Journal of the College of Specific Education for Educational and Specific Studies Issue (23) Feb 2023

Effect of different processing of white kidney beans on physicochemical and sensory characteristics of fortified pasta

by

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Abstract

The effect of using different replacement levels of white kidney bean flour to improve the nutritional quality and functional properties of wheat pasta was conducted. wheat flour was replaced by 10, 20 and 30% of treated white kidney bean (soaked, cooked or germinated) to produce fortified pasta. Chemical, physical, mineral content of raw material were determined. Chemical, physical, texture, quality attributes and organoleptic characteristics of pasta were determined. Results related that, the germination treatment led to increase total protein content and decrease the total carbohydrate content of white kidney bean with significant difference compared to other treatments. The control uncooked pasta recorded the highest value of hardness compared to other fortified samples. All fortified cooked pasta recorded higher values of cooking yield compared to control pasta on contrary to the springiness, gumminess and chewiness which slightly increase with the increasing replacement levels of treated white kidney bean.

Key words: wheat flour, fortified pasta, white kidney beans, germination, texture profile, soaking.

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Introduction

Food is considered a good source of biologically active compounds that exhibit a great impact to improve the overall status of human health. Individuals worldwide gradually shift their diet to foods rich in vitamins, polyphenols, carotenoids, essential oils, proteins, and peptides (Jakubczyk et al., 2020).

Plant proteins have been used extensively for many years in the food industry as food product ingredient due to the amino acid content (Horax et al., 2004). Grain legumes are an excellent source of protein, carbohydrates, dietary fiber, vitamins, minerals and phytochemicals (Tharanathan and Mahadevamma, 2003) which has led to the increase in consumption worldwide. Additionally, Animal proteins are better assimilated than vegetable proteins because plant proteins are deficient in sulphur amino acids (methionine and cysteine), and tryptophan. Therefore, a diet that combines protein-containing foods with complementary cereal amino acids is important to gain the complete amino acid pool (Melo et al., 2012).

Legumes also known as pulses are important food source and play a significant role in traditional diets all over the world (Chung et al., 2008). in Africa especially and other developing countries, animal proteins are grossly inadequate and relatively expensive. Research effort has been intensified towards finding alternative sources of protein from underutilised grain legume seeds in the last decades (Adebowale et al., 2005).

Common bean most popular leguminous vegetable crops grown in (Phaseolus vulgaris L.) is one of the Middle East. It acts as a rich source of proteins, carbohydrates, and nutrients in the human diet. Beans are widely cultivated on newly-reclaimed soils in the Middle East, including Egypt (Wael et al., 2015). Also, Galal and Mohamed, (2019) stated that, common bean is one of the most important vegetable crops in Egypt for local market and exportation.

The white bean represents the most important nutrition legume in many countries in the world. It has high protein, dietary fibers, and mineral content and it is mainly used in the form of cooked food (Hoxha et al., 2020).

So, this study was conducted to produce some of functional foods such as fortified pasta to reduce malnutrition, to suit diabetics and to improve cardiovascular health by fortification wheat flour with different ratios of some natural food sources such as treated white kidney bean (soaked, cooked and germinated). In addition to their potential role in improving global food security. Also, this study aims to evaluate the final product concerning chemical, physical, and sensory characteristics.

Materials and methods

Materials

Commercial Australian wheat flour obtained from the Egyptian market, at the same time (Produced by five stars milling Co., Suisse, Egypt.) [Strong strength commercial wheat flour, Extraction rate 72%]. White kidney bean (Phaseolus vulgaris L.) was obtained from Alsuhagy for Food Industries, Elkanater Elkhairia, Egypt. Chemicals used in this study were purchased from El-Gomhoria and El Shark El Aost Companies, Egypt. Other ingredients including sugar, salt, active dry yeast, butter and eggs were obtained from local market Giza, Egypt.

Methods

Preparation of raw materials

Preparation of soaked Kidney bean flour

The kidney bean flour was prepared according to the method described by Giami and Bekebain (1992). One kilogram of kidney bean seeds which was free from dirty and other foreign materials such as stones, sticks, then soaked in 2L tap water for 12 hr. Seeds were ground by using mixer (MIENTA super blender, Model BL -721) and dried in the cabinet dryer (120°C/90 min). During drying, the ground seeds were stirred at intervals of 30 minutes to ensure uniform drying. The ground seeds were sieved to pass through a 300 mesh sieve. The milled seeds kidney bean flour, placed in an aluminum paper. The obtained flour was finally packaged in sealed polyethylene bags due to the hygroscopic nature of the flour until used for blending and analysis.

Preparation of cooked kidney bean flour

100 g of seeds with 300 ml tap water were put in a pressure cooker (Hawkins). The samples were cooked for 50 minutes at 10 pounds per square inch (psi) pressure. Just after steam started coming out from the vent. Cooking time is generally assessed by the softness of the cooked seeds by applying pressure of the fingers (Singh et al., 1991). Then dried at 70 °C for 72 hr. and ground to fine powder in an electric grinder using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979,

Germany) to pass through a 300 mesh sieve and then stored in pouches bags for further use.

Preparation of germinated kidney bean flour

According to Eissa et al. (2007), the white kidney bean was germinated in sterile Petri-dishes lined with wet filter papers for 48 h at 37°C, with frequent watering. The sprouts were rinsed in distilled water and dried at 55–60°C. The dried sample of raw and germinated white kidney bean was ground to fine powder in an electric grinder using a Laboratorial disc mill (Quadrumat Junior flour mill or Model Type No: 279002, ©Brabender ® OHG, Duisburg 1979, Germany) to pass through a 300 mesh sieve and then stored in pouches bags for further use.

Preparation of fortified pasta

Pasta dough for control samples was prepared from 100% strong wheat flour (72% ext.). Experimental fortified samples were prepared with different portions of treated white kidney bean (Table 1). Pasta dough was prepared according to the procedure reported by Collins and Pangloli (1997) on the basis of 600 g flour. All dry ingredients were combined and mixed to produce homogenize mixture. Placed the mixture in a mixing bowl and mixed until the dough formed. The dough was rounded (shaped into a ball), covered with plastic wrap, allowed to rest 30 min, hand-kneaded 1min, divided into approximately 100-g portions and formed using pasta machine (Philips Pastamaker HR2357/05 Machine Corporation, Italy). The drying process of pasta was conducted according to Mostafa (2020), formed pasta was exposed to air-dried at 23-25 °C for 4 h. A fan operated in the room to facilitate drying. The air-dried Pasta transferred to a cabinet dehydrator and dried to moisture content 12 % at 70 °C. Thereafter, cooled at room temperature (25°C±2), placed in plastic bags, sealed the plastic bags and stored at 12-14°C until tested.

Table (1): Pasta formulas

Pasta samples	Strong wheat flour (g)	Common bean treatments (g)		
		Soaking	Cooking	Germination
Control	100	--	--	--
SKB	90	10	--	--
SKB	80	20	--	--
SKB	70	30	--	--
CKB	90	--	10	--
CKB	80	--	20	--
CKB	70	--	30	--
GKB	90	--	--	10
GKB	80	--	--	20
GKB	70	--	--	30

SKB= soaked kidney bean, CKB= cooked kidney bean, GKB= germinated kidney bean

Analytical methods

Chemical composition

Chemical analysis was performed on raw materials and final products. The contents of moisture, protein, fat, crude fiber and ash of raw materials and the biscuits produced were determined according to the AOAC (2012). Total carbohydrates were calculated by difference.

Minerals determination

Mineral quantification was carried out by Atomic Absorption Spectrophotometer (type AAnalyst 400, Perkin–Elmer, Waltham, MA, USA) after sample digestion with HCl as described by Gupta et al. (2012).

Texture profile analysis

Texture profile analysis of pasta

Texture of pasta samples (hardness, springiness, cohesiveness, chewiness and gumminess) was determined by Texture Profiles Analysis (TPA) CT3™ Texture Analyzer (Brookfield) according to Boume (2002). The computer was set for Test works software and an appropriate test was selected for the TPA analysis: test speed 2.50mm/s, load cell 10000g in two cycles for cooked pasta and one cycle for uncooked pasta with 10mm depth. The parameters like length, diameter, speed, the percent compression, and number of cycles were given as input data to the computer before staring the compression of the sample. Then the load cell starts slowly moving downwards, compressing the sample, and wait between first and second compression cycle for 5 seconds. After two cycles the compression of the sample will automatically stop.

Cooking quality of pasta

Pasta cooking quality was determined according to the approved method in AACC (2012). Optimum cooking time was the time required for the opaque central core of the pasta to disappear when squeezed gently between two glass plates after cooking. Cook 25 g of pasta to optimum time in 300 mL tap water in a beaker, rinsed in cold water and drained for 15 min before weighed. Percentage of increased weight calculated as a cooking yield. Solids content in the cooking water was determined by drying at 105 C overnight. The cooking loss was expressed as a percentage between the solid weight and initial dry matter. The nitrogen loss was determined according to the approved Kjeldahl method in American Association of Cereal Chemists (AACC, 2012) using conversion factors of 5.7.

Organoleptic characteristics of pasta

Pasta products were cooked in boiling water without addition of salt, drained and placed in warm conditions until testing. An 18-member semi-trained panel evaluated pasta products for overall quality Color (20), taste (20), texture (20), appearance (20), flavor (20) and overall acceptability (100) (Larmond, 1977).

3.4.12. Statistical analysis

The obtained results were statistically analyzed using SPSS statistical package (Version 20) according to Rattanathanalerk et al. (2005), analysis of variance (ANOVA). Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among various treatments at $p<0.05$.

RESULTS AND DISCUSSION

Effect of processing treatments on chemical composition of common bean

The effect of processing treatments on the approximate chemical composition of common was determined and according to the obtained results (Table 2) it can be noticed that, the soaking treatment led to significantly decrease fat and crude fiber contents ($p \leq 0.05$) comparing untreated common bean, meanwhile the soaking

Table (2): Effect of processing treatments on chemical composition of common bean

Chemical composition (% on dry weight basis)	Untreated common bean	Processing treatments			LSD at 0.05
		Soaking	Cooking	Germination	
Moisture	4.59a	3.86b	3.69bc	3.50c	0.198
Ash	3.18a	3.05a	2.16b	3.22a	0.184
Fat	1.74a	1.59b	1.04d	1.28c	0.103
Protein	20.89c	21.73b	20.93c	23.99a	0.455
Crude fiber	3.50b	3.18c	4.15a	3.32bc	0.273
Total carbohydrates	70.69a	70.46a	71.73a	68.20b	1.485

Means in the same column with different letters are significantly different (P<0.05).

process showed higher protein content (21,73%) compared 20.89% which recorded by the untreated sample with significant difference, while no significant differences regard the ash and total carbohydrates contents. However, after cooking the ash and fat contents significantly decreased (2.16 and 1.04% respectively) compared to untreated common bean (3.18 and 1.74% respectively) in contrast to the fiber content which increase after cooking process. In another study which investigated by Shimelis and Rakshit (2005) they found that soaking treatment led to decrease the ash content compared to cooking and they explained the lower ash content of soaked beans maybe because of not only mineral lixiviation but also antinutritional factors, where there is a positive correlation between ash content, zinc and phytic acid contents in beans (P. vulgaris L.). Thus, a reduction of the ash content may be desirable. Cooking also seems to reduce ash content (Osman, 2007).

4.7. Effect of processing treatments on minerals contents of common bean

The effect of processing treatment on minerals contents (Ca, Mg, Fe and Zn) of common bean are shown in Table 3 and this results indicated that no significant differences between untreated common bean and soaked sample concerning calcium

Table (3): Effect of processing treatments on minerals contents of common bean

Minerals contents (% on dry weight basis)	Untreated common bean	Processing treatments			LSD at 0.05
		Soaking	Cooking	Germination	
Ca	311a	307a	266b	309a	13.211
Mg	73.57 b	69.15 c	58.22 d	80.69 a	3.062
Fe	6.98a	6.57b	5.77c	7.41a	0.625
Zn	4.28b	4.06b	2.97c	4.73a	0.409

Means in the same column with different letters are significantly different (P<0.05).

Thus, germinated sample showed the highest values of magnesium and zinc contents (P < 0.05), while the same aforementioned treatment led to significantly decrease magnesium and iron content compared to untreated sample. On the other hand, the cooking treatment led to decrease all the minerals contents under study with significant differences compared to untreated sample. (80.69mg/100g) and zinc (4.73mg/100g) with significant differences compared to untreated sample and other treated with different processes.

These results are in agreement with Granito et al. (2007) they observed that there was a greater loss of calcium, magnesium, potassium, zinc and iron in cooked beans than in soaked beans cooked without the soaking water. However, minerals lost during cooking lixiviate to the cooking water (Huma et al., 2008) consequently, bean preparations consumed with the cooking water retain those minerals. Also, Ramirez-Cardenas et al. (2008) they found higher contents of zinc and iron in unsoaked beans and calcium and copper in beans cooked with the soaking water. While Pujola et al. (2007) stated that soaking caused a greater loss of total solids, regardless of cooked legumes with or without the soaking water. Also, Huma et al. (2008) found that soaking and cooking can reduce the amount of minerals significantly.

4.11.4. Effect of fortification on cooking quality parameters of cooked pasta

Dried pasta is typically consumed after rehydration by cooking to recover its properties. Therefore, it is important to understand the processes occurring during the rehydration of dried pasta, which is a complicated mass transport process governed by several migration mechanisms of water into the pores (Ogawa and Adachi, 2017). Cooking quality parameters of fortified pasta were exhibited in Table 4. The replacement of wheat flour by different ratios (10, 20 and 30%) of soaked kidney bean led to increase the optimum cooking time of fortified pasta compared to control pasta with significant differences ($P < 0.05$), on contrary the cooked kidney bean which led to significantly decrease the optimum cooking time compared to control pasta, where the extent of protein coagulation and starch gelatinization, and consequently, the overall cooking quality of the final pasta product, is greatly affected by the native properties of protein quantity and quality (El-Sohaimy et al., 2020).

Table (4): Cooking quality parameters of cooked pasta

Cooked Pasta samples	Quality parameters			
	Optimum cooking time	Cooking yield	Cooking loss	Nitrogen loss
Control	12.70d	145.93f	7.08cd	4.55d
10% SKB	13.30c	165.15e	7.50abc	4.75cd
20% SKB	14.40b	196.72d	7.75a	4.87bc
30% SKB	15.25a	218.57c	7.90a	5.27a
10% CKB	11.35e	225.19c	6.52ef	4.69cd
20% CKB	11.10e	258.44b	6.17fg	4.78cd
30% CKB	10.20f	283.57a	6.02g	4.95bc
10% GKB	12.70d	179.88de	6.90de	4.79bcd

20% GKB	12.80cd	198.21d	7.23bcd	4.92bc
30% GKB	13.10cd	217.66c	7.60ab	5.10ab
LSD at 0.05	0.573	17.662	0.426	0.318

Means in the same column with different letters are significantly different (P<0.05).

SKB= soaked kidney bean, CKB= cooked kidney bean, GKB= germinated kidney bean

The results also indicated no significant differences between the control sample and others fortified with 10, 20 and 30% of germinated kidney bean concerning the same parameter.

Cooking loss is defined as the quantity of solids going into water during cooking of pasta which determinant the quality of pasta where compact textured pasta leads to lower cooking loss (Petitot et al., 2010). According to AACC 2012, all the cooking loss obtained values are within the acceptable limits since the solid loss in cooking water should not exceed 9%. Where, the cooking loss of pasta which fortified with 10, 20 and 30% of soaked kidney bean showed higher values compared to control in terms of cooking loss, whilst the replacement of wheat flour by cooked kidney bean (10, 20 and 30%) showed lower values (6.52, 6.17 and 6.02 respectively) compared to control pasta (7.08) with significant differences.

4.11.5. Effect of fortification on texture profile analysis of cooked pasta

The textural properties of cooked pasta are the important parameter to determining the final acceptance by consumers (Tudorica et al., 2002). The textural properties of fortified cooked pasta which containing different replacement levels of treated kidney bean (soaked, cooked and germinated kidney bean) were conducted by texture profile analyzer (TPA) compared to control cooked pasta which produced from 100% wheat flour (72% ext.) and the obtained results wear illustrated in Figures 1, 2, 3, 4 and 5.

Texture profile analysis of cooked pasta represented in hardness, cohesiveness, springiness (also named elasticity), gumminess and chewiness parameters. The lowest value of hardness (4.09 N) was obtained by the control sample, while the fortified samples were gradually increase with the increasing level of treated kidney bean where the highest values of hardness (5.17 and 5.28 N) were recorded by the pasta samples contained 30% soaked kidney bean and other

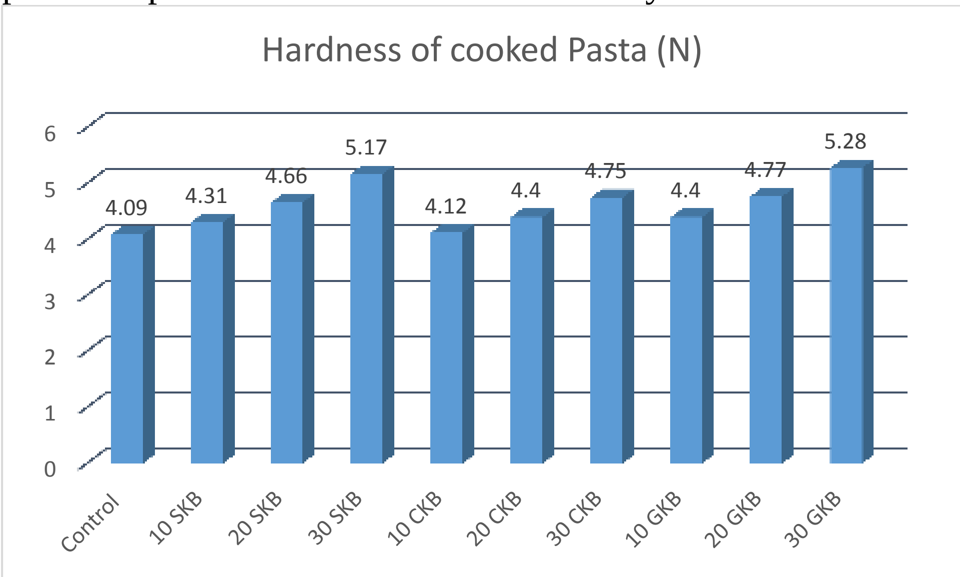

Figure (1): Hardness of cooked pasta

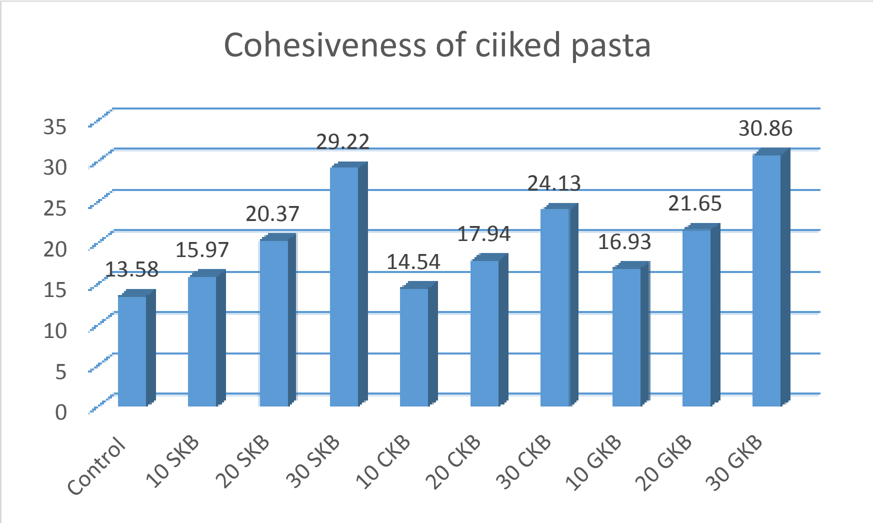

Figure (2): Cohesiveness of cooked pasta

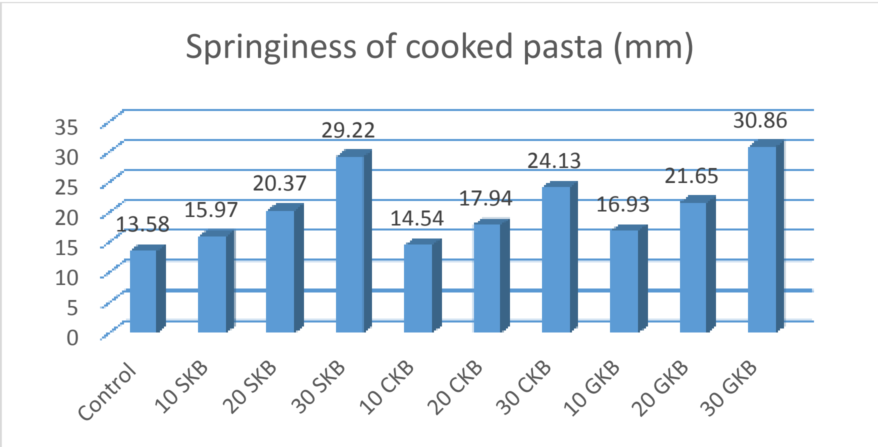

Figure (3): Springiness of cooked pasta

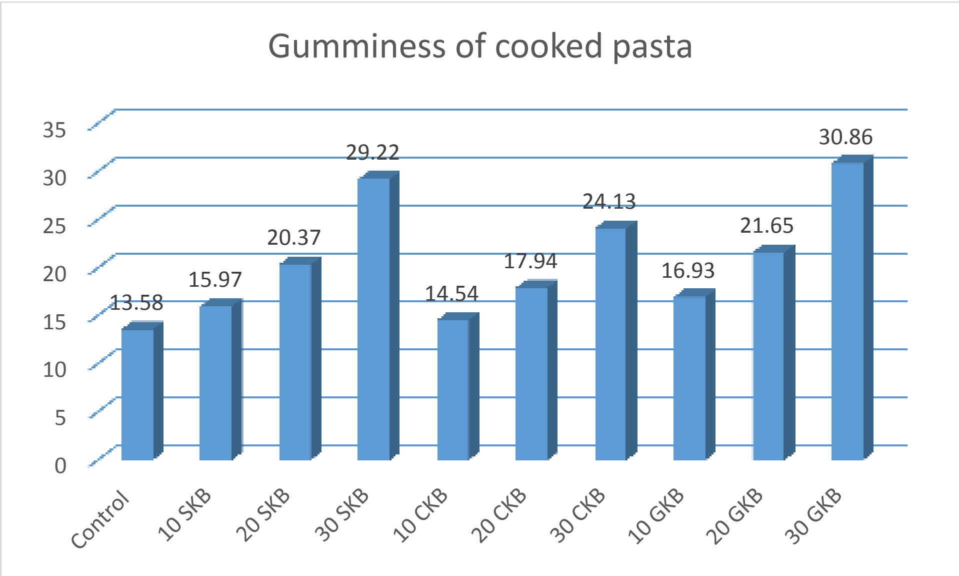

Figure (4): Gumminess of cooked pasta

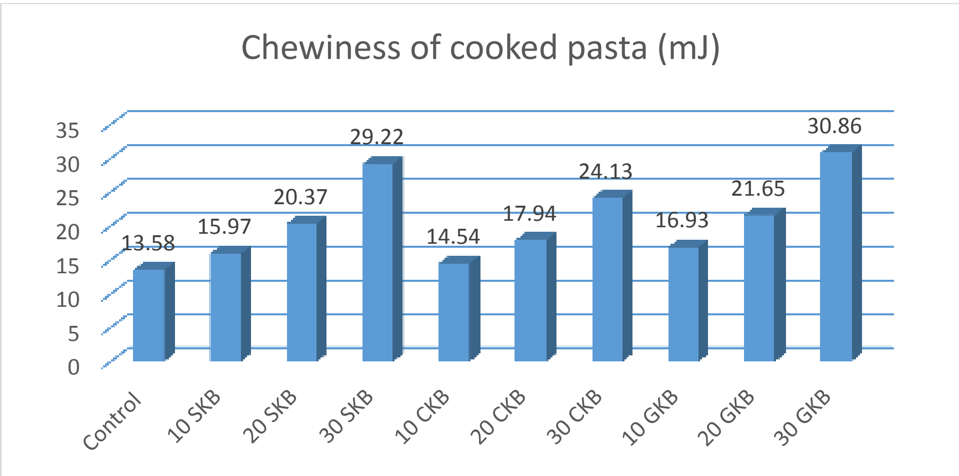

Figure (5): Chewiness of cooked pasta

contained 30% germinated kidney bean respectively. Also, the cohesiveness values were slightly increase with the increasing levels of treated kidney bean and ranged from 0.80 to 1.21 compared to 0.76 which recorded by the control sample.

On the other hand, the lowest values of springiness and gumminess (4.37 mm and 3.11 respectively) were observed by the control sample and also the fortified samples recorded higher values of the same aforementioned parameters compared to control sample meanwhile the fortified samples contained 10, 20 and 30% of cooked kidney bean recorded lower values of springiness and gumminess compared to others fortified with 10, 20 and 30% of soaked or germinated kidney bean. This pattern may be related to the higher cooking loss values (Table 4) as explained by (Flores-Silva et al., 2015). Cohesiveness and springiness values did not record any significant differences between all chickpea fortified pasta formulations except when they were compared to control. However, cohesiveness and springiness parameters indicated how the sample holds together upon cooking, which interpreted the higher values recorded for the legumes fortified pasta than the control sample as reported by Kosović et al. (2016). Also, Petitot et al. (2010) reported that fortification of pasta with legumes flour was reported to decrease the cooking time, increase the cooking lose and also affect the firmness and cohesiveness. on the other hand, El-Sohaimy et al. (2020) reported gumminess and chewiness subsequently followed the hardness pattern to show increasing values along with chickpea increased concentrations.

4.11.6. Effect of fortification on organoleptic characteristics of cooked pasta

Table 5 summarized the sensory evaluation of cooked pasta and from the obtained results it could be noticed that, no significant differences (P < 0.05) between the control pasta (100% wheat flour pasta) and other fortified samples concerning the color values with except the sample contained 30% cooked kidney bean which recorded the lowest score of color value (14.67).

Table (5): Organoleptic characteristics of cooked pasta

Cooked pasta samples	Organoleptic characteristics					
	Color (20)	Taste (20)	Texture (20)	Appearance (20)	Flavor (20)	Overall acceptability (100)
Control	16.15ab	17.05a	18.61a	16.85a	19.08a	87.74a
10% SKB	17.13ab	16.45b	17.83a	16.61a	17.78abc	85.80a
20% SKB	17.56a	15.08c	17.07ab	17.30a	16.52bcd	83.53a
30% SKB	17.80a	14.14d	14.03c	17.52a	14.58d	78.07c

10% CKB	16.06ab	17.50a	19.20a	16.81a	18.25ab	87.82a
20% CKB	15.54ab	16.58b	19.16a	15.93b	17.68abc	84.89a
30% CKB	14.67b	15.02c	19.26a	15.49b	15.71cd	80.15b
10% GKB	16.93ab	16.81a	17.20ab	16.98ab	17.25abc	85.17a
20% GKB	17.55a	15.47c	17.27ab	17.18a	16.03bcd	83.50b
30% GKB	17.98a	14.86c	15.08c	17.50a	15.95bcd	81.37b
LSD at 0.05	2.501	0.772	2.444	1.509	2.515	3.758

Means in the same column with different letters are significantly different (P<0.05).

SKB= soaked kidney bean, CKB= cooked kidney bean, GKB= germinated kidney bean

Also, no significant differences between the control sample and other samples contained 30% cooked kidney bean and other contained 30% germinated kidney bean concerning the taste parameter. However, the lowest scores of texture (14.03 and 15.08) were recorded by the samples fortified with 30% cooked kidney bean and other contained 30% germinated kidney bean respectively with no significant between them, meanwhile no significant differences between the control sample and the rest samples concerning the same aforementioned parameter.

As for the appearance test, no significant differences between the control sample and other fortified samples with except the two samples fortified with 20%

cooked kidney bean and other contained 30% cooked kidney bean which recorded the lowest values (15.93 and 15.49 respectively) with no significant between them.

On the other hand, the replacement ratios of all treatments led to decrease flavor scores compared to the control sample which recorded the highest value (19.08). in generally, the highest value of overall acceptability (87.74) was obtained by the control sample, whereas no significant differences between the control sample and others fortified with 10 or 20% of soaked kidney beans, 10 or 20% of cooked kidney beans, and only 10 % fortified with germinated kidney beans regard the overall acceptability. As reported by Hooper et al. (2019) despite the higher nutritional values of fortified pasta with legumes compared to wheat pasta the consumers preferred the flavor, texture and appearance of the wheat pasta to the dry bean pasta.

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