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Research Article

Effects of Blending Semolina with Egg Powder on Physico- Chemical and Sensory Quality of Macaroni

Abstract

A study was conducted to improve the nutritional status of macaroni product by adding egg powder to semolina flour. The effects of five proportions of egg powder (20%, 25%, 30%, 35% and 40%) were investigated. The result showed that with increase in egg proportion, increase in protein, fat, ash and a reduction in fiber and carbohydrate were observed. Improvement in Fe, Ca and Zn were also observed. Farinograph dough rheology evaluation indicated a drop in water absorption, stability time, time to dough viscosity break and tolerance index. On the other hand, increase in dough development time was noticed. Increase in the egg powder proportion resulted in the reduction of optimum cooking time and hardness. At the same time the water uptake capacity and cooking loss were increased. Addition of egg powder improved the color acceptability in general. However the various proportions didn't show significant difference in color and homogeneity. Sensory evaluation score of macaroni stickiness increased and that of springiness decreased with increase in egg proportion. Overall acceptability decreased with increased in egg proportion. From all trials macaroni with 20, 25 and 30% egg powder were acceptable in many sensory quality attributes and product properties. Macaroni with 30% egg powder, in addition to those qualities, has much better nutrient chemical composition and functional properties than the others.

Introduction

Pasta is a term used for range of products commonly known as macaroni spaghetti, and noodles. Italians, the largest consumers in the world, call these products as pasta alimentare [1]. The wheat preferred for making pasta products is durum. In contrast to common wheat which is used to make bread and oriental style noodles, durum wheat is the hardest wheat and its milling produces a coarse particle called semolina, ideal for making pasta. Pasta products are a source of carbohydrates (74–77%, db) in which interest is increasing due to its nutritional properties, particularly its low glycaemic index (GI) (Monge, 1990). Pasta also contains 11–15% (db) proteins [2]. This provides an opportunity for the use of non-traditional raw materials to increase the nutritional quality of pasta [3]. However, a blended product suffers a deficiency with respect to some quality attributes such as cooking qualityor color.

Pasta products can be dried by different temperature, low, high and ultrahigh, and increasing the drying temperature brings increased firmness values, decreased cooking loss and cooked weight values and also color score dried under high temperature was higher than those for products dried by 60, 70, and 80°C [4].

Eggs are rich source of protein with high biological value. The protein quality of the egg is often the standard for measuring the quality of all other food proteins. Egg powder has deep yellow color with typical composition of protein 47% and fat 43%, sodium 310 mg/100 g, and potassium 535 mg/100 g [5]. Semolina has got a proximate composition of proteins about 13.3%, starch 77.6 %, lipids 1.7% and ashes 1% [6,7].

Fortification of semolina with egg powder can therefore improve the protein and mineral content of the final pasta product which are deficient from the durum semolina pasta product.

Fortification of pasta with egg powder increases the production and demand of egg and brings it into the market chain besides improving the nutritional content of the pasta. However research reports on pasta product production from fortified dry egg powder in Ethiopian is limited. The main objective of this work was to determine the impact of different level of egg powder addition and drying temperature on the cooking quality, sensory attributes and chemical composition of the macaroni. Egg powder was selected for this study as it is only used in fresh home-made pasta and also received less attention than other non-traditional pasta raw material like legume flours such as bean and chickpea.

Materials and Methods

Raw materials

Semolina flour was obtained from Dire Dawa Food Complex Private Limited Company while egg powder obtained after drying by using forced air oven drier as suggested by Joel et al, [8].

Chemical composition of semolina and egg powder

Moisture content of both raw materials and product were determined according to AACC (2000) [9]. Total protein content was determined using Kjeldahl procedure with a nitrogen-to-protein conversion factor of 5.8. Total carbohaydrate content was determined by a difference, which is, subtracting percentage sum of ash, moisture, protein, fiber and fat from 100. Ash analysis is done by incinerating the sample at 550°C for 12 hrs. Fat content (soxhlet extraction method) and fibers were determined according toAACC (2000) [9], method.

Minerals such as iron, Zinc and Calcium compositions were determined by atomic absorption spectrophotometer. Determination of β-carotene was carried by spectrophotometer (GENWAY, Model 6505, CECIL instruments, England). β-carotene extraction followed by sample and standard preparation were performed. Then the absorbance is measured at 450nm for both the sample and standard solution. The wet and dry gluten were determined by the method as described in AACC (2000) [9], method No. 38–10. All analyses were conducted in triplicate.

Particle size distribution of semolina and egg powder

Particle size distribution of semolina and egg powder were analyzed in triplicate by using shaker (Sieve Shakers, Model RX-30-E 12, U.S.A) fitted with different sieve sizes (750, 500, 250, 180 and 90 μm) and the percentage of particles that pass through the sieve was calculated.

Farinograph test

This was done by a method described in AACC [9], Method 54-21 at 30±0.2°C using a 300g mixing bowl at a mixing speed of 63 rev min^{-1}, by using farinograph. From the resulting curve farinogram indices was measured by the farinogram software (Brabender ® Farinogram version: 3.6, 1996-2005, Microsoft Corporation). These were:Water absorption (%), dough development time (min), Stability time (min), mixing tolerance index (FU) and time to break down (min).

Macaroni processing

A mixture of 1/3 egg yolk and 2/3 egg white powder was formed and blended with semolina flour at ratio of 0%, 20%, 25%, 30%, 35% and 40% and then extruded using laboratory Extruder (Model 'Minilab '30S'', China). From each mix, 300 g was hydrated with tap water to 32% (wb) moisture content by mixing for 15 min (60 rpm). The product was then extruded (single screw) and dried under oven (Scientific series 2000, Model 220, South Africa) by 90°C to 12% moisture content [10], adjusting the air flow and decreasing the relative humidity gradually.

Macaroni cooking quality

Cooking time: Dried Macaroni was cooked in water (2 L/100 g) containing 0.7% (w/v) of sodium chloride. Optimal cooking time (T) was indicated when the white core of the macaroni disappears when squeezed between two transparent glass plates (approved method of AACC [9]. All analyses on cooked macaroni were made on pasta cooked at T + 1 min.

Water uptake quality in cooked Macaroni: Water uptake was evaluated on a 50 g dry Macaroni sample by measuring the weight (W) of pasta before and after cooking and calculated using the equation:

$$\text{Water uptake (\%,db)}=\left(\frac{W_{\text{cooked pasta}}}{W_{\text{drypasta}}}-1\right)\times 100$$

Cooking loss: The dry matter content of a dry macaroni sample was first determined. Then the pasta sample was cooked at T + 1 min and its dry matter content was determined by a two-stage drying procedure. First, a pre-weighed cooked pasta sample was dried in an oven at 50 °C for 2 days. The sample was then ground and an aliquot was weighed and dried in oven at 130 °C for 2 h.

The cooking loss was calculated as:

$$\text{Cooking loss (\%,db)}=\left(\frac{Dm_{\text{cooked pasta}}}{Dm_{\text{drypasta}}}-1\right)\times 100$$

Texture profile analysis

The texture analyzer (TA-XT plus, Model plus, England) was used to compress a single strand of raw macaroni at a constant deformation rate of 1 mm/s to 70% of the initial thickness. The probe was retracted and held stationary before performing the next test. From texture profile analysis, hardness (force attained during the compression) was obtained.

Sensory analysis

Sensory acceptability evaluation was carried out by 50 panelists. Sensory analyses on macaroni samples cooked in water (2 L/100 g) at T+1 minute were presented in a random order to each panelist separately. The panelists were asked to score different quality characteristics, including homogeneity, stickiness, springiness, flavor, color and overall acceptability.

Data analysis

Analysis of variance (ANOVA) for triplicate data was carried out to investigate the effects of egg proportion and drying temperature on sensory and physico-chemical properties of the product using SAS software (SAS Institute and Cary, NC. USA). Duncan Multiple Range Test was used for multiple mean separations at 5% probability level.

Results and Discussion

Chemical composition of semolina

Chemical composition of semolina flour is shown in the table 1. The moisture content of semolina flour was 11.79%,

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which is higher than (9.5%) reported by Sawsanet al, [11]. Protein content was 14.2% and this value meets protein levels, >13%, which is the desired level for high quality pasta as reported by Chilloet al, [3]. The fat content of the semolina found as 1.5% which is almost similar to the value (1.7%) reported by Maud et al. (2010). The fat content is influenced by the degree of germ and aleurone layer removal on the durum wheat milling for semolina extraction. It is also determine the stability of the flour. The semolina carbohydrate content indicated to be 71.2%, while the semolina fiber content was found to be 0.43%, which was close to the range of 0.175%–0.35% reported by Sawsanet al, [11]. The semolina fiber content is influenced by the durum wheat variety, durum wheat grain quality and the semolina extraction levels on the durum wheat milling [12].

The wet gluten content of semolina in this study was 30.10% and the dry gluten content was 12.63%. The desired bright yellow color of semolina and its products are imparted by the carotenes content of semolina. In this work the β- carotene was determined as 6.07ppm as indicated in the table 1. The ash content was 0.75% nearly similar to those reported as 0.94% by Sabaniset al. (2006) and 0.79 % by Yalla and Manthey [13]. The iron, zinc and calcium contents were determined as 15.67µg/g (ppm), 14.60µg/g and 232.0µg/g, respectively.

Chemical composition of egg powder

The moisture content was 6.67% and this result is similar to the report (6.74%) of Joel et al, [8]. This moisture content is low enough to extend the shelf life of the egg powders in an environment of low humidity. Protein content of the egg powder was 38.23% somewhat lower than the report of Kumaravelet al. [14], showing that there is no adverse effect by the oven drying method on the protein content. The fat content was 15.11%. This is known to enhance the emulsification process in foods and diminish foaming potentials [15]. These characteristics including oiliness may not be reflected much in this study due to low fat content

(low egg yolk in egg powder) and are a quality defect in pasta processing if fat content is high.

Carbohydrate and ash content of the egg powder were determined as 42.63% and 3.37% respectively.

The egg powder had high mineral contents indicating it is a good source of calcium content. The iron, calcium and zinc contents of the egg powder were 33.20µg/g, 1110µg/g and 26.17µg/g, respectively.

Particle size distribution of semolina and egg powder

The difference in particle size distribution of raw materials has impact on the hydration properties. If there is a large particle size difference, it will result into heterogeneous hydration of particles and formation of large dough lumps (Maud et al., 2010), which may result in uneven drying and white specks. Durum wheat semolina particle size distribution was characterized by mono modal feature (single peak) as depicted in figure 1.

Table 1: Chemical composition of semolina and egg powder (g/100g, db).

	Semolina	Egg powder
Moisture (%)	11.79±0.35	6.67±0.25
Protein (%)	14.19±0.12	38.23±0.5
Fat (%)	1.53±0.15	15.11±0.10
Carbohydrate (%)	71.21±0.32	42.63±0.79
Ash (%)	0.75±0.05	3.37±0.15
Fe (ppm)	15.67±0.31	33.20±0.92
Ca (ppm)	232.00±7.21	1110±9.0
Zn (ppm)	14.60±0.40	26.17±0.47
Fiber (%)	0.43±0.32	
β-carotene (ppm)	6.07 ±0.42	
Wet gluten (%)	30.10±0.30	
Dry gluten (%)	12.63±0.15	

Note: values= mean ± SD.

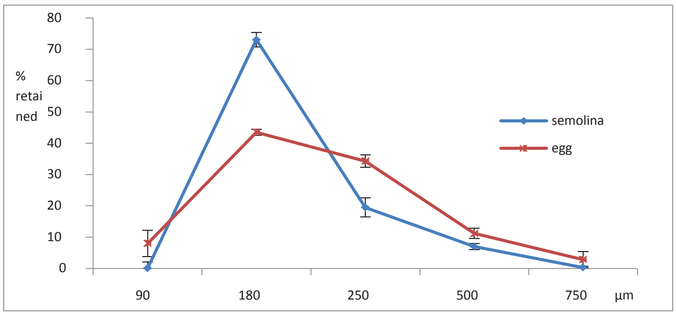

Figure 1: Particles size distribution of semolina and egg powder.

The majority of the particles of semolina lay above 250µm sieve size. Egg powder had modified mono modal feature (high width peaks) where the greater part of particles lay between 250 and 180 µm sieve size. From The majority of the particles of both semolina and the egg powder shared a common particle size range which could give uniform hydration level during dough formation and drying.

Farinograph test

The water absorption (WA) of semolina with 20 to 30% egg powder added showed no significant difference (P>0.05) from that of the control (Table 2). The WA of samples with 30 to 40% egg powder showed no significant differences (P>0.05) within themselves. However, those of the samples with 35 and 40% egg powder were significantly (P<0.05) lower in value than the control sample. The WA across the different blending ratio had ranged between 57.13–52.17%. The quantity of added water is considered to be very important for handling of the dough materials; there hydration and the gluten protein network development [16].

Dough stability time (ST) (Table 2) showed that all samples containing egg powder had significantly (P<0.05) lower values as compared to that of the control (5.17 minutes). The highest MTI (68.67 FU) was recorded for the sample with 40% egg proportion and the next highest (52.00 FU) for the sample with 35% egg powder both of which significantly different from

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each other and from the rest of the samples with increased egg proportion. All egg proportion except those with 35 and 40% egg powder proportion which had shown the longest duration (7.30 and 7.58 minutes) of DDT with no significant difference between them. A report by Dhawanet al. [16], showed that many of these farinographic test parameters could be affected due to weakening of the gluten matrix by the incorporation of non-gluten flour.

Effects of egg powder addition to semolina on chemical composition of macaroni

The highest (11.68%) moisture content was recorded for the control sample and the lowest (7.71%) for macaroni with 40% egg powder. From the result, the moisture content of the macaroni decreased as the egg powder proportion increased. This may be due to that moisture migration is easily take place as egg powder proportion increases as it creates porous structure diluting the gluten network in the product. As the proportion of the egg powder increased, the protein content of the macaroni showed increment due to higher protein in the egg powder (38.23%) than in the semolina. Fresh pasta production from wheat, rice and egg white, high protein increment were reported due to the presence of egg in the formulation [17]. The fat content of macaroni samples with 35 and 40% egg powder was the highest (6.00% each). This was significantly higher than the fat content of the rest of the samples. Cristinaet al. [17], stated that pasta product containing egg powder (30%) increased in the fat content within the range of 4.8-6.0%. The ash content showed increment as the ratio of egg powder increased because of higher (3.37%) ash content in the egg powder than in the semolina (0.75%). The highest (2.26%) belonged to the macaroni having 40% egg powder and the lowest (0.71%) to the control. According to Kexuan and Khalil [18], the ash content of macaroni was reported as 0.72% indicating that all the macaroni containing the egg powder are high in ash content. The highest fiber content (0.43%) was recorded for the control and the lowest (0.08%) for macaroni with 40% egg powder. The data shown (Table 3) indicated that the addition of egg powder into the semolina improved all the minerals contents of the macaroni.

Effects of egg powder proportion on macaroni cooking quality

The optimum cooking times (OCT) had varied significantly among all the macaroni samples except of those with 20 and 25% which had the longest cooking times (8.42 and 8.34 minutes) after the control with no significant difference between them. Ferreira et al. (2004) reported a diminution of cooking time in pasta products made from wheat and soya. Hardness decreased significantly as the egg powder proportion increased among all macaroni with different egg proportions. The highest hardness (22.79 N) was registered for the control and the lowest (10.54 N) was for the macaroni with 35% egg powder.

The water uptake capacity values increased as the egg proportion increased, ranging from 122.5% of the control to 147% of that with 40% egg powder. According to Taha [19], cooking water uptake capacity was higher in all egg powder

Table 2: Effect of egg proportion, on the water absorption (WA), dough development time (DDT), stability time (ST), time to break down (TB-), mixing tolerance index (MTI) of semolina flour.

Egg Proportion (%)	Parameters				
	WA (%)	DDT (min)	ST (min)	TB (min)	MTI (FU)
0	57.13±0.25[a]	4.43±0.15[e]	5.17±0.21[a]	8.57±0.40[a]	33.33±2.52[a]
20	56.67±0.35[a]	5.20±0.20[d]	3.17±0.21[b]	7.17±0.21[b]	37.00±2.65[a]
25	55.83±1.04[a]	5.70±0.10[c]	2.93±0.12[cb]	6.43±0.12[c]	42.00±2.65[b]
30	54.50±0.50[ab]	6.53±0.25[b]	2.87±0.15[cb]	5.97±0.45[dc]	44.67±1.53[b]
35	52.47±2.25[b]	7.30±0.20[a]	2.67±0.08[c]	5.57±0.25[de]	52.00±3.61[c]
40	52.17±2.84[b]	7.58±0.14[a]	2.03±0.35[d]	5.23±0.21[e]	68.67±3.21[d]
CV	2.85	2.96	6.53	4.58	5.98

Values followed by different letters with in a column indicates significant difference (P<0.05). Note: values = mean ± SD.

Table 3: Effect of egg powder proportion on the chemical compositions of semolina macaroni (g/100g, db).

Compositions (%)	0	Egg powder Proportions (%)				
		20	25	30	35	40
Moisture	11.68±0.15[a]	9.81±0.19[b]	9.77±0.20[b]	9.64±0.15[b]	8.83±0.21[c]	7.71±0.24[d]
Protein	14.09±0.35[f]	17.88±0.41[e]	19.06±0.41[d]	20.20±0.27[c]	21.51±0.57[b]	22.74±0.32[a]
Fat	1.42±0.23[d]	4.33±0.21[c]	4.37±0.06[c]	5.13±0.15[b]	6.00±0.10[a]	6.00±0.10[a]
CHO	71.33±0.20[a]	66.28±0.47[b]	64.90±0.05[c]	63.08±0.28[d]	61.48±0.44[e]	60.90±0.34[e]
Fiber	0.43±0.20[a]	0.29±0.02[b]	0.20±0.02[c]	0.17±0.02[d]	0.12±0.01[e]	0.08±0.00[f]
Ash	0.71±0.11[e]	1.41±0.03[d]	1.71±0.04[c]	1.82±0.03[c]	2.08±0.07[b]	2.26±0.03[a]
Fe (ppm)	15.90±0.10[e]	17.53±0.50[d]	20.51±0.19[c]	21.33±0.38[b]	22.15±0.14[a]	22.71±0.37[a]
Ca (ppm)	233.3±3.06[f]	416.67±3.5[e]	456.3±3.51[d]	494.67±4.51[c]	540.00±2.0[b]	582.00±2.65[a]
Zn (ppm)	14.89±0.13[e]	17.50±0.44[d]	18.29±0.26[c]	18.78±0.24[cb]	19.24±0.23[b]	20.11±0.17[a]

Values followed by different letter with in the same row indicate significant difference (P<0.05).

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supplemented macaroni except the control. The cooking loss increased as the percentage of egg ingredients increased. The addition of nongluten flours in the production of pasta products was reported to dilute the gluten strength and to interrupt and weaken the overall structure of the pasta products increasing the cooking loss.

Effects of egg proportion on sensory quality of macaroni

Regardless of egg proportion, adding egg powder to the semolina increased color acceptability score as compared to the control (Table 4). According to Debbouz, et al. [20], pasta color is essential for assessing pasta quality and generally consumers prefer pasta with a bright yellow color. The flavor increased as the egg powder proportion increased and this is due to flavor fragment increment in the egg components. The score indicated the product homogeneity accepted moderately. The stickiness ranged from 3.16 to 2.51 and the acceptability was decreased with increasing egg proportion. The control was more acceptable than any of the egg macaroni.

The scores of springiness were highest (4.15) for the control and lowest (1.98) for macaroni with 40% egg powder. However, all the scores were in the same range of acceptability between moderately and slightly springy. Overall acceptability shows a decrease as the ratio of egg powder increased. The result obtained goes parallel with the finding of Sawsanet al. [11] who indicated that the addition of non-gluten material like barley flour decreased the overall acceptability [21-24].

Conclusions

The study showed that addition of egg powder to semolina had significant effects on the physicochemical and sensory quality of the macaroni product. Most chemical compositions of macaroni had improved by the addition of egg powder but some of the sensory qualities of macaroni were influenced negatively. Among all the five semolina egg powder proportions tested, macaroni with 20%, 25% and 30% showed much close superior quality with the control samples than that processed by blending with 35% and 40% egg powder proportion.

Profit oriented sectors may give attentions and engage in such practice in producing value added fortified pasta products especially for young people and infants who need proteins for their active growth and development of body.

Table 4: Effects of Main factors on score of sensory quality attributes of elbow macaroni product.

Proportion %	Parameters					
	Color	Flavor	Homogeneity	Stickiness	Springiness	Overall A.
0	4.31±2.13^{c}	5.21±1.08^{c}	4.06±0.96^{a}	2.51±0.97^{c}	4.15±0.98^{a}	5.72±0.86^{a}
20	5.63±1.00^{a}	5.40±1.07^{c}	4.11±0.82^{a}	2.68±0.70^{cb}	3.49±1.06^{b}	5.21±0.91^{b}
25	5.71±0.66^{a}	5.44±1.05^{bc}	4.00±0.89a	2.69±0.89cb	3.39±1.00cb	5.07±1.60cb
30	5.85±0.85^{a}	5.83±0.97^{ab}	4.02±0.75^{a}	2.80±0.83^{b}	3.17±0.95^{c}	4.85±1.58^{cd}
35	5.63±0.57^{a}	5.67±0.97^{ab}	4.06±0.69^{a}	3.09±1.11^{a}	2.74±1.10^{d}	4.61±1.57^{ed}
40	5.13±0.65^{b}	5.90±0.96^{a}	4.12±0.79^{a}	3.16±1.00^{a}	1.98±1.00^{e}	4.36±2.07^{e}
CV	20.72	18.14	20.10	32.87	32.13	30.02

Values followed by different letters with in a column indicates significant difference ($P<0.05$). Note: values= mean ± SD.

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