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Processing Gluten- Free Noodles Fortified with Chickpea Flour

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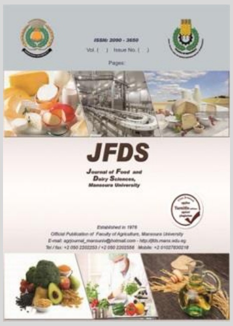

ABSTRACT

The aim of this study was to determine the quality attributes of chickpea enriched rice noodles. Black rice-chickpea pastas were produced from different blends 10–30% of chickpea flour and black rice flour. The protein, fat, ash, Ca, Mg and P content were observed higher for chickpea flour. The noodles' proximate composition, cooking quality, and sensory characteristics were determined. Results showed an increment in protein content (9.23 – 16.54 %), fat (2.64 – 4.14 %) and ash (1.91 – 2.71 %). Fortification with chickpea flour reduced cooking time (8.5 – 7.32 min) but increased cooking loss from 2.48 to 4.18 %. Black rice noodles enriched with 30% chickpea flour was highly ranked for sensory attributes. Chickpea flour can be successfully using in the noodles formula and improving the nutritional quality of noodles. In conclusion, this study found that black rice-chickpea noodles are a nutritional alternative to traditional rice noodles, as well as providing variety to dietary categories for celiac disease sufferers.

Keywords: Gluten-free noodles, black rice, chickpea, amino acid, pasting properties

INTRODUCTION

Pasta products, such as dry macaroni, noodles, and spaghetti, are among the most popular dishes worldwide and have evolved into an international cuisine. According to the International Pasta Organization (IPO), pasta consumption grew globally during the shutdown, and pasta exports increased by 25% in six months (IOP,2021).Dried pasta is easy to prepare, store, and match with a variety of sauces and seasonings, making it a nice, healthful, and "favorite" dish during this trying time. Even though many pasta types are created from common wheat or other flour supplemented with some beneficial components, the best quality pasta products are often made from durum wheat flour (semolina).People with celiac disease and others who desire to avoid gluten-based goods from their diet for health reasons now consume gluten-free (GF) pasta (Marti and Pagani, 2013).GF products are mostly inferior in nutritional and low cooking quality to wheat products (Marti and Pagani,2013).

Gluten-free pasta presents a number of difficulties. Gluten, a protein found in wheat, is not present in GF flour (e.g., rice, tubers, maize, millet, sorghum, etc.), causing the cooking quality and texture of GF pasta to be unacceptable. Gluten is an essential ingredient to build protein structure, which holds the starch in place and forms a protein network (Murray *et al*.,2004 and Mariotti *et al*.,2011). Gluten is a fundamental property to build dough's viscoelastic characteristics (Mariotti *et al*.,2011). GF flours' viscoelastic characteristics depend on the starch component properties (Padalino *et al*.,2016). Some GF flours that have been reported to be successful in making pasta are amaranth flour, rice flour, millet flour, maize flour, modified cassava flour, quinoa flour, buckwheat flour, or a mixture thereof (Schoenlechner *et al*., 2010; Sholichah *et al*., 2020and Yulianti *et al*.,2019). An additive may be selected to increase a cohesive mass in GF pasta. The alternative ingredients observed to emulate gluten's functionality are enzymes, proteins, and hydrocolloids (Padalino *et al*., 2016). Guar gum was previously utilised in noodles prepared with a combination of modified cassava flour, rice flour, and maize flour. The results show that adding guar gum to non-wheat noodles improves viscosity peak, breakdown viscosity, cooking time, and cooking loss (Ratnawati and Afifah, 2018). Rice is used in many foods such as bread, cakes and noodles. Rice starch is also used in many food applications. Rice flour is mainly used for making desserts, noodles, and sweets and as a thickener for custards, gluten free bread, salad dressing, tortillas besides sauces (Chandra and Samsher, 2013). A few rice varieties have unique characteristics in terms of their chemical composition, color and aroma.

Black rice (BR) is rich in carbohydrates and micronutrients. It also a good source of antioxidants such as phenolic compounds, which protect against diseases like cardiovascular disease and cancer (Saenkod *et al*., 2013 and Sompong *et al*., 2011). Aside from crackers, BR is used as a filler in sweets. Because it contains a phenolic mixture, particularly anthocyanins, it is considered a functional food. The demand for black rice is rapidly expanding in the United States and the European Union, owing to its worth as a health food in addition to its organic foodstuff colour.BR extract enhanced the plasma profile. BR provides a number of nutritional advantages over regular rice, including greater protein and mineral content. It contains a low fat content, high biological value protein, and is a good source of vitamins, as well as insoluble fiber (Oko *et al*., 2012 and American Culinary Federation Education Foundation, 2016).

Chickpea (Cicer arietinum L.) is a nutrient-dense pulse, and chickpea proteins are high in all essential amino acids, particularly lysine and threonine, according to Meng

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et al. (2010). Chickpea has been shown to provide a variety of medicinal and therapeutic effects, including antihypertensive and antihyperglycemic activity (Mokni *et al.*, 2015 and Li *et al.*,2015). However, adding nutritional and functional components like CF can have a detrimental affect on the final product's processing, textural, and sensory qualities, which is mostly due to the diluting effect of gluten-forming proteins in the system (Jia *et al*.,2019).

MATERIALS AND METHODS

Material

Black rice (Zizania aquatica) grains were brushed from Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt.

Chickpea grains (Cicer arietinum L.) were brushed from local market, Tanta, Gharbia,Egypt.

Xanthan gum was obtained from Egyptian International Trade Company, Sayeda Zainab, Giza, Egypt.

Methods

Preparation of black rice and chickpea flour

chickpea grains and black rice were hand-sorted To remove extraneous contaminants such as stones, broken, damaged and off-color grains and sticks , the black rice and chickpeas were crushed to flour in a grinder Quadrumat junior mill (Brabender- made in Germany) and sifted through a 60-mesh stainless steel sieve (250 m particle size). Each type of flour was vacuum-packed into nylon bags for future usage.

Fig 1. black and chick peas flour used in noodles preparation

Preparation of noodles

100 g black rice flour, 40 ml water, 1.5 g xanthan gum, and 0.5 g salt made up the control noodle formula. Three more noodle examples were made by replacing black rice flour with 10%, 20%, and 30% chickpea flour. The various formulations were turned into noodles, and the dough was allowed to rest for 30 minutes in a plastic bag.The dough was put through a tiny noodle hand machine multiple times with the spacing between the rollers steadily reduced, and the noodle strands were cut to the desired length with a sharp knife (12 cm). According to Nermin, (2013), the noodle strands were chopped and dried at 50 degrees Celsius after being cut

Proximate chemical composition

Moisture, ash, crude fiber, protein (N x 5.75), fat, and carbohydrate were determined by difference for black rice, chickpea flour, and noodles combined with chickpea flour at different ratios, according to the techniques provided in AOAC (2010).Meanwhile, the energy value was determined using the formula below based on their crude protein, fat, and available carbohydrate content: According to the AOAC, 2010 energy value (kcal/100 gm) = (Crude protein 4) + (carbohydrate 4) + (Crude fat 9).

Minerals content

Atomic absorption spectrophotometry (GBC Avanta E, Victoria, Australia) using Flam Photometer Apparatus was used to determine zinc (Zn), potassium (K), phosphorus (P), iron (Fe), magnesium (Mg), and calcium (Ca) (AOAC, 2010).

Determination of amino acids **of black rice and chickpea flour**

Extraction of amino acids was done by SYKAM S433 Amino Acids Analyzer as previously described (Knežević *et al*.,2009).The amino acids evaluation was performed at 60 °C with a gas flow rate of 0.5 ml/min, and reproducibility of 3 %. The amino acids were expressed as percentages of the total protein (Trajković *et al.*,1983).

Pasting properties

The pasting properties of tested flour samples as pasting temperature, peak viscosity, trough viscosity, and final viscosity were measured using a Rapid Visco Analyzer RVA 4500 (AACC, 2010). A 3 g (dry weight basis) sample was put into a canister with 25 mL of distilled water. It was equilibrated for 1 minute at 50°C, then heated to 95°C for 4 minutes, kept at 95°C for 7 minutes, cooled to 50°C for 4 minutes, and kept at 50°C for 2 minutes.

Cooking quality of noodles

Cooking Time

The time required for the centre of the noodles strand to disappear while cooking was used to determine the cooking time (every 30 s)noodle samples were squeezed between glass slides to transparent (Ritthiruangdej *et al., 2011).*

Cooked weight

The method described by Olaoye *et al*. (2007) was used to calculate the cooked weight. In 300 ml boiling water, 10 g dried noodles were cooked. Noodles were cooked until the white center was no longer visible. Aluminum foil was used to cover the beaker. Weighing the wet mass after the cooked noodles had been drained for 2.5 minutes yielded the cooked weight of the noodles.

Cooking Loss

The cooking loss was calculated using AACC-approved technique 66–50.01, which is defined as the amount of solid substances lost into the cooking water (AACC, 2000). A ten-gram sample of noodles was cooked in 500 millilitres of boiling distilled water. 50 mL distilled water was used to rinse the cooked noodles. In a beaker, the cooking water and rinse water were collected and poured into an agar plate.

Swelling index

The AACC-approved technique 66–50.01 (AACC, 2000) was used to determine the swelling index of cooked noodles, which was computed as follows:

Indicator of swelling (percentage) = (Weight of noodles after drying) (Density of cooked noodles)- (Weight of noodles after drying).

Water absorption

Water absorption was determined according to the AACC-approved method 66–50.01 (AACC, 2000). Ten grams of dried noodle samples were pre-weighed and boiled in 300mL of water for the cooking time which previously determined. Then, Noodles were removed and weighed, the weight difference before and after cooking was used to calculate the water absorption as follows: Water absorption (%) = 100 Weight of raw noodles Weight of cooked noodles- Weight of raw noodles x cooked weight Noodles (10g) were cooked in 300ml distilled water in a beaker for the recommended cooking time, rinsed with distilled water, drained, and allowed to cool at room temperature for 5 minutes. The cooked noodles were then reweighed after cooling. The weight of the cooked food was measured in grammes.

Sensory evaluation of noodles

For the optimum cooking time, noodle samples were boiled in water. 10 untrained panelists rated optimally cooked noodles for color, flavor, taste, texture, and overall acceptability using nine-point hedonic scales, where 9 = strongly like and 1 = extremely dislike. Sensory attributes were used to determine the ideal ratio of turnip powder in the noodles when compared to the control.

Statistical Analysis

The data was analysed with (SPSS) Windows and the results were recorded as means (Ver.10.1). To find differences between treatments, Duncan comparisons and one-way analysis of variance (ANOVA) were performed (Armitage and Berry, 1987).

RESULTS AND DISCUSSIONS

1. Chemical Composition of black rice and chickpea flour

Table 1 shows chickpea flour had the highest values in crude protein being (21.52%), fat (4.90%) and ash content (3.04 %) than those of black rice flour which contained 9.12% of protein, 2.75% of fat and 1.83% of ash.On the other hand, black rice flour had the highest value in fiber (1.96%) and carbohydrates (77.01%).The chemical composition of black rice is in agreement with those of Abd El-Rahman and Shehata (2010) and Fatchiyah *et al.* (2020).The result of the chemical composition of chickpea flours was confirmed by those of El-Shimy (2013) and Wani and Kumar (2014).

Table 1. Proximate chemical composition of black rice and chickpeaflour (%)

Component %	Black Rice flour	Chickpea flour
Moisture	7.33	8.24
Protein	9.12	21.52
Fat	2.75	4.90
Ash	1.83	3.04
Crude fiber	1.96	1.54
Total carbohydrates	77.01	60.76
Energy (kcal/ 100g)	369.27	373.22

2. Minerals content

The ash level of black rice and chickpea flour was significant since it included nutritionally important minerals. Some of these minerals are shown in Table (2). P, Mg, and K are minerals that are necessary for human health. They've been recommended as having the potential to prevent people against obesity and metabolic diseases (Nielsen ,2010 and Cai *et al*.,2016).The phosphorus (220.15), magnesium (165.23), and calcium (130.54) content of chickpea flour was higher than that of black rice. This results in agreement with those of Dandachy *et al.* (2019). Black rice had a relatively high levels of iron (7.76 mg/100g), zinc (6.01 mg/100g), potassium (156.36 mg/100g) compared with chickpea flour. These results were in harmony with those stated by FAO (1993) and Abd El-Rassol *et al.* (2005), Badawy and Mahgoub (2015) & Abouel-Yazeed *et al.* (2019).

In comparison to the necessary daily dietary limits (for children aged 6-59 months), black rice (BR) might be regarded a decent source of Fe and Zn, averaging 4.1 mg/24h for Fe and Zn, respectively (WHO/WFP/UNICEF 2007).

Table 2. Mineral content of black rice and chickpea flour on a dry weight basis (mg/100g).

Mineral content	Black Rice flour	Chickpea flour
Mg	129.92	165.23
Ca	52.13	130.54
K	156.36	150.65
P	159.87	220.15
Fe	7.76	4.11
Zn	6.01	2.65

3. Pasting Properties

Pasting is a process that occurs after starch dissolves and gelatinizes. Granular enlargement, exudation of molecular components from the granule, and eventual granule disruption are all part of the process (Thomas *et al*., 1999).

Table 3 summarizes the findings of the current investigation on the pasting properties of black rice and chickpea flour. The cooking time is represented by the peak time, while the minimum temperature required to cook flour is indicated by the minimum temperature (Iwe *et al*.,2016). The minimal temperature required for flour cooking was supplied by the pasting temperature (Iwe *et al*.,2016). The pasting temperature is the temperature at which the viscosity begins to rise.

Peak viscosity refers to the level of starch swelling or water-binding capability during the heating process (PV).Viscosity was reduced (breakdown viscosity) once PV was attained, indicating the degree of stability of swollen starch granules during cooking (Wani *et al*.,2012). The cooked paste's final viscosity indicates its stability (Iwe *et al*.,2016). Low cooking intolerance is associated with high breakdown because starch granules have a low capacity to resist shear forces (Chung *et al*., 2012) The retrogradation or staling of the flour paste is referred to as setback (Iwe *et al*.,2016).

Table 3. Pasting Properties of black rice and chickpea flour

Pasting Properties	Black Rice flour	Chickpea flour
Pasting Temperature (°C)	69.50	73.51
Peak time (min)	5.62	5.95
Peak Viscosity (cP)	475	445
Breakdown (cP)	235	182
Final Viscosity (cP)	632	594
Setback (cP)	220	206

Table 3 shows that chickpea flour has a low peak viscosity (445 cp), final viscosity (594 cp), and setback (206 cp). It was discovered that chickpea flour may be employed as a paste with ease, but that it is not resistant to shearing and is difficult to regress. All of these features are linked to the high fat content of the meat (Table 1).Higher fat content has been shown to restrict starch from swelling as it absorbs water and inhibits interactions among the starch molecules, as well as between starch and its stirring paddles, as a result affecting pasting viscosity. Higher fat content can also obstruct the directional organization of distributed starch molecule chains, making retrograde more difficult In a range of culinary goods, such as soups and sauces, where retrogradation causes viscosity loss and precipitation, the ability to lower retrograde is helpful (Adebowale and Lawal, 2003)..

4. Total Amino Acid Contents of Black Rice and chickpea flour.

The amount of amino acids in a food is a good predictor of its nutritional value. In the black rice and chickpea samples examined, nine of the key necessary amino acids were found (except for tryptophan). Histidine, threonine, valine, tyrosine, methionine, lysine, isoleucine, leucine, and phenylalanine were among them. Essential amino acids must be consumed in sufficient proportions in the normal human diet because they are not generated by the body.

Table 4. Amino acid composition of black rice and chickpea flour

Amino acids %	Black Rice flour	Chickpea flour
	Essential Amino Acids (EAA)	
Threonine	5.1	3.9
Valine	5.7	4.0
Methionine	3.2	1.1
Isoleucine	4.7	4.3
Leucine	8.9	6.7
Phenylalanine	5.9	6.3
Tyrosine	3.5	7.8
Lysine	3.5	2.7
Histidine	2.1	1.1
Total EAA	42.6	37.9
	non-Essential Amino Acids (NEAA)	
Asparagine	8.3	12.3
Serine	5.4	5.5
Glutamine	17.4	18.2
Proline	3.9	2.7
Glycine	4.2	4.1
Alanine	6.1	4.5
Arginine	8.0	10.6
Total NEAA	53.30	58.9
Total AA	95.9	95.8

The highest amount of essential amino acid found in black rice flour was leucine (8.9g/100 g protein) followed byphenylalanine (5.9g/100 g protein), while the highest amount of essential amino acid in chickpea flour was tyrosine (7.8g/100 g protein) followed by leucine (6.7g/100 g protein). The content of essential amino acids (42.6 g/100 g protein) is significantly higher in black rice flour than in chickpea flour (37.9g/100 g protein).The results of the present study indicate that black rice flour is excellent sources of total, essential, amino acids and are comparable to chickpea flour.

Apart from that, aspartic and glutamic acids are said to affect rice flavour, particularly the sweetness and characteristic "umami" flavour (Kasai *et al.*, 2001). Rice contains a higher concentration of amino acids and protein than most other cereals (FAO, 1992).

Previously, Kamara *et al.* (2010) demonstrated that the quantity of amino acids contained in rice grains has a significant impact on the sensory aspects of cooked rice, influencing the overall acceptance of a rice variety.

5. Chemical Composition of gluten-free noodles fortified with chickpea flour

Table 5 shows the chemical composition of chickpea flour-fortified noodles. The moisture level of the noodles fortified with 30% chickpea flour increased from 9.45 percent in control noodles to 10.51 percent in noodles fortified with chickpea flour. This could be due to the chickpea flour used in the recipe has a high moisture content. Food moisture content is used as a criterion for food quality.

Table 5. Proximate chemical composition of noodles fortification with chickpea flour at different levels

Components	Control	noodles formula		
		(A)	(B)	(C)
Moisture	9.45^{d}	10.23^{c}	10.40^{b}	10.51^{a}
Protein	9.23^{d}	11.27^{c}	13.62^{b}	16.54^{a}
Fat	2.64^{d}	3.24^{c}	3.65^{b}	4.14^{a}
Ash	1.91^{d}	2.26^{c}	2.41^{b}	2.71^{a}
Crude fiber	1.84^{a}	1.79^{a}	1.53^{b}	1.49^{b}
Total carbohydrates	74.93^{a}	71.21^{b}	68.39^{c}	64.61^{d}
Energy (kcal/ 100g)	360.40^{c}	359.08^{d}	360.89^{b}	361.86^{a}

Control = 100% black rice flour
A= 90% black rice flour + 10% chickpea flour
B= 80% black rice flour + 20% chickpea flour
C = 70% black rice flour + 30% chickpea flour

Conversely there was an increase in protein content from 9.23% in control noodles formula to 16.54% in noodles formula fortified with 30% chickpea flour. This increase could be due to that fortification effect caused by its the high protein content of chickpea flour(Table 1).Fortification of chickpea flour in noodles formulation resulted in significant ($P < 0.05$) increases in protein, fat and ash contents of the noodles when compared with those of control (Table 5).These increases are an expected result due to the chickpea rich chemical composition (Table 1).Thus, the incorporation of chickpea flour into the noodles formulas could improve the mineral intake, as ash is indicative of the amount of minerals contained in any food sample(Olaoye *et al*., 2007). These findings are consistent with those of Osorio-Daz *et al.*,2008, who found that as the amount of chickpea flour in the composite pasta increased, protein, ash, and fat content increased while fiber decreased.

The increasing levels addition of chickpea flour resulted in decreasing the carbohydrate content of noodle samples.

6. Noodle quality

Table 6 represents the results of the cooking quality of the noodles. Cooking time and cooking loss are crucial factors in determining whether or not pasta is acceptable to consumers. Cooking time and loss are undesirable because they show a high energy requirement for cooking, whereas high cooking loss indicates a high starch solubility, resulting in poor pasta quality. The cooking time and cooking loss of the chickpea Shorter cooking time (8.0 -7.32 min) and higher cooking loss (2.89 - 4.18) were recorded for the chickpea fortified rice noodles compared to cooking time (8.5 min) and cooking loss (2.48%) of the un-fortified rice noodles. These findings corroborate those of Petitot *et al.* (2010), who found that adding legume flours (split pea and faba bean) to wheat flour reduced pasta cooking time while increasing cooking loss.

Table 6. Cooking quality of noodles fortification with chickpea flour at different levels.

Parameters	Control	Noodles formula		
		(A)	(B)	(C)
Cooking time(min)	8.50[a]	8.00[b]	7.57[c]	7.32[d]
Cooking loss (%)	2.48[d]	2.89[c]	3.48[b]	4.18[a]
Cooking weight(g)	28.40[a]	27.87[b]	27.12[c]	26.76[d]
Swelling index(ml/g)	5.67[a]	5.50[b]	5.28[c]	4.99[d]
Water absorption (%)	199.51	190.12	184.59	179.01

Control = 100% black rice flour
A= 90% black rice flour + 10% chickpea flour
B= 80% black rice flour + 20% chickpea flour
C = 70% black rice flour + 30% chickpea flour

The increased cooking loss seen in the pasta samples can be attributed to the gluten-free pasta structure weakening, allowing soluble solids from the pastas to leach into the cooking water (Rayas-Duarte *et al*., 1996). Higher cooking loss can also be ascribed to increased starch degradation (Lorenz *et al*., 1993), which is produced by increased water penetration in the pasta core, resulting in physical disruption of the pasta matrix due to the lack of gluten in all of the ingredients used for pasta production (Chillo *et al*., 2008).

Increase in cooked weight was a measure of the quantity of water absorbed by the product. The cooked weight reduced dramatically as the percentage of chickpea flour in blends increased.As indicated in Table 6, the cooked weight of the control sample (28.4 g) was the highest, followed by noodles fortified with 10% chickpea flour (27.87 g), noodles fortified with 20% chickpea flour (27.12 g), and noodles fortified with 30% chickpea flour (26.76 g).

In terms of swelling index, the chickpea flour noodles samples had slightly lower values than the control noodles. As a result of the rivalry between fibre and starch for water absorption, starch components may have absorbed less water during the optimum cooking time, resulting in lower swelling indices. Therefore, increasing fiber contents generally results in lower swelling of starch and swelling index.

The WAI is a measurement of a food's ability to retain water (Singh,2001). Rice flour noodles have a better water absorption capacity than those made from other grain flours. These findings are in line with Chandra and Samsher (2013), who discovered a reduced WAI (1.92 g/g) in rice flour.

7. Sensory attributes of the gluten-free noodles

The sensory evaluation of a product is one of the most essential criteria for determining its quality and acceptability. The sensory features of a product determine its quality first, followed by its price. Sensory evaluation is an important consideration that is used to assess panelists'/consumers' reactions to the final product (Meilgaard *et al.,* 2007).

The results of the sensory evaluation of the chickpea fortified noodles and the unfortified rice noodles are presented in Table7. Sensory evaluation values for color increased in the fortified noodles formula with increasing proportion of chickpea flour in the noodles, the lowest values being (8.9) with the un-fortified formula Thus, noodles samples fortified with 30% chickpea flour were most preferred to the panelists in terms of color. This could be due to the yellowness of the chickpea fortified noodles. The flavor of the chickpea-fortified noodles, which were 30% chickpea-fortified, was appreciated. These findings differ slightly from those of Bouasla *et al*. (2017), who reported no colour or flavour variations between rice pastas enriched with 10, 20, or 30% legume flours (yellow pea, chickpea, and lentil) and 100% rice pasta. It's possible that variations in the content and quality of the bean flour used in the pasta recipe are to blame.

Table 7. Sensory evaluation of noodles fortification with chickpea flour at different levels

Parameters	Control	Noodles formula		
		10%	20%	30%
Color	8.9[d]	9.1[c]	9.3[b]	9.5[a]
Flavor	8.1[d]	8.4[c]	8.5[b]	8.8[a]
Taste	8.2[d]	8.4[c]	8.7[b]	9.1[a]
Texture	7.8[d]	8.2[c]	8.5[b]	8.8[a]
Over all acceptability	8.4[d]	8.5[c]	8.8[b]	9.1[a]

Control = 100% black rice flour
A= 90% black rice flour + 10% chickpea flour
B= 80% black rice flour + 20% chickpea flour
C = 70% black rice flour + 30% chickpea flour

Sensory values for texture of the chickpea flour fortified noodles increases with increasing levels of chickpea flour (30%) in the noodle's formulation. This may be due to high protein contents of the chickpea flour fortified noodles. The increase in overall acceptability was due to increase in sensory quality characteristics such as color, flavor and taste scores of instant noodles. These findings corroborate those of Bolarinwa and Oyesiji,2021, who found that rice pasta supplemented with 15% soybean flour ranked highly for sensory qualities.

Fig. 2. prepared noodles samples

CONCLUSION

The addition of chickpea flour to black rice noodles created a healthier alternative to plain rice noodles. Chickpea-fortified black rice noodles possessed more protein and other chemical components, as well as a better color, than unfortified black rice noodles. Supplementation decreased the cooking time, but slightly increased the cooking loss. Cooked fortified black rice noodles at 30% fortification level was satisfactory and highly rated in terms of color, taste, odor, texture and overall acceptance.

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تصنيع نودلز خالية من الجلوتين مدعمة بدقيق الحمص

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أجريت هذه الدراسة بغرض الاستفادة من دقيق الحمص في تصنيع خلطات غير تقليدية من النودلز الخالية من الجلوتين. تم انتاج ثلاث خلطات من النودلز باستخدام (١٠-٣٠%) من دقيق الارز الأسود ودقيق الحمص بالاضافة للعينة الكنترول المصنعة من دقيق الأرز الأسود. تم تقدير التركيب الكيميائي وجودة الطهي والخصائص الحسية للنودلز. وأظهرت النتائج زيادة في محتوى البروتين (٩,٢٣ – ١٦,٥٤%) والدهون (٢,٦٤ – ٤,١٤%) والرماد (١,٩١- ٢,٧١%) في العينة المدعمة ب٣٠% دقيق الحمص. وأدت اضافة دقيق الحمص الى خلطات النودلز في خفض زمن الطهي من ٨,٥ الى ٧,٣٢ دقيقة في عينات النودلز المدعمة بدقيق الحمص ولكنها عملت على زيادة فقد الطهي من ٢,٤٨ الى ٤,١٨ واحتلت عينات النودلز المصنعة من الأرز الأسود والمدعمة بنسبة ٣٠% من دقيق الحمص أعلى درجات القبول من حيث الخصائص الحسية لذا توصي الدراسة ان النودلز المصنعة من الأرز الأسود ودقيق الحمص هي بديل غذائي لنودلز الأرز التقليدية, فضلا عن توفير مجموعة متنوعة من الفئات الغذائية لمرضى الاضطرابات الهضمة.