Journal of King Saud University – Science 34 (2022) 101833

Contents lists available at ScienceDirect

Journal of King Saud University – Science

journal homepage: www.sciencedirect.com

Original article

Technological and nutritional properties of instant noodles enriched with chickpea or lentil flour

Hala Bayomy [a,b,*], Eman Alamri [a]

[a] Department of Nutrition and Food Science, Tabuk University, Saudi Arabia
[b] Department of Food Science and Technology, Damanhour University, Egypt

ARTICLE INFO

Article history:
Received 11 February 2021
Revised 6 January 2022
Accepted 10 January 2022
Available online 15 January 2022

Keywords:
Instant noodles
Enriched
Rheology
Nutritional value
Cooking quality

ABSTRACT

Objective: To increase the nutritional value of instant noodles, enriched wheat flour with selected legume flours, chickpea or yellow lentil, at substitution ratios of 15%, 20%, and 25%.
Methods: The technological and nutritional properties of the obtained instant noodles were studied in terms of proximate analysis, energy, cooking quality, amino acids content, rheological properties, and sensory evaluation.
Results: Enrichment of durum wheat flour with lentil or chickpea flour improved the resulting instant noodles in terms of protein, crude fat, ash, and crude fiber contents, and contributed in reducing carbohydrates and energy obtained. Lysin, tryptophan, and threonine contents in durum wheat noodles were found to be 2.31, 1.09, and 3.15 g/100 g protein, respectively, which increased to 3.32, 1.34, and 3.45 g/100 g protein, respectively, with 25% replacement of chickpea flour. Greater increases were obtained with 25% replacement with lentil flour as the concentration of lysin, tryptophan, and threonine reached 3.34, 1.27, and 3.61 g/100 g protein, respectively. As the replacement ratio increased, the total essential amino acids increased from 36.96 % to 39.01% with 25% replacement of chickpea flour and 38.59 % with 25% replacement of lentil flour. Water absorption increased significantly from 59.71% to 69.01% with increasing proportion of chickpea or lentil flours in dough mixtures. The elevation in arrival time, dough development time, and stability time among the flour blends with 15% to 25% chickpea or lentil flours ranged from 1.7 to 2.1 min, 4.8 to 5.9 min, and 2.8 to 4.8 min, respectively. Sensory evaluation showed that the panelists significantly ($p < 0.05$) preferred replacing wheat flour with chickpea flour than lentil flour.
Conclusion: Present study concluded that durum wheat flour can be replaced with 25% chickpea flour or 20% lentil flour to improve the nutritional value without negatively affecting rheological properties, cooking characteristics, or sensory qualities.

1. Introduction

Instant noodles are frequently eaten around the world, especially among children. The 2021 World Instant Noodles Association report confirmed that the consumption of instant noodles has grown steadily and continues to grow. Statistically, 116.5 billion servings of instant noodles were eaten around the world. By simple calculation, as many as 319 million servings are eaten daily. According to the global demand from 2016 to 2020, the consumption of instant noodles increased by 162.7% and 166.7% in Saudi Arabia and Egypt, respectively. As the number of serving reached to 830 and 350 million in Saudi Arabia and Egypt in 2020, respectively, as estimated by the World Instant Noodles Association in May 2021. In spite of the location, age, or gender of the consumer instant noodles are loved as a global food, despite their low nutritional values. Chowdhury et al., (2020) indicated that the instant noodles contain 8.5% to 12.5% protein with deficiency of other main nutrients, such as dietary fiber and vitamins. On the same content Sikander et al., (2017) found that the instant noodles contain about 2 % of dietary fibre, the thiamine content of commercial Asian instant noodles ranged between 0.077 and 0.156 mg/100 g (Bui and Small, 2008), whereas riboflavin varied between 0.37

* Corresponding author at: PO Box: 4279, Saudi Arabia.
E-mail address: hala.biomy@agr.dmu.edu.eg (H. Bayomy).
Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.jksus.2022.101833
1018-3647/

and 0.48 mg/g (Watanabe and Ciacco, 1990). To improve the nutritional quality of food products such as noodles, the inclusion of other nutritional sources rich in essential amino acids and fatty acids is therefore necessary (Onyema et al., 2014; Rodríguez De Marco et al., 2018; Chowdhury et al., 2020). Legumes are associated with the health benefits of the Mediterranean diet (Rebello, et al., 2014). Scientific research indicated that many bioactive compounds, including phytosterols, dietary fiber, oligosaccharides, proteins, and bioactive peptides, are found in legumes. Due to their beneficial nutritional and health effects, legumes can be used to enrich instant noodles (Singh et al., 2017; Sońta and Rekiel, 2020). Chickpeas and lentils are members of *Leguminosae*. Chickpeas (*Cicer arietinum*) are part of the *Cicer* genus. In the Middle East, chickpeas are widely used for hummus, which is characterized by a high nutritional profile in comparison to cereals. Chickpeas have a high protein content (20.9–25.27%) with high levels of lysine, low lipid content, and accessible iron and calcium (Dhawan et al., 1991). Lentil (*Lens culinaris Medik*.) is one of the most important sources of protein, which ranges from 20.6% to 31.4% (Urbano et al., 2007; Jarpa-Parra, 2018), and is an excellent source of essential amino acids except for methionine and cysteine (Rozan et al., 2018). This study aimed to formulate, improve, and assess the nutritional value of instant noodles enhanced with selected legume flours (chickpea or yellow lentil) with higher replacement rates than that studied by Sofi et al. (2020); Kaya et al. (2018) and Abd El-Fatah et al. (2013). To determine the best addition rate for each flour in terms of sensory evaluation and cooking properties, then studied the rheological properties, proximate chemical composition, energy, and amino acids contents of the prepared noodles.

2. Materials and methods

2.1. Materials

Durum wheat flour (*Triticum durum*), yellow lentils, and smaller chickpea seeds, which are called desi or hummus, were obtained from the local market in Tabuk, Kingdom of Saudi Arabia. The chemicals and reagents used in this study were of high quality and obtained from Sigma-Aldrich, USA.

2.2. Methods

2.2.1. Preparation of chickpea and yellow lentil flours

Lentil and chickpea seeds were ground a few times in a coffee grinder (model GVX212, Krupps, Essen, Germany). The obtained flours were sieved with a 30-mesh electronic screen and kept until tested in an air-tight container.

2.2.2. Manufacture of instant noodles

The production of instant noodles was carried out according to the method mentioned by Kuen et al. (2017), as shown in Table 1.

First, the salt was dissolved in water then the flour was added gradually and other ingredients to the mixer (Kenwood kitchen machine) at slow speed. Once the mixing was finished, around a minute after, the bowl and beater were scraped off. Next, the mixture speed was increased for about four minutes then stopped for two minutes to scrape the bowl and beater. The formed dough was covered with plastic tarpaulin and left to rest for 15 min. Then the dough was rolled and flattened, with taking care to avoid the dough sticking to the cutting board. A dough sheet was produced by flattening the dough through the pasta machine rolls to produce uniform sheets with the required thickness (1.5 mm). The sheets were rolled with leaving gap in the middle, then folded, and passed again through the rolls. After sheeting, the dough sheet was cut longitudinal in to noodle strands with a slitter in the pasta machine. The strands of noodles were divided into smaller portions and distributed to prevent the strands from sticking together during steaming. The noodles were steamed for 10 min in a steamer. Finally, the steamed noodles were dried in a tray dryer at 50 °C until the desirable moisture content (5–7%) was reached. Afterward, the noodles were cooled to room temperature. Then, the dried instant noodles were packed in polyethylene bags and stored at 12 to 14 °C until tested.

2.2.3. Proximate composition and energy value

Proximity composition of raw flours and obtained dried cooked instant noodles was carried out. Dried cooked instant noodles were ground well using laboratory mill (model GVX212, Krupps, Essen, Germany) with a screen size of 30 mesh to determine crude fiber, ash, protein (total nitrogen × 5.7), and crude fat contents using Association of Official Agricultural Chemists (AOAC) methods 978.10, 923.03, 979.09, and 945.38F, respectively (AOAC, 2006), in the National Research Center, Doke, Egypt. Means and standard deviations of data are expressed on the basis of dry weight (db) from three replicates. Total soluble carbohydrates were calculated by the difference. Energy was calculated considering the energy value of 4 kcal/g protein, 9 kcal/g lipids, and 4 kcal/g carbohydrates according to Simanjuntak et al., (2020).

2.2.4. Amino acid analysis

The AOAC Official method 982.30E (a,b,c) chapter 45.3.05, 2006 was used to assess the amino acid profile of cooked and dried instant noodle samples using a Beckman 7300 High Performance Amino Acid Analyzer (Beckman Instruments, Inc., Palo Alto, CA, USA) with ninhydrin detection by using a single buffer (2% Li-citrate, 1% LiCl, 1% HCl) and post-column o-phthalaldehyde (OPA) derivatization with 20% acetonitrile/0.1% formic acid as isocratic mobile phase. Amino acid/ninhydrin conjugates were recognised by retention time and quantified using integrated peak areas. A hydrolysate obtained by alkaline hydrolysis of a sample was analyzed for tryptophan, following Tkachuk and Irvine (1969).

2.2.5. Rheological properties

The rheological properties of the different flour blends including water absorption, arrival time (min), dough development (min), stability time (min), degree of softening (B.U), elasticity (B.U), extensibility (min), proportional number and energy (cm^2) were

Table 1
Formulation and ingredients added for the production of instant noodles.

Ingredients	Control	15% Chickpea	20% Chickpea	25% chickpea	15% lentils	20% lentils	25% lentils
Durum wheat flour (gm)	100	85	80	75	85	80	75
Chickpea flour (gm)	0	15	20	25	0	0	0
Yellow lentils flour (gm)	0	0	0	0	15	20	25
potato starch (gm)	10	10	10	10	10	10	10
Salt (gm)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Water (ml)	52	52	52	52	52	52	52

measured using the brabender Extensograph (Brabender, Duisburg, Germany) and Brabender farinograph (Farinograph-E, Brabender, GmbH and Co. KG, Duisburg, Germany) following the AACC 54–21 and 54–10 standard methods (AACC, 2000).

2.2.6. Cooking characteristics of instant noodles

The cooking characteristics of instant noodles include cooking time, water uptake during cooking, and cooking loss, were performed according to Javaid et al., (2018). Cooking time is indicated when the white core of the noodles disappeared when pressed between two glass plates according to method 66–50, AACC (2000). Water uptake was estimated by calculating the weight of noodles before and after cooking using the equation:

$$Water\ uptake(\%,\ db) = (Weight\ of\ cooked\ noodles - Weight\ of\ raw\ noodles) / Weight\ of\ raw\ noodles\ sample \times 100$$

Cooking loss was measured by evaporation of cooking water to dryness in the oven at 100 °C following AACC method no. 66-50 (2000), and is calculated as:

$$Cooking\,loss(\%,db) = (Dried\,residue\,after\,cooking\,/\,Noodle\,weight\,before\,cooking) \times 100$$

2.2.7. Sensory evaluation

Cooked instant noodles samples were coded and presented to 37 female panelists including students, scholars, and staff of the nutrition and food science department at Tabuk University with age ranges between 18 and 48 years. For all the samples, the panelists scored the appearance, flavor, taste, texture, and overall acceptability with the help of a nine-point hedonic scale, with 9 indicating extreme like and 1 indicating extreme dislike (Liu et al., 2019).

2.2.8. Statistical analysis

The means were compared between all values obtained from all blends using Tukey's test at a 5% level of significance using analysis of variance (ANOVA). Data are presented as mean ± standard deviation in all estimates except amino acids content.

3. Results and discussion

3.1. Proximate composition and energy value

The proximate composition of raw flours and instant noodles are presented in Table 2. As shown chickpea (23.63%) and lentil (26.31%) flours have nearby two folds of protein content compare with wheat flour (12.51%), crud fat and fiber content of chickpea and lentil flour is also higher compared to wheat flour. This may be a reason for the high nutritional value of the noodles resulting from mixing wheat flour with chickpea flour or lentil flour. Regarding the chemical composition of obtained noodles, the total protein increased significantly from 12.79% in the control to 15.31% with 25% chickpea substitution and to 15.84% in instant noodles enriched with 25% lentils. According to Hefnawy et al. (2012), chickpea and lentil are considered rich protein sources. Wang (2017) illustrated that lentil and chickpea flour contain 16.53% and 16.10% protein, respectively.

Crude fat in the control instant noodles was 2.62% and 3.36% in noodles with 25% chickpea substitution. Ash content significantly ($p < 0.05$) increased from 1.47% in control noodles to 1.94% in noodles enriched with 25% chickpea. The ash content in noodles enriched with 25% lentil flour was 1.93%. Crude fiber increased three-fold from the control sample (1.53%) to instant noodles substituted with 25% lentil flour (4.58%) due to the high fiber content in chickpea and lentil flours, especially since whole chickpeas and lentils seeds was used to produce the enriched noodles. The highest carbohydrate content (81.49%) was calculated for noodles made from durum wheat flour only, while the lowest value was calculated as 74.57% for noodles enriched with 25%lentils. Energy varied from 390.53 kcal/100 g for instant noodles enriched with 25% lentils to 401.1 kcal/100 g for the control instant noodles with slight significant between instant noodles enriched with the same ratio of chickpea and lentil flours.

As demonstrated by Brummer et al. (2015) and Jarpa-Parra (2018), lentil flour is richer in fiber and protein than chickpea flour but lower in fat. Thus, enrichment of durum wheat flour with lentils or chickpeas flour improved the resulting instant noodles in terms of protein, crude fat, ash, and crude fiber contents, and contributed to reducing carbohydrates and energy obtained from every 100 g. This confirms Abd El-Fatah et al. (2013) finding that the supplemented instant noodles with 15% of chickpeas increased significantly protein content, ether extract, ash and crude fiber from 10.14, 12.00, 1.00 and 1.15%, respectively for control to 12.35, 12.73, 1.48 and 1.69% db, respectively for noodles supplemented with 15% chickpea while, Total carbohydrate decreased significantly from 75.71 to 71.75% (db) for control and noodles supplemented with 15% chickpea, respectively.

3.2. Amino acid analysis

Due to the low nutritional value of wheat protein, and specially the deficiencies in lysine, tryptophan, and threonine (Šramková et al., 2009), our aim was to enrich noodles with high-nutritional-value sources like chickpea and lentil flour, which could provide an effective solution to protein-calorie malnutrition, especially in developing countries. Chickpea and lentil flours are superiority sources of essential amino acids, especially lysine, phenylalanine, valine, threonine, methionine and tryptophan thus, they are excellent complements to wheat flour or good sources of

Table 2
Proximate composition (%, db) and energy value (kcal/100 g) of raw flours and obtained noodles produced with different blends.

Samples	Total protein	Crud fat	Ash content	Crud fiber	Carbohydrate	Energy
Raw flours						
Wheat flour	12.51 ± 0.76	1.85 ± 0.03	1.28 ± 0.07	2.32 ± 0.51	82.04	394.85
Chickpea flour	23.63 ± 0.21	6.33 ± 0.33	2.84 ± 0.47	4.38 ± 0.71	62.82	402.77
lentil flour	26.31 ± 0.59	2.77 ± 0.60	2.78 ± 0.26	3.19 ± 0.78	64.95	389.97
Obtained noodles produced with different blends:						
Control	12.79 ± 0.21[d]	2.62 ± 0.04[b]	1.47 ± 0.06[d]	1.53 ± 0.03[e]	81.49[a]	401.1[a]
15%chickpea	14.36 ± 0.09[c]	3.06 ± 0.08[a]	1.74 ± 0.15[bc]	2.19 ± 0,06[de]	78.65[b]	399.58[a]
20%chickpea	14.85 ± 0.36[bc]	3.23 ± 0.00a	1.86 ± 0.05[a]	3.53 ± 0,27[abc]	76.53[c]	394.59[b]
25%chickpea	15.31 ± 0.11[ab]	3.36 ± 0.12a	1.94 ± 0.24[a]	4.07 ± 0.14[ab]	75.32 [cd]	392.76[bc]
15%lentils	14.67 ± 0.26[bc]	2.38 ± 0.07c	1.72 ± 0.20[c]	2.75 ± 0.32 [cd]	78.48[b]	394.02[b]
20%lentils	15.25 ± 0.04[ab]	2.79 ± 0.08[b]	1.80 ± 0.07[ab]	3.27 ± 0.07[bc]	76.89[c]	393.67[bc]
25%lentils	15.84 ± 0.19[a]	3.21 ± 0.07[a]	1.93 ± 0.04[a]	4.58 ± 0.36[a]	74.57[d]	390.53[c]

Means ± SD for flour and obtained noodles, data with different letters are significantly different ($p < 0.05$) for each parameter among noodles (column).

plant protein. The amino acid profiles for instant noodles with different proportions of chickpea or lentil flour substitution are presented in Table 3. The data showed that lysin, tryptophan, and threonine contents in durum wheat noodles were 2.31, 1.09, and 3.15 g/100 g protein, respectively, which increased to 3.32, 1.34, and 3.53 g/100 g protein, respectively, substituting 25% with chickpea flour. Significant increases were obtained by substituting 25% with lentil flour: the concentrations of lysin, tryptophan, and threonine reached 3.34, 1.35, and 3.61 g/100 g protein, respectively. Total essential amino acids varied from 36.96 to 39.01 g/100 g protein for the control and instant noodles with 25% chickpea, respectively. Generally, increasing the substitution ratio increased the total essential amino acids and decreased the sum of non-essential amino acids. Amino acids content was in the range of those recorded by Martínez-Villaluenga et al. (2010) and Mahmoud et al., (2012) for supplemented pasta with processed lupin and pigeon pea flours.

3.3. Rheological properties

The rheological properties of the different blends were measured with a farinograph and extensograph, as listed in Table 4. The farinograph results demonstrated the effect of adding chickpea or lentil flours to durum wheat flour. The water absorption required to reach the farinogram curve on the 500 Brabender units (BU) line increased significantly from 59.71% to 69.01% with increasing chickpea and lentil flour proportion in the mixtures. The water absorption increased after adding chickpea or lentil flour for several reasons, including the high fiber content of instant noodles enriched with chickpea or lentil flour. Substituting wheat flour with legume flours in proportions ranging from 15 to 25% dilutes the gluten content of the dough; the high protein content of chickpea and lentil flours increases the mixture's ability to absorb water due to chickpea and lentil protein fractions, such as globulins, which interact with gluten protein in the dough. The same effect on water absorption was reported by Ribotta et al., (2005) when heat-treated full-fat soy flour, enzyme-active defatted soy flour, and soy protein isolates were used for 5% to 12% substitutions of wheat flour. Also, the fiber content is one of the factors that affect the mixture's ability to absorb water, as it increased by 15% in the noodles mixture resulting from the 25% substitution of wheat flour with aleurone flour (Xu et al., 2020). Sabanis et al. (2006) found that the amount of water adsorption required to center the farinograph curve on the 500 BU line increased gradually with increasing chickpea flour content. The differences in arrival time, dough development time, and stability time among the 15% to 25% flour blends with chickpea or lentil flours ranged from 1.7 to 2.1 min, 4.8 to 5.9 min, and 2.8 to 4.8 min, respectively. The proteins in chickpeas and lentils reduced the stability of the dough and increased its development time due to the dilution of gluten. There may be competition between gluten and legume proteins added to the water and delaying the hydration process. The observed effects of delaying dough development and stability times agree with the findings reported by Ribotta et al. (2005) who supplemented wheat flour with soy flour. The degree of dough softening increased with increasing chickpea or lentil flours percentage in the blends under study, from 80 BU for the control to 97 BU for dough with 20% chickpea flour. This trend might have resulted from the dilution of gluten.

The extensograms indicated the increased elasticity and decreased extensibility with increasing chickpea ratio until 25% and lentil flour until 20% but increasing the lentil substitution ratio up to 25% resulted in a significant ($p < 0.05$) decrease in elasticity, while extensibility maintained the same decreasing trend. As the substitution level increased from 0% to 25% w/w, a slight increase in the area under the curve was observed, which is the energy required to break the strength of the dough after 135 min according to the standard method (AACC, 2000). The dough was still elastic, easy to handle, and produced a noodle dough with a fine texture (Table 4). Feillet and Dexter (1996) found that the rheological properties of durum wheat dough improved when chickpea flour was used as a substitute for 5% and 10% (w/w) of wheat flour in the noodles industry. Sabanis et al., (2006) confirmed that lasagna dough is produced with greater strength and extendable consistency by substituting chickpea flour for wheat flour (5–20% w/w), which enabled the lasagna to stay strong and flexible. Calculated proportional number significantly varied depending on the

Table 3
Amino acids profile (g/100 g protein) for instant noodles substituted with different proportions of chickpea or lentil flour.

Amino acids	Control	Chickpea			lentils		
		15%	20%	25%	15%	20%	25%
Non-essential amino acids							
Aspartic acid	5.61^{c}	6.18^{b}	6.54^{ab}	6.70^{a}	6.31^{b}	6.61^{a}	6.91^{a}
Serine	5.03^{d}	5.29^{cd}	5.48^{bc}	5.66^{ab}	5.73^{ab}	5.84a	5.96^{a}
Glutamic acid	30.24^{a}	28.61^{b}	27.80^{b}	26.89^{c}	28.40^{b}	27.62^{b}	26.85^{c}
Proline	10.48^{a}	9.92^{b}	9.52^{bc}	9.21^{c}	9.82^{b}	9.59^{bc}	9.52^{bc}
Glycine	3.24^{c}	3.38^{b}	3.42^{b}	3.43^{b}	3.43^{b}	3.57^{a}	3.63^{a}
Alanine	3.13^{d}	3.26^{bc}	3.33^{b}	3.51^{a}	3.20^{cd}	3.25^{bc}	3.31^{b}
Arginine	4.23^{c}	5.24^{a}	5.38^{ab}	5.52^{a}	5.03^{b}	5.09^{b}	5.16^{ab}
Total	**62.96^{a}**	**61.88^{b}**	**61.47^{bc}**	**60.92^{c}**	**61.92^{b}**	**61.57^{b}**	**61.34^{bc}**
Essential amino acids							
Cysteine	2.67^{a}	2.67^{a}	2.67^{a}	2.68^{a}	2.40^{b}	2.31^{bc}	2.23^{c}
Methionine	1.95^{a}	1.86^{b}	1.83^{c}	1.80^{c}	1.91^{a}	1.89^{b}	1.88^{b}
Isoleucine	3.90^{ab}	3.94^{a}	3.95^{a}	3.97^{a}	3.82^{b}	3.79^{bc}	3.77^{c}
Leucine	6.73^{c}	6.82^{b}	6.85^{b}	6.95^{a}	6.81^{b}	6.84^{b}	6.87^{b}
Phenylalanine	4.80^{d}	4.87 ^{cd}	4.89^{c}	4.92^{bc}	4.94^{bc}	4.99^{ab}	5.04^{a}
Histidine	3.06^{a}	3.02^{b}	2.99^{b}	2.97^{b}	3.04^{ab}	3.03^{ab}	3.03^{ab}
Valine	3.89^{c}	3.89^{c}	3.90^{c}	3.93^{c}	4.02^{b}	4.06^{ab}	4.11^{a}
Lysine	2.31^{c}	2.91^{b}	3.12^{ab}	3.32^{a}	2.93^{b}	3.13^{ab}	3.34^{a}
Tryptophan	1.09^{c}	1.16^{bc}	1.25^{ab}	1.34^{a}	1.22^{b}	1.30^{ab}	1.35^{a}
Threonine	3.15^{c}	3.42^{b}	3.42^{b}	3.53^{a}	3.55^{ab}	3.58^{a}	3.61^{a}
Tyrosine	3.41^{cd}	3.50^{bc}	3.59^{ab}	3.60^{a}	3.36^{d}	3.41^{cd}	3.36^{d}
Total	**36.96^{c}**	**38.06^{b}**	**38.46^{b}**	**39.01^{a}**	**38.00^{b}**	**38.34^{b}**	**38.59^{b}**

Data for obtained noodles with different letters are significantly different ($p < 0.05$) for each amino acid (row).

Table 4
Rheological properties of instant noodles with different substitution proportions of chickpea or lentil flour.

Flour blends	Farinograph characteristics					Extensograph characteristics			
	Water absorption %	Arrival time (min)	Dough development (min)	Stability time (min)	Degree of softening (B.U)	Elasticity (B.U)	extensibility (min)	Proportional number	Energy (cm^2)
Control	59.71 ± 1.72^{b}	1.7 ± 0.2^{d}	4.8 ± 0.2^{c}	4.7 ± 0.5^{ab}	80 ± 5.0^{c}	355 ± 34^{c}	105 ± 8.5^{a}	3.38c	73 ± 3^{e}
15%chickpea	61.36 ± 2.03^{b}	1.9 ± 0.2^{b}	5.4 ± 0.3^{b}	4.8 ± 0.5^{a}	95 ± 10.0^{a}	390 ± 51^{ab}	95 ± 4.5^{ab}	4.10^{bc}	78 ± 2de
20%chickpea	62.87 ± 0.84^{b}	1. 8 ± 0.4^{c}	5.6 ± 0.1^{ab}	4.3 ± 0.5^{bc}	97 ± 5.0^{a}	410 ± 29^{a}	88 ± 7.0^{bc}	4.66^{ab}	82 ± 6 ^{cd}
25%chickpea	69.01 ± 3.77^{a}	2.1 ± 0.3^{a}	5.9 ± 0.7^{a}	4.0 ± 0.0^{c}	95 ± 5.0^{a}	370 ± 39^{b}	73 ± 7.0 ^{cd}	5.07^{a}	87 ± 2^{ab}
15%lentils	60.46 ± 0.86^{b}	1.7 ± 0.1^{d}	5.0 ± 0.2^{c}	3.9 ± 0.6c	90 ± 00^{b}	365 ± 20^{c}	102 ± 3.0^{ab}	3.58^{c}	79 ± 3^{d}
20%lentils	62.53 ± 1.38^{b}	1.9 ± 0.3^{b}	5.5 ± 0.4^{b}	3.4 ± 0.6d	95 ± 5.0^{a}	380 ± 05^{bc}	82 ± 5.5^{c}	4.63^{ab}	84 ± 5^{bc}
25%lentils	67.93 ± 0.93^{a}	1.9 ± 0.3^{b}	5.7 ± 0.2^{ab}	2.8 ± 0.4e	95 ± 5.0^{a}	325 ± 35^{d}	65 ± 6.0^{d}	5.00^{a}	89 ± 2^{a}

Means ± SD (of duplicates) with different letters are significantly different ($p < 0.05$) for each parameter (column); BU: Brabender unit.

chickpea and lentil flour proportion, ranging from 3.38 for the control dough to 5.07 for 25% chickpea dough.

3.4. Cooking characteristics of instant noodles

The data obtained for the cooking characteristics of the produce cooked instant noodles are summarized in the ANOVA table in Table 5.

Samples with different ratios of chickpea or lentil flour showed significant changes ($p < 0.05$) in the cooking characteristics compared to the control instant noodles. The control instant noodles had the longest cooking time (4.29 min), which decreased with increasing proportion of non-gluten chickpea or lentil flour, reaching 3.17 min by increasing the portion of chickpea flour to 25%. This decrease might be due to chickpea and lentil starch usually requiring shorter cooking times than wheat starch. Our data agree with those reported by Petitot et al. (2010) and Slinkard (2014), where the addition of legume flours (split pea and fava bean) led to a decrease in cooking time.

Increased water uptake during cooking is necessary in the quality control of pasta products. Gulia et al. (2014) indicated that high-quality pasta products should absorb at least twice their weight after boiling in water. Table 4 shows that the highest water uptake (222%) was achieved for instant noodles prepared with 20% chickpea flour and 80% durum wheat flour, whereas the lowest value (183%) was absorbed by instant noodles enriched with 25% lentil flour. Water uptake increased when cooking noodles enriched with chickpea or lentil flour up to 20% compared to the control due to the increase in protein content; increasing the chickpea or lentil flour ratio to 25% resulted in a significant decrease ($p < 0.05$) in water uptake due to the competition between protein and starch for water, which resulted in lower water availability for the swelling of starch. These results agree with those of Khatkar and Kaur (2018), who explained that the combination of soy protein in semolina flour up to 10% caused a significant ($p < 0.05$) increase in water absorption during poling, but after that, water absorption significantly decreased.

Table 5
Cooking characteristics of instant noodles substituted with different proportions of chickpea or lentil flour.

Type of Noodles	Cooking time (min)	Water uptakes (%, db)	Cooking loss (%, db)
Control	4.29 ± 0.11^{a}	198 ± 7.5 ^{cd}	4.21 ± 0.26^{c}
15%chickpea	3.81 ± 0.24^{bc}	203 ± 11.0^{c}	4.26 ± 0.17^{c}
20%chickpea	3.31 ± 0.19^{d}	222 ± 6.2^{a}	5.75 ± 0.14^{b}
25%chickpea	3.17 ± 0.23^{d}	186 ± 4.3^{de}	6.88 ± 0.13^{ab}
15%lentils	4.06 ± 0.34^{ab}	219 ± 3.6^{ab}	4.34 ± 0.22^{c}
20%lentils	3.52 ± 0.08 ^{cd}	207 ± 8.1^{b}	6.29 ± 0.38^{a}
25%lentils	3.38 ± 0.12^{d}	183 ± 3.5^{e}	7.07 ± 0.19^{a}

Means ± SD for obtained noodles with different letters are significantly different ($p < 0.05$) for each parameter (column).

Cooking loss was significantly ($p < 0.05$) affected by the addition of chickpea or lentil flour. The control instant noodles prepared from 100% durum wheat flour had the lowest (4.21%) cooking loss; the highest value (7.07%) was obtained from instant noodles made from 75% durum wheat flour and 25% lentil flour. Although the addition of chickpea or lentil flours negatively influenced the cooking loss, the percentages are still acceptable for consumers and industry according to Feillet and Dexter (1996), who reported that noodle-leached components should not exceed 10% during cooking. The increasing cooking loss with increases in the substitution rate with chickpea or lentil flour occurred due to the dilution of the gluten, which thus weakened the formed glutenous network and reduced the ability to retain soluble materials in accordance with Wood (2009).

3.5. Sensory evaluation

The sensory evaluation of the instant noodles made by substituting a percentage of the wheat flour with chickpea or lentil flour is presented in Table 6. The sensory characteristics of instant noodles, such as taste, appearance, flavor, texture, and overall acceptability, guide consumers when making purchasing decision. So, instant noodles should have an attractive visual quality and an appropriate texture and taste after preparation.

Generally, the results of the sensory evaluation showed that the panelists significantly ($p < 0.05$) preferred replacing wheat flour with chickpea over lentil flour. The lower consumer acceptance of noodles made with the addition of lentil flour corresponded to its coarse texture, unpleasant mouth fullness, and unpleasant flavor compared to the alternative noodles with a hummus flour. The instant noodles produced by substituting 25% of the wheat flour with chickpea flour received the highest sensory evaluation in terms of taste, appearance, flavor, and overall acceptance, but the evaluation of texture decreased significantly with increasing the substituting ratio. The instant noodles with 15% lentils received a better sensory evaluation than the samples with the highest replacement ratio as shown in Table 6. Our results agree with those of Wójtowicz and Mościcki (2014), who reported that precooked pasta products enhanced with legume flour up to 30 g/100 g received an excellent sensory evaluation, including the firm texture and the compact inner structure. The scores received by Mahmoud et al., (2012) from the sensory valuation indicated that defatted lupine noodles at substitution portion of 5–20% had higher flavor and overall acceptability scores with non-significant differences compared to those made from wheat flour only. According to Giacco et al., (2016), spaghetti with a high protein

Table 6
Sensory evaluation of instant noodles with different proportions of substituted chickpea or lentil flour.

Types of noodles	Taste	Appearance	Flavour	Texture	Overall Acceptability
Control	6.83 ± 0.15^{b}	7.90 ± 0.15^{b}	7.50 ± 0.52 ^{cd}	8.05 ± 0.55 ^{cd}	8.40 ± 0.54^{abc}
15%chickpea	7.27 ± 0.04^{b}	8.75 ± 0.27^{a}	8.05 ± 0.10^{bc}	8.95 ± 0.14^{a}	8.75 ± 0.05^{ab}
20%chickpea	8.64 ± 0.26^{a}	8.70 ± 0.31^{a}	8.75 ± 0.14^{a}	8.75 ± 0.10^{ab}	8.86 ± 0.52^{ab}
25%chickpea	8.75 ± 0.25^{a}	8.85 ± 0.36^{a}	8.95 ± 0.05^{a}	8.30 ± 0.05^{abc}	9.00 ± 0.00^{a}
15%lentils	8.13 ± 0.32^{a}	7.44 ± 0.32^{bc}	8.62 ± 0.38^{ab}	8.24 ± 0.16^{bc}	8.45 ± 0.25^{abc}
20%lentils	8.46 ± 1.63^{a}	7.69 ± 0.53^{bc}	7.78 ± 0.22 ^{cd}	7.55 ± 0.15^{de}	8.36 ± 0.14^{bc}
25%lentils	7.26 ± 0.54^{b}	7.25 ± 0.05^{c}	7.35 ± 0.45^{d}	7.05 ± 0.40^{e}	7.18 ± 0.44^{c}

Means ± SD (for 37 panelists) with different letters are significantly different ($p < 0.05$) for each parameter (column).

content can be obtained by adding up to 35% soy flour without adversely affecting flavor or texture.

4. Conclusions

Instant noodles enriched with chickpea or lentil flour helped to achieve our goal to produce instant noodles that are acceptable to the consumer and have high nutritional value with higher protein, fiber, and amino acid contents and lower carbohydrate and energy obtained from 100 g. The total essential amino acids increased with the increasing substitute ratio. The proteins of chickpeas and lentils reduced the stability of the dough and increased its development time; the dough was still elastic and easy to handle and produced noodle dough with a fine texture until the substitution ratio reached 25 %. The sensory evaluation showed that the panelists significantly ($p < 0.05$) preferred replacing wheat flour with chickpea flour over lentil flour. Generally, present study concluded that durum wheat flour can be replaced with 25% chickpea flour or 20% lentil flour without negatively affecting rheological properties, cooking characteristics, or sensory qualities.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations of interest

None.

Contributors

Both authors work together in each part in this study.

I confirm that no part of this paper has been published any where.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

References

AACC, 2000. Approved methods of American Association of Cereal Chemists, method 66–50, method 76–21. AACC International, St. Pual, MN.
Abd el-fatah, N., Metwalli, A.A., Shams, O.S., 2013. Preparation and evaluation of instant noodles supplemented with natural sources of high lysine content. Egypt. J. Agric. Res. 91 (3), 1065–1081.
AOAC, 2006. Official Methods of Analysis of AOAC International. Washington, DC.
Brummer, Y., Kaviani, M., Tosh, S.M., 2015. Structural and functional characteristics of dietary fibre in beans, lentils, peas and chickpeas. Food Res. Int. 67, 117–125.
Bui, L.T.T., Small, D.M., 2008. The impact of flours and product storage on the thiamin content of Asian noodles. LWT-Food Sci. Technol. 41 (2), 262–269.
Chowdhury, S., Nath, S., Pal, D., Murmu, P., Dora, K.C., Rahman, F.H., 2020. Fortification of wheat based instant noodles with Surimi powder: A review. Curr. J. Appl. Sci. Technol., 117–125
Feillet P. Dexter EJ., 1996. Quality requirements of durum wheat for semolina milling and pasta production, in Pasta and Noodle Technology, ed. by Kruger JE, Matsuo RB and Dick JW. American Association of Cereal Chemists, Inc., St Paul, Minnesota, pp. 95–131.
Dhawan, K., Malhotra, S., Dahiya, B.S., Singh, D., 1991. Seed protein fractions and amino acid composition in gram (*cicer arietinum*). Plant Food Hum. Nutr. 41 (3), 225–232.
Giacco, R., Vitale, M., Riccardi, G., 2016. In: Pasta: Role in diet. The Encyclopedia of Food and Health, pp. 242–245.
Gulia, N., Dhaka, V., Khatkar, B.S., 2014. Instant noodles: processing, quality, and nutritional aspects. Crit. Rev. Food Sci. Nutr. 54 (10), 1386–1399.
Hefnawy, T.M.H., El-Shourbagy, G.A., Ramadan, M.F., 2012. Impact of adding chickpea (*Cicer arietinum* L.) flour to wheat flour on the rheological properties of toast bread. Int. Food Res. J. 19 (2).
Jarpa-Parra, M., 2018. Lentil protein: a review of functional properties and food application. An overview of lentil protein functionality. Int. J. Food Sci. Technol. 53 (4), 892–903.
Javaid, A.B., Xiong, H., Xiong, Z., Soomro, A.H., Zia-ud-Din, Ahmad, I., Nawaz, A., Ullah, I., 2018. Effects of xanthan gum on cooking qualities, texture and microstructures of fresh potato instant noodles. J. Food Meas. Charact. 12 (4), 2453–2460.
Kaya, E., Yılmaz Tuncel, N., Tuncel, N.B., 2018. Utilization of lentil, pea, and faba bean hulls in Turkish noodle production. J. Food Sci. Technol. 55 (5), 1734–1745.
Khatkar, A.B., Kaur, A., 2018. Effect of protein incorporation on functional, thermal, textural and overall quality characteristics of instant noodles. J. Food Meas. Charact. 12 (3), 2218–2229.
Kuen, N. H., Hamid, M. A., Mamat, H., Akanda, J. H., Ahmad, F., 2017. Effect of chickpea and okara composite flours on the quality of instant noodles. In 1st International Conference on Social, Applied Science and Technology in Home Economics (ICONHOMECS 2017). Atlantis Press.
Liu, R., Solah, V.A., Wei, Y., Wu, G., Wang, X., Crosbie, G., Fenton, H., 2019. Sensory evaluation of Chinese white salted noodles and steamed bread made with Australian and Chinese wheat flour. Cereal Chem. 96 (1), 66–75.
Mahmoud, E.A.M., Nassef, S.L., Basuny, A.M.M., 2012. Production of high protein quality noodles using wheat flour fortified with different protein products from lupine. Ann. Agric. Sci. 57 (2), 105–112.
Martínez-Villaluenga, C., Torres, A., Frias, J., Vidal-Valverde, C., 2010. Semolina supplementation with processed lupin and pigeon pea flours improve protein quality of pasta. LWT – Food Sci. Technol. 43 (4), 617–622.
Onyema, C.T., Ekpunobi, U.E., Edowube, A.A., Odinma, S., Sokwaibe, C.E., 2014. Quality assessment of common instant noodles sold in Nigeria markets. Am. J. Anal. Chem. 05 (17), 1174–1177.
Petitot, M., Boyer, L., Minier, C., Micard, V., 2010. Fortification of pasta with split pea and faba bean flours: Pasta processing and quality evaluation. Food Res. Int. 43 (2), 634–641.
Rebello, C.J., Greenway, F.L., Finley, J.W., 2014. A review of the nutritional value of legumes and their effects on obesity and its related co-morbidities. Obes. Rev. 15 (5), 392–407.
Ribotta, P.D.; Arnulphi, S.A León, A.E., 2005. Effect of soybean addition on rheological properties quality of wheat flour. Journal of the Science of Food and Agriculture, Vol.85, No.11, (August, 2005), pp. 1889-1896, ISSN 1097-0010
Rodríguez De Marco, E., Steffolani, M.E., Martínez, M., León, A.E., 2018. The use of Nannochloropsis sp. as a source of omega-3 fatty acids in dry pasta: chemical, technological and sensory evaluation. Int. J. Food Sci. Technol. 53, 499–507. https://doi.org/10.1111/ijfs.13609.
Rozan, M.A., Bayomy, H.M., Boriy, E.G., 2018. Effects of turmeric addition on chemical composition, antioxidant activity and sensory evaluation of lentil soup. Alexandria Sci. Exchange J. 39 (1), 1–6.
Sabanis, D., Makri, E., Doxastakis, G., 2006. Effect of durum flour enrichment with chickpea flour on the characteristics of dough and lasagne. J. Sci. Food Agric. 86 (12), 1938–1944.
Sikander, M., Malik, A., Khan, M.S.G., Qurrat-ul-ain, K.R., 2017. Instant noodles: are they really good for health. A Review. Electron. J. Biol. 13 (3).
Simanjuntak, D.S., Agustina, L., Nugroho, A., 2020. Sensory and chemical properties of cookies formulated with South Kalimantan's local comodities. EandES 443 (1), 012103. https://doi.org/10.1088/1755-1315/443/1/012103.

Singh, B., Singh, J.P., Shevkani, K., Singh, N., Kaur, A., 2017. Bioactive constituents in pulses and their health benefits. J Food Sci Technol 54 (4), 858–870.
Slinkard, M., 2014. Fortification of Pasta with Chickpea and Quinoa flours (Doctoral dissertation). University of Missouri–Columbia.
Sofi, S.A., Singh, J., Mir, S.A., Dar, B.N., 2020. In vitro starch digestibility, cooking quality, rheology and sensory properties of gluten-free pregelatinized rice noodle enriched with germinated chickpea flour. LWT 133, 110090. https://doi.org/10.1016/j.lwt.2020.110090.
Sońta, M., Rekiel, A., 2020. Legumes-use for nutritional and feeding purposes. J. Elementol. 25 (3).
Šramková, Z., Gregová, E., Šturdík, E., 2009. Chemical composition and nutritional quality of wheat grain. Acta Chim. Slovaca 2 (1), 115–138.
Tkachuk, R., Irvine, G.N., 1969. Amino acid compositions of cereals and oilseed meals. Cereal Chem. 46, 206–218.
Urbano, G., Porres, J.M., Frías, J., Vidal-Valverde, C., 2007. Chapter 5 nutritional value. In: Yadav, S.S., McNeil, D.L., Stevenson, P.C. (Eds.), Lentil. Springer Netherlands, Dordrecht, pp. 47–93. https://doi.org/10.1007/978-1-4020-6313-8_5.
Wang, J.W., 2017. Physicochemical Properties of Rice noodles as Affected by Addition of Canadian Lentil and Chickpea Flours (Doctoral dissertation).
Watanabe, E., Ciacco, C.F., 1990. Influence of processing and cooking on the retention of thiamine, riboflavin and niacin in spaghetti. Food Chem. 36 (3), 223–231.
Wójtowicz, A., Mościcki, L., 2014. Influence of legume type and addition level on quality characteristics, texture and microstructure of enriched precooked pasta. LWT-Food Sci. Technol. 59 (2), 1175–1185.
Wood, J.A., 2009. Texture, processing and organoleptic properties of chickpea-fortified spaghetti with insights to the underlying mechanisms of traditional durum pasta quality. J. Cereal Sci. 49 (1), 128–133.
World Instant Noodles Association, 2021. Global Report; World Instant Noodles Association: Tokyo, Japan Accessed on May 2021 https://instantnoodles.org/en/noodles/market.html, .
Xu, J., Bock, J.E., Stone, D., 2020. Quality and textural analysis of noodles enriched with apple pomace. J. Food Process. Preserv. 44 (8). https://doi.org/10.1111/jfpp.v44.810.1111/jfpp.14579.