.19[a] ±0.23	1.48[a] ±0.13	1.65[a] ±0.42	1.45 ±0.14	1.57[a] ±0.24	1.29[a] ±0.07	1.50[a] ±0.18
Methionine***	1.25[b] ±0.06	1.40[ab] ±0.14	1.51[ab] ±0.16	1.39[ab] ±0.17	1.55[a] ±0.07	1.38[ab] ±0.14	1.49[ab] ±0.01

* Results are means ± standard deviation, (n = 2), Values within the same row with the same letter are not significantly different ($p < 0.05$).

** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.

*** Essential amino acids.

These results support those of Tyagi et al. (2007) who reported that nutritive value of cereal products protein can be improved by the use of protein rich full fat and defatted mustard flour. The high total amino acid percentage of garden cress seeds was reported also to makes it a significant contribution to the supply of essential amino acid in the diet (Gokavi et al., 2004 and Singh et al., 2015).

Protein quality of noodles

Data given in Table 8 show the protein quality of noodles supplemented with up to 20% of DYMSF and/or DGCSF. The parameters used in the evaluation of protein quality were essential amino acid index (EAAI), biological value (BV), and protein efficiency ratio (PER).

EAAI is one of the important indices used in the evaluation of protein quality (Sosulski and Holt, 1980, Bender and Milward, 2012). EAAI of the noodle samples containing DYMSF and DGCSF was higher than that of control one and ranged from 68.18 to 73.68.

The same trend was observed with regard to BV which is a measure of the absorbed proportion of protein from a food to be incorporated into the proteins of the body (Friedman, 1996; Ijarotimi et al., 2015). The increase in biological value of noodles' protein ranged from 4.2% in case of incorporation level of 10% DGCSF to 10.1% in case of 20% DYMSF.

PER represents the gain of a test subject weight divided by the unit intake of a particular food protein. It has been used as a parameter for evaluating the quality of proteins (FAO/WHO, 1991). Results show that incorporation of DYMSF and /or DGCSF resulted in an improvement in the protein efficiency ratio of the diet. However, FAO (2011) recommended the use of other parameters such as amino acids profile in combination with PER to better understanding the quality of protein.

Milward (2012) recalculated the values for adult indispensable amino acid requirements taking into consideration N balance values for miscellaneous losses. The adjusted values suggested by the author were 18, 26, 19, 16, 20, 16, 4, 14 mg/kg per day for the amino acids isoleucine, leucine, lysine, methionine + cysteine, phenyalanine + tyrosine, threonine, tryptophan and valine, respectively. Fig. 2. illustrates the percentage indispensible amino acid content provided by 100 g of noodles supplemented with defatted mustard and /or garden cress seed flours. Results showed that 100 g of noodles supplemented with 20 % of DYMSF can provide an adult person weighing 70 kg with 71, 56, 68, 45, 53, 79, 46 and 78% of the daily indispensable amino acid needs (isoleucine, leucine, lysine, methionine + cysteine, phenyalanine + tyrosine, threonine, tryptophan and valine, respectively) requirements. The correspondent values in case of 20% DGCSF were 59, 48, 61, 37, 46, 70, 39 and 68%, respectively.

Sadeghi and Bhagya (2008) indicated that mustard protein has high protein quality indices and could be used as a good source of protein in high-protein formulations for adults. They concluded that in general, enrichment with mustard protein improved all the nutritional qualities of the spaghetti. On the other hand, Singh et al. (2015) suggested the use of garden cress seeds as a rich source of essential amino acid (total of 47.08%) and high quality protein.

Cooking quality of noodles

Cooking quality of noodles as affected by the supplementation with DYMSF and/or DGCSF is depicted in Table 9. Cooking loss was increased as the incorporation level of DYMSF and/ or DGCSF increased. Noodles with DYMSF had relatively higher cooking loss than those containing DGCSF. This could be attributed to the replacement of the gluten-containing wheat

TABLE 8. Protein nutritional quality of noodles supplemented with defatted yellow mustard and garden cress seed flours (g/100 g)*, **.

	Control	M10	M20	G10	G20	MG10	MG20
EAAI	64.42	68.86	73.68	68.18	70.64	68.27	72.03
BV	58.52	63.36	68.61	62.62	65.30	62.71	66.82
PER	2.10	2.24	2.38	2.20	2.28	2.22	2.33

* EAAI = Essential Amino Acid Index, BV= Biological Value, and PER= Protein Efficiency Ratio.

** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.

flour with other flours contains no gluten. Higher cooking losses in pasta supplemented with protein and fiber sources was previously reported (Bergman et al.,1986, Bahnassey and Khan 1986 and Mridula et al. 2006). The dilution of wheat flour with a non-gluten material might have a weakening effect on the gluten network leading to an interruption in the overall structure of noodles. This, by its turn might allow the leaching of solids from pasta during cooking. (Rayas-Durate, et al., 1996). Moreover, Tudoricâ et al. (2002) reported that the increase in cooking loss in pasta containing fiber sources could be attributed to the competitive hydration tendency of fiber resulting in disruption of the protein-starch matrix and the uneven distribution of water within the pasta matrix, thus prevent the swelling of starch due to limited water availability.

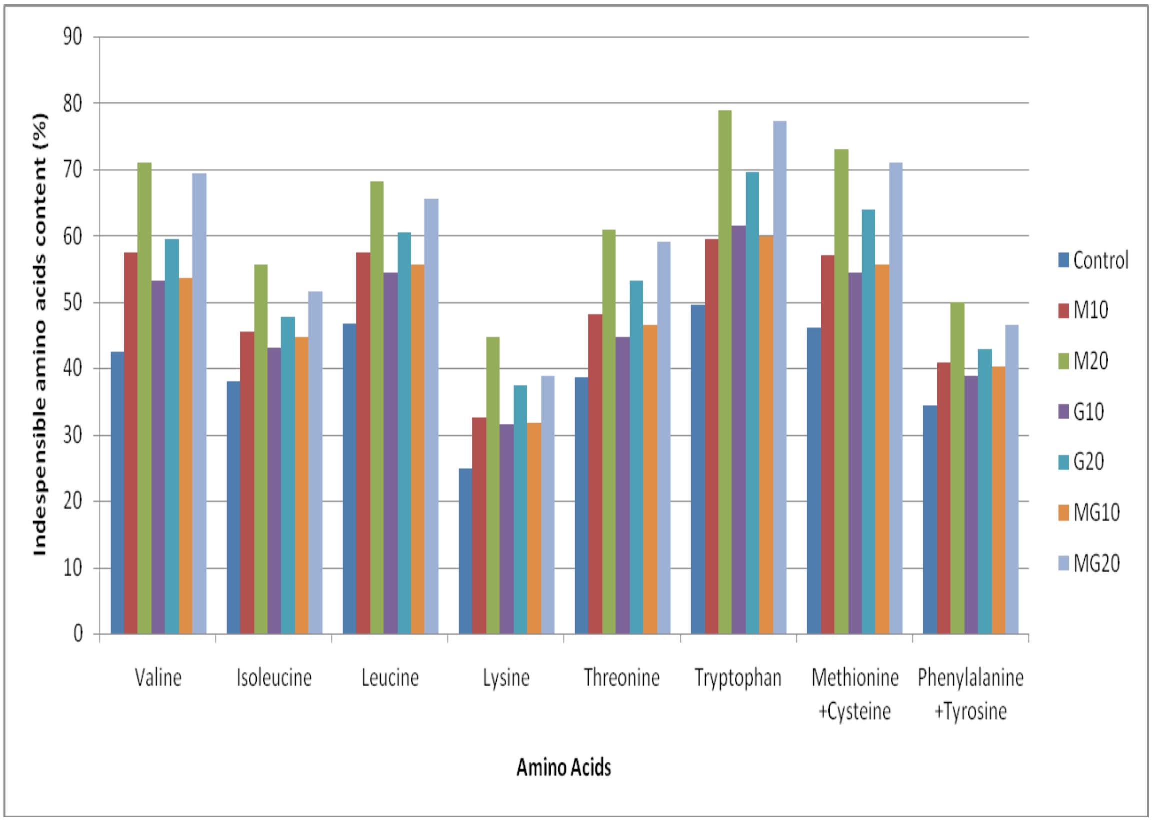


Fig. 2. Percentage adult indispensible amino acids content of noodles (as per 100 g noodles / day).

TABLE 9. Cooking quality of noodles supplemented with defatted yellow mustard and garden cress seed flours*, **.

	Control	M10	M20	G10	G20	MG10	MG20
Cooking loss (%)	6.74[c] ± 1.01	10.03[b] ± 0.18	12.81[a] ± 0.21	10.34[b] ± 0.32	13.51[a] ± 0.39	13.12[a] ± 0.14	13.19[a] ± 0.7
Water uptake (%)	120.23[e] ± 1.87	149.34[c] ± 3.11	182.92[a] ± 5.30	121.98[e] ± 2.24	153.07[ab] ± 0.59	135.48[d] ± 3.50	155.80[b] ± 0.54
Volume expansion (%)	108.72[d] ± 4.25	127.00[b] ± 3.52	145.5a ± 1.61	117.31[c] ± 6.44	122.47[bc] ± 3.47	121.74[bc] ± 2.69	122.51[bc] ± 1.57

* Results are means ± standard deviation, (n = 3).
Values within the same row with the same letter are not significantly different ($p < 0.05$).
** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.

Noodles containing DYMSF and/or DGCSF showed higher water uptake when compared to control one. This uptake was positively correlated to the incorporation levels of those two flours. In parallel, and as a result of the increased water uptake, volume expansion of noodles was increased by increasing the incorporation level DYMSF and/or DGCSF.

Kaur et al. (2013) reported that high protein, high fiber pasta has the tendency to expand more during cooking. They concluded that increase in water uptake and volume expansion of pasta could be attributed to the fine particle size and the high contents of both fiber and protein with greater water hydration capacity.

Sensory characteristics of noodles

The sensory characteristics of noodles supplemented with DYMSF and/or DGCSF were evaluated for different parameters and the results are presented in Table (10). Color of noodles containing 10% DYMSF significantly scored higher than control and other noodles samples, while those containing 20% were comparable (non significant difference) to the control one. Contrary to that, noodles with 10 and 20% DGCSF were significantly lower in color than control noodles. This could be attributed to the desirable yellow color of defatted DYMSF as previously discussed by Sadeghi and Bhagya, (2008). On contrast, the undesirable dark color of DGCSF had a negative effect on color scores by the panelists. Also, noodles supplemented with DYMSF and/or DGCSF had significantly lower scores for softness and stickiness than control ones. However, noodles with defatted DYMSF scored significantly higher scores than DGCSF ones. For taste and odor, noodles containing DGCSF were significantly inferior (but still acceptable) to control and DYMSF noodles. This could be attributed to the spicy aroma, bitter and pungent taste, and unusual tangy flavor (Juma and Martin, 2011) that didn't meet the preferences of the panelists. In general, overall acceptability of noodles supplemented with 10 and 20% DYMSF significantly resembled the control noodles, while those containing DGCSF were significantly lower, but were still acceptable to the panelists. However, this undesirable effect was alleviated by blending DYMSF with DGCSF at both 10 and 20% defatted seed flour incorporation levels.

Conclusion

In our present investigation, DYMSF and DGCSF showed promising nutritional benefits when incorporated into noodle formulations. Incorporation of DYMSF and/or DGCSF into noodles formulation resulted in an increase in protein, fiber and mineral contents. This could present an important option to nutrition programs directed to vulnerable groups suffering from mineral deficiency symptoms and malnutrition. Amino acids profile was improved as the essential amino acid content increased , as well as the protein quality parameters (EAAI, BV and PER). Thus could be interpreted to a higher protein quality and suggests both DYMSF and/or DGCSF to be a natural complementary to cereal proteins. Higher cooking loss, expansion and water uptake were also observed as a result. Sensory analysis

TABLE 10. Sensory characteristics of noodles supplemented with defatted yellow mustard and garden cress seed flours*, **.

	Control	M10	M20	G10	G20	MG10	MG20
Color	7.7^{b} ±0.13	8.4^{a} ±0.52	7.7^{b} ±0.67	6.9^{c} ±0.32	6.2^{d} ±0.42	6.2^{d} ±0.42	5.5^{e} ±0.53
Softness	8.9^{a} ±0.10	8.1^{b} ±0.32	7.7^{bc} ±0.48	7.4^{c} ±0.52	6.6^{d} ±0.32	6.3^{de} ±0.52	5.8^{e} ±0.79
Stickiness	8.5^{a} ±0.17	7.9^{b} ±0.57	8.0^{ab} ±0.67	6.7^{cd} ±0.67	5.9^{e} ±0.57	7.2^{c} ±0.79	6.3^{cd} ±0.48
Taste	8.2^{a} ±0.13	8.0^{ab} ±0.67	7.4^{bcd} ±0.70	7.8^{abc} ±0.79	7.2^{cd} ±0.70	6.8^{e} ±0.79	6.2^{e} ±0.49
Odor	8.4^{a} ±0.22	8.4^{a} ±0.52	8.0^{a} ±0.82	7.1^{bc} ±0.67	6.1^{d} ±0.32	7.4^{b} ±0.70	6.7^{c} ±0.82
Overall acceptability	8.3^{a} ±0.62	8.2^{a} ±0.79	8.2^{a} ±0.63	7.5^{b} ±1.18	6.4^{cd} ±0.53	7.0^{bc} ±0.67	6.0^{d} ±0.82

* Results are means of panelist scores ± standard deviation, (n = 10).
Values within the same row with the same letter are not significantly different ($p < 0.05$).
** Control = noodles containing 100% wheat flour, M10= noodles containing 10% DYMSF, M20= noodles containing 20% DYMSF, G10= noodles containing 10% DGCSF, G20= noodles containing 20% DGCSF , MG10 = noodles containing 5% DYMSF and 5% DGCSF , MG20= noodles containing 10% DYMSF and 10% DGCSF.

showed that in general, produced noodles were of good sensory characteristics and were comparable to the control ones when using DYMSF, with lower scores (but still acceptable) in case of using DGCSF).. Further future studies in the area of our work should take into account the use of DYMSF and/or DGCSF in other food products. Increasing the quality of these products and the nutritional value as well should also be taken into consideration.

Conflict of Interest

The authors have declared no conflict of interest.

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الإستفادة من دقيق بذور الخردل و حب الرشاد منزوعى الدهن فى إنتاج نودلزعالية القيمة الغذائية

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تم فى هذه الدراسة إستخدام دقيق بذور الخردل الأصفرو حب الرشاد منزوعى الدهن بنسب تصل الى ٢٠٪ بغرض إنتاج خلطات نودلز ذات قيمة غذائية عالية، و قد تم تقدير الخصائص التغذوية و خصائص الجودة للنودلز الناتجة، حيث تم دراسة محتوى النودلز الناتجة من العناصر الغذائية الكبرى و العناصر المعدنية و تحليل الأحماض الأمينية و خصائص جودة البروتين و كذلك صفات الطهى و صفاتها الحسية .

و قد أظهرت النتائج أن استخدام دقيق بذور الخردل الأصفر و حب الرشاد منزوعى الدهن قد أدى الى زيادة محتوى النودلز من البروتين و الألياف بنسب تصل الى ١,٤١ و ٤,٦٤ مرة عن نظيريهما فى النودلز المرجعية، على التوالى، فى حين إنخفض المحتوى من الكربوهيدرات و الدهون. كذلك إحتوت عينات النودلز الناتجة على كميات أكبر بدرجة معنوية من عناصر الكالسيوم و الحديد و الفوسفور و المغنسيوم و المنجنيز و الزنك، إضافة الى هذا فقد حدث تحسن فى صفات المحتوى من الأحماض الأمينية الأساسية و القيمة الحيوية و معدل كفاءة البروتين.

و قد اتضح من اختبارات الطهى للنودلز الناتجة حدوث إرتفاع فى معدل الفقد أثناء الطهى و كذلك إمتصاص الماء و الزيادة فى الحجم. أما نتائج التقييم الحسى فقد أظهرت أن عينات النودلز الناتجة كانت مقبولة من الناحية الحسية لصفات اللون و النعومة و الالتصاق و الطعم و الرائحة و مدى القبول العام مع ميزة نسبية لتلك العينات المحتوية على دقيق بذور الخردل الأصفر عن مثيلتها المحتوية على دقيق بذور حب الرشاد منزوع الدهن.