Evaluate Gluten-free Macaroni with Chia Seeds and Psyllium as Alternative Gluten to Celiac Diseases

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ABSTRACT

This investigation was accomplished to evaluate the raw materials like wheat flour 72% extract, chia seeds, soybean, yellow maize, and psyllium as alternative gluten to prepare different blends of macaroni gluten-free (GF) for celiac diseases (CD). Chemical composition, total dietary fiber fractions, minerals content, antioxidant capacity, and their activity were determined in raw materials. From the results, it could be noticed that the soybean and chia had the highest content from protein and total lipids; meanwhile, the psyllium had contained the highest amounts from crude fiber and dietary fibers fractions. Minerals content observed that the chia, soybean, and yellow maize have the highest amounts from the Mg, Na, K, P, and F, respectively, than other raw materials. Moreover, soybean, yellow maize and chia had the highest contents in antioxidant capacity and activity.

The quality of the macaroni at different levels was evaluated through cooking tests (increase in weight and volume, and cooking loss), chemical composition (starch, amylose, and amylopectin), and color, also, sensory analysis by means of acceptance testing. The results reported that the gluten-free macaroni had higher nutritional value and superior technological characteristics. Sensory analysis results showed that pasta with 50% chia, 25% soybean, 20 maize and 5% psyllium had higher rates of acceptability then came followed by 50% chia, 30% soybean, and 15maize, 5% psyllium, and 50% chia, 35% soybean, and 10 maize, 5% psyllium. Meanwhile, the macaroni with the worst acceptance in the blend was the one with 50% chia flour, soybean 40%, yellow maize 5%, and psyllium 5%, and also it was triggered the lowest acceptance with regards to color.

From the obvious results, it could be recommended that the macaroni which consists till 50% chia, 35% soybean, 10% yellow maize, and 5% psyllium was with increased in nutrition value and color.

Keywords: Macaroni, cooking loss, amylase, amylopectin

INTRODUCTION

Gluten-sensitive enteropathy is an inflammatory disease which refers to celiac disease (CD). It could have caused the ingestion of gluten which affecting 1% of the population worldwide **(Catassi and Yachha, 2009)**.
The special advantage of CD is flattening of the intestinal villi, which decreases the surface region and out comes in alimentary malabsorption. Evermore people follow a gluten-free diet, because there has been an increase in the number of individuals diagnosed with the disease and for this reason it has been explained that gluten intake may be due to gastrointestinal symptoms in some persons without CD **(Biesiekierski *et al.,* 2011)** or because of false beliefs. This has led to elevate gluten-free bakery products in the supermarket at recent years **(Cureton and Fasano, 2009).**

The persons with CD troubles still have desorder finding GF products for the reason that of expensive for price, and poor sensory characteristics. These agents are accountable for hampering the GF diet system and for lack of satisfaction **(Do Nascimento *et al.,* 2013).**

The process developing of GF products stays a technological challenge may be caused to the gluten in different cereal-based products, particularly in bread and pasta making. **(Capriles *et al.,* 2015)**،

Chia seeds (*Salvia hispanica* L.) had contained healthy ω- 3-fatty acids, and high nutrition compositions. In addition, the seeds had contained high amounts from polyphenols and natural antioxidants, such as caffeic acid, rosmarinic acid, myricetin, quercetin, and others (**Hrnčič *et al.,* 2020).**

The corn color is mainly due to the presence of natural antioxidant likes phenolic acids, carotenoids, and flavonoids. Pigments are generally mostly concentrated in the thick pericarp or in the aleurone layers of kernels, and also in corn cobs (**Paulsmeyer *et al.,* 2017).**

Soybean (*Glycine max* (L.) had contained high amounts of protein and fat ranged 35–42% and 16-27%, respectively. This led to the soybean is one of the valuable and more cultivated crops **(Kumar *et al.,* 2006).**

Psyllium seed consists of *Plantago afr*a L. (*Plantago psyllium* L.). Husk and seeds is however commonly also referred to as psyllium. psyllium husk are obtained by milling the seed to remove the hulls **(Wärnberg *et al.,* 2009).**

Psyllium was chosen because it is stable at various pH levels and temperatures, being similar to gluten in food. Moreover, psyllium can be as alternative for fat or thickening factor. Also, psyllium and gluten free flour have possibility in novel ingredients for patients with celiac disease **(Zandonadi *et al.,* 2009).**

This study aimed to elaborate gluten-free macaroni with the raw materials (chia seeds, soybean, yellow maize, and psyllium) to prepare macaroni with

high technological characteristics and nutrition value similar to those produced with wheat flour.

MATERIALS AND METHODS

Materials:

Wheat (*Treatucm astivum* L.), Chia seeds (*Salvia hispanica* L.), Yellow maize (*Zea mays* L.), and also, psyllium husk (*Plantago ovate*), were obtained from the Field Crops Research Institute**,** Agricultural Research Center, Egypt

Methods:

Determination of chemical composition of raw materials

Chemical composition as protein, fat, crude fibers and ash content were determined in raw materials according to the methods of **AOAC (2010)** and also, total carbohydrates were determined by differences. Total dietary fibers, soluble and insoluble dietary fibers were determined in raw materials according to **Prosky *et al.* (1988).**

Determination of minerals content:

Macro elements (calcium and magnesium) and Microelements (iron, zinc, manganese, selenium, aluminum and copper) of raw materials were determined according to the method of the **AOAC. (2010),** using Atomic Absorption Spectrophotometer (Perkin Elmer, Model 3300, Germany). Phosphorus was determined by spectrophotometer using molybdovan date method according to the **AOAC. (2010),** while sodium and potassium contents were determined by Flame Photometer (CORNING 400, serial No. 4889.UK).

Macaroni preparation processing:

The ingredients preparation processing macaroni are reported in Table (1). The ingredients were mixed in Hobert mixture at high speed until uniformly (10 min.) and the required amount of water was added. Macaroni was processed using a Demaco (De Francise Machine Corporation), it was dried at 60^{o}C for 24h and the relative humidity was from 75 to 85% according to the method described by **Dexter *et al.* , (1994).**

Table (1): Ingredient of macaroni blends

Blends	Wheat	Chia	Soybean	Yellow maize	Psullium
Control	100	---	---	--	---
Blend 1	--	50	25	20	5
Blend 2	---	50	30	15	5
Blend 3	---	50	35	10	5
Blend 4	---	50	40	5	5

Determination of ABTS, DPPH and FRAP radical solutions

The ABTS was determined according to **Re *et al.,* (1999).** The working solution absorbance was 0.75-0.80 at 734 nm.

The DPPH was prepared and determined according to **Brand- Williams *et al.* (1995);** its absorbance was 0.75-0.80 at 525 nm.

The FRAP was prepared and determined as described by **Benzie and Strain (1996).**

Estimation of antioxidant activity from raw materials extract

The total phenolic content in the different samples was measured using the method of **Qawasmeh *et al.* ,(2012)** with Folin-Ciocalteu reagent. Gallic acid was used as standard (1 mg/ml) and the results were expressed as gallic acid equivalents (GAE mg/g of dry weight).

The total flavonoids content was determined by the method of **Eghdami and Sadeghi (2010).** The absorbance was measured against a blank solution at 510 nm and the total flavonoids content was expressed in terms of milligrams of quercetin equivalent per gram dry weight (mg QE /g of dry weight).

Cooking properties of macaroni

The changes in volume, weight and cooking loss were determined according to **Bilgiçli *et al.* ,(2011).** Ten g of macaroni control and its blends were cooked for 18 min in 300 ml of distilled water. To determine the volume increase, uncooked and cooked macaroni blends were put into a graduated cylinder with the specific amount of distilled water, the increase in water level was measured. The volume increase was calculated as the percentage difference in the volume of uncooked and cooked macaroni divided by the volume of uncooked macaroni. The weight increase was determined as the percentage difference in weight of uncooked and cooked (after draining) macaroni divided by the weight of uncooked macaroni. Cooking loss, the weight of total solids expressed as a percentage was determined by drying the cooking water to constant weight at 100 °C.

Determination of starch in macaroni before and after cooking:

Starch was determined by the method of dispersal in CaCl2, followed by iodine spectrophotometry **(Idris, 2001).** The blue color intensity was measured at 610 nm using WPA S101 spectrophotometer.

Estimation of amylose content in macaroni before and after cooking:

A rapid colorimetric method described by **William *et al.* (1975)** was used for estimating the amylose content. The volume was diluted to 50ml and the absorbance of blue colour was measured at 625 nm after 5 minutes.

Determination of amylopectin in macaroni before and after cooking:

The amylopectin content of starch was calculated by difference. Amylose content was calculated as percentage (%) from the starch. Then amylose percent was subtracted from 100 to obtain amylopectin content of starch **(Idris , 2001) .**

Color measurement of macaroni blends

Color measurements were performed using Minolta chroma meter CR-400 (Minolta, Osaka, Japan). The numerical values of the color were expressed as lightness (*L**, light-dark), redness (*a**, ±red-green) and yellowness (*b**, ±yellow blue) according to **Francis (1998).**

Sensory evaluation of macaroni blends:

Samples of the variable macaroni were cooked to optimum cooking time (10 minute for macaroni) and with optimum boiling water (1 liter/100g sample). Then rinsed and drained off. A panel of twenty experienced panelists were chosen to judge the quality of the macaroni (external appearance, firmness, stickiness, color, aroma, taste and general acceptability)-using the scoring test of 5 points described by **Bahnassey and khan (1986).**

Statistical analysis:

The data obtained were analyzed using Statistical Package for Social Sciences program (SPSS) for Windows, (version 13 SPSS Inc., Chicago. USA). The results were expressed as mean ± SD. Tested for significance using one-way analysis of variance "ANOVA" according to **(Armitage and Berry 1987).**

RESULTS AND DISCUSSION

Chemical composition of raw materials

Chemical composition and total fiber fractions were estimated in raw materials (wheat flour, chia seeds, soybean, yellow maize, and psyllium and the findings are illustrated in Table (2). From the results, it could be noticed that the soybean had contained rich amounts from protein and total lipids by 36.27 and 23.51**%,** these results confirmed by **Kumar *et al.,* 2006).** Followed by chia seeds was 24.43 and 20.34% in protein and fat, respectively. **Ixtaina *et al.* (2011)** who found that the chia seed had contained high amounts from protein, fats, carbohydrates, high dietary fiber and ash were ranged 15-25%, 20-30%, 26-41%, 18-30%, and 4-5%, respectively, in addition minerals, vitamins, and dry matter were 90-93 and high source of natural antioxidants.

Moreover, psyllium, chia seeds, and soybean were the highest in crude fiber by 60.66, 11.36, and 8.72%, and ash content was 23.33, 9.62, and 5.29%,

respectively. Meanwhile, wheat flour and yellow maize were the highest in total carbohydrates by 84.16 and 83.01%.

The results in the same table showed that the psyllium was the highest in total dietary fiber (82.26%) followed by soybean and chia seeds were 36.20 and 28.35%, respectively. As well, the yellow maize lower in dietary fiber was 14.72% and wheat flour was the lowest than other raw materials such as psyllium husk as a dietary fiber which have been utilized extensively for food recipes and in produce food **(Verma and Mogra, 2015).** In soybeans had concentrated levels of TDF, IDF and SDF were 35.9 ± 4.6, 26.2 ± 1.9 and 9.7 ± 3.3 g/100 g, respectively **(Písaříková and Zralý, 2010).** The chia seeds are also a significant source of protein (19–23%) and dietary fiber (18–30%), vitamin and mineral **(Coelho and Salas-Mellado, 2015).**The total dietary fiber content of wheat ranges from 9 to about 20% (dry weight basis) and is composed of both insoluble and soluble fractions (**Gartaula *et al.*, 2018).**

Table (2): Chemical composition of raw materials

Chemical composition	Wheat flour	Chia seeds	Soybean	Yellow maize	Psyllium
Crude protein %	12.45 ±0.91	24.43 ±1.92	36.27 ±3.61	8.49 ±0.97	1.33 ±0.01
Crude fiber%	0.71 ±0.03	11.36 ±0.91	8.72 ±1.04	4.14 ±0.16	60.66 ±0.02
Total lipids%	2.07 ±0.04	20.34 ±1.86	23.51 ±2.15	3.16 ±0.06	2.7 ±1.28
Ash content%	0.61 ±0.02	9.62 ±0.02	5.29 ±0.06	1.20 ±0.09	23.33 ±4.36
Total carbohydrates %	84.16 ±3.19	34.25 ±1.37	26.21 ±2.07	83.01 ±4.28	11.98 ±0.78
Total dietary fiber % (TDF)	8.24 ±1.25	28.35 ±1.26	36.20 ±3.28	14.72 ±1.05	82.26 ±6.28
Insoluble dietary fiber% (IDF)	6.10 ±0.92	18.70 ±1,21	24.13 ±1.94	10.16 ±0.61	54.84 ±4.27
Soluble dietary fiber % (SDF)	2.09 ±0.04	9.35 ±0.15	12.06 ±1.35	4.56 ±0.08	27.42 ±2.36

Values are mean and SD (n = 3).

Minerals content of raw materials

Minerals content as Mg, Na, K, Zn, P, Fe, Ca, and Cu were determined in raw material and the results are in Table (3). The results observed that the chia seeds the highest content in the minerals by 245.0, 120.0, 410.0, 4.0, 450.0, 9.0, 218.0, and 3.0 mg/100g dry weight respectively , these results confirmed

by **Levent (2017)** who found that the chia seed had contented of Ca, P, K, Mg, Fe, and Zn increased in noodles containing chia seed. Followed by soybean had contained 110.0, 94.0, 650.0, 3.0, 385.0, 6.0, 140.0 and 4.0 mg/100g and yellow maize was 90.0, 85.0, 215.0, 3.0, 310.0, 5.0, 200.0 and 3.0 mg/100g**.** Whilst, psyllium and wheat flour were lower than other raw materials. The minerals content level in the different plants is dependent on environmental and various agents through agronomic practices **(Devi *et al.,* 2013).**

Table (3): Minerals content of raw materials on dry weight basis mg/100g

Chemical composition	Wheat flour	Chia seeds	Soybean	Yellow maize	Psyllium
Magnesium	12.94±0.11	245.0±2.47	110.00±3.49	95.00±2.36	53.00±0.94
Sodium	20.58±0.43	120.0±1.25	94.00±3.14	85.00±3.15	65.00±0.83
Potassium	140.21±8.26	410.0±3.49	650.00±5.61	215.00±1.49	115.00±1.04
Zinc	0.48±0.04	4.00±0.01	3.00±0.04	3.00±0.02	1.00±0.00
Phosphorus	210.00±5.13	450.0±4.21	385.00±2.46	310.00±2.58	185.00±1.39
Iron	6.75±0.08	9.00±0.04	6.00±0.04	5.00±0.07	2.00±0.01
Calcium	18.25±0.18	218.00±1.28	140.00±1.46	200.00±2.05	40.00±0.57
Copper	1.75±0.01	3.00±0.02	4.00±0.01	3.00±0.01	1.00±0.00

Values are mean and SD (n = 3).

Antioxidant capacity and activity of raw materials

Antioxidant capacity was determined in raw materials and the results are reported in Table (4). From the results, it could be noticed that the soybean the highest in antioxidant capacity as ABTS, DPPH and FRAP were found 5.15, 3.64 and 7.50 Mmol (Trolox equivalent antioxidant capacity) $TEACg^{-1}$, respectively. DPPH is a radical that variations into a steady compound by interacting with an antioxidant. Therefore the possibility of soybean accession to scavenge DPPH radicals indicating that it is an electron donor which can react with free radicals to transform them to more stable products and thereby terminate radical chain reactions. Followed by yellow maize was 3.89, 3.81, and 5.12 Mmol $TEACg^{-1}$ and chia seeds was 3.21, 2.43 and 3.39 Mmol $TEACg^{-1}$, respectively. **Sargi *et al.,* (2013)** found that chia seeds which capable inhibiting the activity of ABTS cation radicals and also chia seeds exhibit the capacity to scavenge synthetic DPPH radicals and decrease iron ions. In addition, **Khampas *et al,*. (2013)** who found the total antioxidant capacity was significantly correlated with TEAC, DPPH, FRAP, and TPC. TPC had positive and significant correlations with TEAC, FRAP, and DPPH. Positive and significant correlations between DPPH with TEAC and FRAP were observed, whereas FRAP had a close association with TEAC. This information was used for corn to development of healthy food products and pharmaceutical

industries. Meanwhile psyllium and wheat flour were the lowest in antioxidant capacity. **Patel *et al.* (2016)** observed that the DPPH scavenging activity and ABTS for antioxidant activity is a percent inhibition of ABTS+, of the psyllium plant. The maximum activity was found in the seed extract, followed by leaf and husk extracts. Therefore, the natural antioxidant present in the psyllium seeds may be scavenging the free radical due to their electron donor ability (**Fan *et al.*, 2014).**

The results from the same table showed that the total phenolic content and total flavonoids compounds were the highest in soybean followed by yellow maize, chia seeds and psyllium hull. Meanwhile, the wheat flour was the lowest in the total phenolic content and total flavonoids compounds. These results confirmed with **Mujić *et al.* (2011)** who found that the soybeans (*Glycine max* (L.) Merr) is a legume that is universally consumed. A soybean is a complex food matrix containing a wide array of bioactive phytochemicals like isoflavones, and total phenolics content.

For this reason, the chia seed is rich in vitro antioxidant activity **(Marineli *et al.*, 2014 and Porras-Loaiza e*t al.*, 2014).** Moreover, corn (*Zea mays* L.) has colors like white, yellow, orange, purple, and black. These pigments of corn are rich in phytochemicals and many secondary metabolites such as phenolic compounds, carotenoids, and flavonoids **(Žilić *et al.*, 2012).** As well as, *Plantago ovata,* commonly called psyllium, is known to be a rich source of phytochemicals such as phenols and flavonoids compounds (**Yasin *et al.*, 2020)**.

Table (4): Antioxidants of raw materials

Antioxidants	Wheat flour	Chia seeds	Soybean	Yellow maize	Psyllium
ABTS Mmol $TEACg^{-1}$	0.51 ±0.02	3.21 ±0.02	5.15 ±0.12	3.89 ±0.16	2.52 ±0.25
DPPH Mmol $TEACg^{-1}$	0.72 ±0.01	2.43 ±0.01	3.64 ±0.03	3.81 ±0.17	1.73 ±0.14
FRAP Mmol $TEACg^{-1}$	0.10 ±0.00	3.39 ±0.02	7.50 ±0.14	5.12 ±0.00	1.65 ±0.01
Total phenolic acids mg GAE /g of dry weight	0.50 ±0.01	0.98 ±0.04	3.51 ±0.02	2.01 ±0.01	0.72 ±0.04
Total flavonoid mg QE /g dry weight	0..20 ±0.01	0.53 ±0.01	1.32 ±0.01	0.75 ±0.09	0.24 ±0,02

Values are mean and SD (n = 3).

Cooking characterization of the macaroni

The increases of weight and volume and also cooking losses were evaluated in macaroni different blends and the results are reported in Table (5). The results illustrated that the volume and weight were elevated in macaroni made from wheat flour 72% extract by140.25 and 164.28% to 230.59 and 246.92% in blends made from chia seeds 50%, soybean 40%, yellow maize 5.0% and psyllium 5% as alternative gluten. These increases in volume and weight may be due to the chia seeds and soybean had contained high amounts from dietary fiber which absorption the water. Moreover, the psyllium was the highest in crude fiber and dietary fibers therefore the function properties of it were as an alternative to gluten and keeping of water. **Capitani *et al.,* (2012)** stated that even though the soluble fiber (SF) content is low, the mucilage fulfills the functional property of water retention.

The results from the cooking losses in the macaroni different blends are reported in the same table. The results indicated that the macaroni made from wheat flour 72%extract give the best quality of cooking loss (6.21%). Whilst, the different blend observed that when increase added soybean in macaroni blends 2, 3, 4 and 5 were 7.65, 8.08, 9.23 and 11.12%, respectively. These results confirmed with **Hummel (1966)** classified pasta according to the loss of solids: up to 6% is characteristic of pasta made from the wheat of very good quality, up to 8% of average quality, and values equal to or greater than 10% are low-quality pasta. The added chia flour improved the quality of the pasta by reducing the loss of solids. The result can be attributed to the composition of the chia grain, which rich in protein and this causes the retention of amylose during cooking (**Chillo *et al.,* 2008** and **Zhao *et al.,* 2005)**, upon adding flours of legumes (bean and chickpea) to pasta, observed an increase in the loss of solids during cooking**.**

Table (5): Percentage of cooking test parameters of macaroni blends

Blends	Volume increase	Weight increase	Cooking loss
Control	140.25±2.35d	164.28±1.97 d	6.21±0.18 d
Blend 1	185.65±2.37c	183.39±2.28c	7.65±1.25c
Blend 2	200.14±3.21b	215.19±2.68ab	8.08±1.39 b
Blend 3	212.38±3.48ab	230.17±3.01 ab	9,23±0.98 ab
Blend 4	230.59±3.86a	246.92±2.83 a	11.12±0.68 a

Values are mean and SD (n = 3); where: Mean values in the same column and with the different letter are significantly different at 0.05 levels.

Chemical composition of macaroni before and after cooking:

Chemical composition as starch, amylose and amylopectin content were determined in macaroni before and after cooking and the findings are tabulated

in Table (6). The macaroni before cooking were decreased in starch, amylase and amylopectin when the soybean powder was increased in the different blends. Whilst, after cooking the macaroni blends were 25, 30, 35 and 40 % soybean powder were decreased in starch by 20.20, 17.28, 16.47 and 14.52%, respectively, compared with control macaroni was found 25.48%. Moreover amylase and amylopectin were reduced by 23.03, 21.82, 19.87 and 18.32%, respectively; in amylase than control macaroni was 24.27%. In addition, amylopectin was decreased by 24.81, 23.97, 22.77 and 21.51%, respectively; than control macaroni was 25.50%. These decreases may be due to the blend macaroni had contained different levels from the raw materials which contained high amounts from dietary fiber and natural antioxidants. Moreover, the elevating of celiac disease (CD) and gluten-related troubles give to increase consumer request for gluten-free products. Starch plays an significant role in the bakery products and has an even more become better role in gluten-free products. Starch is used in food ingredient to get better properties gluten-free products, such as the specific volume, color, crumb structure, and texture.

Regular pasta, which is made from semolina, is not an ideal source of dietary fiber as most have been removed during the milling of the grain. There is good evidence that regular consumption of wholegrain cereals offers a reduced risk of certain diseases like type 2 diabetes and cardiovascular disease (**Zong *et al.,* 2014)**. Despite this knowledge, the daily intake of dietary fiber falls well short of daily recommendations, with more than 90% of the population of the USA, for example, not meeting target levels (**Jones, 2014).**

Table (6): Starch, amylose and amylopectin content of macaroni before and after cooking.

Blends	Starch %		Amylose %		Amylopectin %	
	Before cooking	After cooking	Before cooking	After cooking	Before cooking	After cooking
Control	70.12 ±1.24^{a}	52.25 ±1.26 ^{a}	24.76 ±0.14 ^{a}	18.75 ±0.24^{a}	44.67 ±0.51 ^{a}	33.28 ±0.21 ^{a}
Blend 1	65.61 ±1.56^{ab}	52.36 ±1.28^{ab}	21.45 ±0.18^{ab}	16.51 ±0.27^{ab}	39.75 ±0.36^{ab}	29.89 ±0.35^{ab}
Blend 2	60.24 ±1.58ab	45.83 ±1.67^{ab}	20.86 ±0.12^{ab}	15.53 ±0.19^{ab}	37.67 ±0.41^{ab}	28.341 ±0.29^{ab}
Blend 3	54.63 ±1.23^{b}	42.63 ±0.98 ^{b}	19.67 ±0.19 ^{b}	14.76 ±0.12 ^{b}	35.58 ±0.38 ^{b}	26.78 ±0.31 ^{b}
Blend 4	49.47 ±0.98 ^{c}	41.29 ±0.75 ^{c}	18.12 ±0.11 ^{c}	14.10 ±0.11 ^{c}	33.56 ±0.26 ^{c}	25.34 ±0.21^{c}

Values are mean and SD (n = 3); where: Mean values in the same with the letter are significantly different at 0.05 levels.

Color analysis of different blends macaroni

Greater intensity of the yellow color is a highly desirable feature in pasta products because this is one of the most influential visual appeals in the acceptance of pasta **(Chang and Flores, 2004).**

Table (7) showed that the color values of the macaroni blend gluten-free made with chia seeds, soybean, yellow maize, and psyllium as alternative gluten at different levels. The color of the blends 1, 2, 3, and 4 were darker than the standard, which was shown by lower luminance values and a greater tendency to red (higher a* values) and blue (lower b* values), indicating that the dark pigmentation of the chia flour and increasing added of soybean was significantly influenced the color of the macaroni. These data corroborate the study by **Bordin and Roque-Specht (2012)** on pastas with added soybean fiber. The control pasta differed statistically from others featuring greater intensity of the yellow color (b* value), favoring acceptability, which was expected because the added chia flour made the pasta darker.

Table (7). Color analysis of different blends macaroni

Pan bread formulae	*L**	*a**	*b**
Control wheat	$65.5^{a} \pm 1.68$	$1.2^{e} \pm 0.01$	$37.4^{a} \pm 1.25$
Blend 1	$59.4^{b} \pm 1.76$	$2.1^{d} \pm 0.01$	$32.5^{b} \pm 1.36$
Blend 2	$53.1^{c} \pm 1.23$	$3.1^{c} \pm 0.02$	$34.7^{b} \pm 1.54$
Blend 3	$51.9^{c} \pm 1.38$	$3.7^{c} \pm 0.02$	$29.3^{c} \pm 0.98$
Blend 4	$46..6^{d} \pm 1.15$	$4.1^{b} \pm 0.03$	$26.1^{c} \pm 0.73$

Values are means ± SD (n = 3). Means followed by different letters in the same column are , significantly different ($P \leq 0.05$)

Sensory properties of different blends macaroni

The results of the sensory analysis are shown in Table (8). It can be observed that the macaroni with better acceptance by the tasters in the blend (1) was the one containing 50% of chia flour, soybean 25%, yellow maize 20%, and psyllium 5%, and which it was the most accepted with respect to the aroma, color, stickiness and firmness attribute, followed by the macaroni blend (2) with 30% soybean and 15 maize and blend (3) was contained 35% soybean and 10% yellow maize. Meanwhile, the macaroni with the worst acceptance in the blend (4) was the one with 50% chia flour, soybean 40%, yellow maize 5%, and psyllium 5% and also it was triggered the lowest acceptance with regards to color. This fact can be explained by the very dark color of the pasta to which consumers are not accustomed. Similar results were also reported by **Bordin and Roque-Specht (2012),** while developing pastas with different concentrations of soybean fiber, of which the pasta with 6% fiber was preferred in terms of flavor.

Table (8): Sensory properties of different macaroni:

Blends	External appearance	Firmness	Stickiness	Color	Aroma	Taste	General acceptability
Control	5.00 ±0.03[a]	4.70 ±0.02 [a]	4.30 ±0.04 [a]	4.70 ±0.02 [a]	4.50 ±0.04[2a]	4.50 ±0.03 [a]	4.62 ±0.02 [a]
Blend 1	4.05 ±0.03[ab]	4.10 ±0.02 [b]	4.05 ±0.04a	4.50 ±0.03 [b]	4.00 ±0.02[ab]	4.25 ±0.02 [b]	4.16 ±0.02 [b]
Blend 2	3.75 ±0.02[ab]	3.75 ±0.01[bc]	3.75 ±0.02[ab]	4.00 ±0.02[bc]	3.75 ±0.01 [b]	3.75 ±0.02[bc]	3.79 ±0.02[bc]
Blend 3	3.50 ±0.01[b]	3.25 ±0.01[bc]	3.25 ±0.01 [b]	3.50 ±0.02 [c]	3.50 ±0.01 [c]	3.25 ±0.01 [c]	3.38 ±0.01 [c]
Blend 4	3.00 ±0.01[c]	2.75 ±0.01 [c]	2.75 ±0.01 [c]	2.75 ±0.01d	3.00 ±0.01d	2.75 ±0.01d	2.33 ±0.01d

Values are mean and SD (n = 3); where: Mean values in the same with the letter are significantly different at 0.05 levels.

Conclusions

From the obvious results, it could be conclusion that the chia seeds, soybean, and yellow maize had the highest nutritional value and antioxidant activity; meanwhile, psyllium has too high amounts from crude fiber and dietary fiber fractions. Therefore the macaroni which consists of 50% chia, ٢5% soybean, 10% yellow maize, and 5% psyllium (blend 3)was increased in nutrition value and color.

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ملخص البحث

تقييم المكرونة الخالية من الجلوتين مع بذور الشيا والقشرة الخارجية للسان الجمل كبديل للجلوتين لأمراض الاضطرابات الهضمية.

تم إجراء هذا البحث لتقييم المواد الخام مثل دقيق القمح خلاصة ٧٢٪ وبذور الشيا وفول الصويا والذرة الصفراء والقشرة الخارجية للسان الجمل كجلوتين بديل لتحضير خلطات مختلفة من المكرونة الخالية من الجلوتين لأمراض الاضطرابات الهضمية. تم تحديد التركيب الكيميائي ومحتوى الألياف الغذائية الكلية ومحتوى المعادن ومضادات الأكسدة ونشاطها في المواد الخام. من النتائج ، يمكن ملاحظة أن فول الصويا والشيا يحتويان على أعلى محتوى من البروتين والدهون الكلية. كما احتوى والقشرة الخارجية للسان الجمل على أعلى كميات من الألياف الخام والألياف الغذائية. اما محتوى المعادن لوحظ أن الشيا وفول الصويا والذرة الصفراء تحتوي على أعلى كميات من Mg و Na و K و P و F على التوالي مقارنة بالمواد الخام الأخرى. علاوة على ذلك ، احتلت الذرة الصفراء وفول الصويا والشيا أعلى محتوى في قدرة ونشاط مضادات الأكسدة.

تم تقييم جودة المكرونة بمستويات مختلفة من خلال اختبارات الطهي (زيادة الوزن والحجم ، الفاقد في الطبخ) ، والتركيب الكيميائي (النشا ، والأميلوز ، والأميلوبكتين) ، وكذلك اللون ، والتقييم الحسي عن طريق اختبار القبول. أشارت النتائج إلى أن المكرونة الخالية من الجلوتين لها قيمة غذائية أعلى وخصائص تكنولوجية أعلى. أظهرت نتائج التحليل الحسي أن المكرونة التي تحتوي على ٥٠٪ شيا ، و ٢٥٪ فول الصويا ، و ٢٠ ذرة ، و ٥٪ والقشرة الخارجية للسان الجمل لديها معدلات قبول أعلى يليها بنسبة ٥٠٪ شيا ، و ٣٠٪ فول الصويا ، و ١٥ ذرة ، و ٥٪ والقشرة الخارجية للسان الجمل ، ويليها نسبة ٥٠. ٪ شيا ، ٣٥٪ فول الصويا ، ١٠ ذرة ، ٥٪ والقشرة الخارجية للسان الجمل. وفي الوقت نفسه ، كانت المكرونة ذات أسوأ قبول في الخلطة هي تلك التي تحتوي على ٥٠٪ دقيق الشيا ، وفول الصويا ٤٠٪ ، والذرة الصفراء ٥٪ ، والقشرة الخارجية للسان الجمل ٥٪ ، وأيضًا كانت أقل قبول من حيث اللون.

من النتائج الواضحة ، يمكن التوصية بزيادة قيمة المكرونة حتى هذه النسب ٥٠٪ شيا و ٣٥٪ فول الصويا و ١٠٪ ذرة صفراء و ٥٪ والقشرة الخارجية للسان الجمل من حيث القيمة الغذائية واللون.

الكلمات المفتاحية: المكرونة ، الفاقد في الطبخ ، الأميليز ، الأميلوبكتين