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Evaluation of the Stability of the Physico-chemical Properties and Sensory Qualities of Farfalle Pasta from the Region of Guelma, Algeria

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ABSTRACT

Introduction: In the Algeria food industry, reproducibility of quality pasta remains an important challenge. The objective of this study was to evaluate the stability of the physico-chemical and sensory qualities of pasta produced from the Guelma region. **Methods:** The stability of physico-chemical characteristics of both semolina and pasta was evaluated repeatedly over three months. For semolina, the tests included particle size, colour, moisture, ash content and gluten index. For pasta, morphometry, colour, cooking quality (optimal cooking time (OCT), water uptake), cracking rate and manufacturing defect, ash, moisture content as well as sensory qualities were evaluated. **Results:** The stability of semolina in the standard manufacturing process was characterised by rates of moisture at 14.46 ± 0.36%; ash content 0.68 ± 0.04%; gluten index 83.75 ± 1.5% ; semolina colour (L: 84.95 ± 0.39, a: -3.43 ± 0.08, b: 37.30 ± 0.57 minimum); and + 50% with grain size: 200 µm <diameter <250 µm. Meanwhile, the pasta was characterised by rates of moisture equivalent to 11.88 ± 0.42%; ash content 0.74 ± 0.02%; pasta colour (L: 79.41 ± 1.57; a: -2.14 ± 0.39; b: 38.05 ± 2.35); optimal cooking time (8.95 ± 0.40 min) and water uptake (149.56 ± 2.23 (g/100 g of raw pasta). Sensory analysis of pasta samples scored higher than 5 for each attribute and sex differences among the assessors were registered for colour, smell and taste ($p<0.05$). **Conclusion:** Physico-chemical properties and sensory qualities of Farfalle pasta were found to be within acceptable ranges throughout the duration of the experiment indicating stability and reproducibility of the standard manufacturing process used in the Algerian pasta industry.

Keys words: Pasta, physico-chemical criteria, semolina, sensory qualities

INTRODUCTION

The Algerian population is characterised by a food fashion based mainly on grain consumption in all its forms (bread, pasta, couscous, etc.). In 2003, cereals accounted for 54% of energy intake and 62% of the daily protein intake in the Algerian food consumption model (Padilla, Ahmed &

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Wassef, 2005). Among the highly consumed foods is pasta that has become very popular worldwide as well as in Algeria too. Also, according to OECD/FAO Algerian couscous and pasta consumption rose to 204 kg/ per capita in 2015 (OECD/FAO, 2015). This product is mainly used as an energy source due to its high content of carbohydrates (74–77%, db), and it is known to be a good source of low glycemic index (GI) (Bjorck, Liljeberg & Ostman, 2000; Monge *et al.*, 1990). However, it is a poor source of protein (unless supplemented) (Chillo *et al.*, 2008) and its protein has a low amount of the essential amino acids of lysine and threonine (the first and second limiting amino acids), common to most cereal products (Abdel-Aal & Hucl, 2002).

From the technological point of view, the manufacturing process is relatively simple; pasta products are produced by mixing milled durum wheat (semolina: the main product of durum milling), water, and sometimes optional ingredients. These ingredients are typically added to a continuous, high capacity auger extruder, which can be equipped with a variety of dies that determine the shape of the pasta. The pasta is then dried and packaged for the market (Padalino *et al.*, 2014).

Also, in industrial processing units, repeatability of the manufacturing process and measuring equipment which is normally constant remains a problem to be resolved. This study attempts to determine stability in order to highlight the differences between the average spreads obtained by several operators (Lacroix, 2015). The main objectives of this study were to analyse and evaluate the physic-chemical and sensorial qualities of Farfalle pasta from one batch of production; then to evaluate the stability and reproducibility of manufacturing operations of Farfalle pasta in the second batch of production to ensure the same physico-chemical and sensorial qualities.

METHODS

The study was conducted from early October to late March 2015. Physico-chemical tests (in triplicate) and sensory analysis were used at monthly intervals to assess the overall quality of pasta (Farfalle pasta). Two series of tests were carried: one for analysis of the raw material (semolina), and the second for the end-product (Farfalle pasta) as shown in Figure 1.

First 3 and then 2 lots (n=3/n=2) of semolina durum wheat were used in the

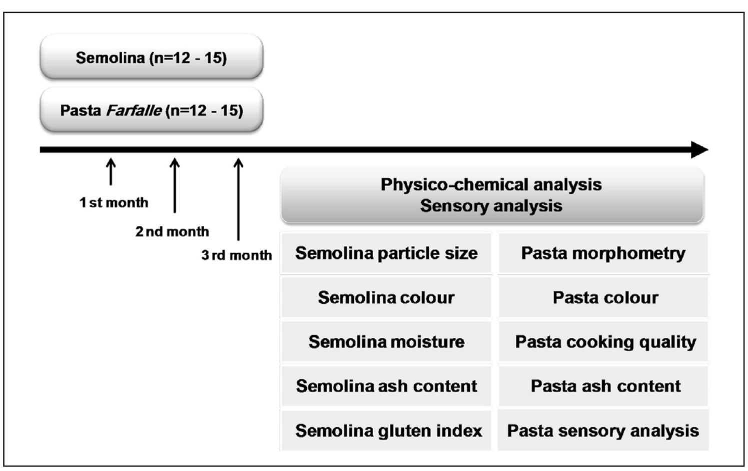

Figure 1. Experimental design physico-chemical and sensory analysis of semolina and Farfalle pasta were performed over a period of three months

first month with each lot being analysed in triplicate. These lots of semolina were used to produce the first batch of Farfalle pasta which was analysed in triplicate. Then 3 lots (n=3) of semolina durum wheat were used in the second month and each lot was analysed in triplicate. These lots of semolina were used to produce the second batch of Farfalle pasta which was analysed in triplicate. Finally, first 3 then 2 lots (n=3/ n=2) of semolina durum wheat were used in the last month of the experimentation with each lot being analysed in triplicate. These lots of semolina were used to produce our third batch of Farfalle pasta, which was also analysed in triplicate.

Semolina quality evaluation

Semolina particle size

Granularity or particle size (PS) of a ground material, such as semolina, is the particle distribution of the material, which can be determined by a system of sieving. The first operation is homogenisation of the semolina samples (using a rotative mixer) in order to have a representative sample. Then 100 g sample of semolina (in triplicate) was sieved over a Rotachoc (CHOPIN Technologies, Villeneuve-la-Garenne-France) sieve for 10 min. When the sifting was completed, the fractions of all the sieves were collected and weighed in order to plot the granulation curve of the sample.

The distribution of the semolina depended on the diameter of the sieve (decreasing diameter: 600 µm, 500 µm, 450 µm, 355 µm, 250 µm, 200 µm, 150 µm), and results were expressed as a percentage of the original weight of the sample according to the American Association of Cereal Chemists approved methods (AACC-international 66-20, 2000).

Semolina colour

Durum semolina colour was determined using a Konica Minolta colorimeter model CR-410 with a D65 illuminant (KONICA MINOLTA, Tokyo-Japan). Colour readings were expressed on the CIE (1976) colour space system for L* (lightness; 0 = black, 100 = white), a* (red-green; +a = redness, -a = greenness) and b* (yellow-blue; +b = yellowness, -b = blueness). Differences in particle size have a significant effect on colour readings. Semolina samples with similar particle size distributions were used for comparability.

Semolina moisture

The water content in the wheat is inversely related to the amount of dry matter. The semolina moisture was determined using a halogen moisture HG63 (Mettler Toledo, Switzerland). Moisture content was expressed as a percentage (%) of the product mass.

Semolina ash content

To determine semolina ash content, AACC Method 08-01.01 was used. Samples (5 g) were incinerated overnight in a muffle furnace (600ºC) (AACC-international, 2000). Results were expressed as a percentage (%) of the product mass.

Semolina gluten index

Durum semolina gluten index was determined using AACC Standard Method 38-12.02 (AACC-international, 2000). Gluten separated from semolina by Glutomatic (Perten) was centrifuged to force wet gluten through a specially constructed sieve under standardised conditions. The percentage of wet gluten remaining on the sieve after centrifugation was defined as the Gluten Index.

The Gluten Index was calculated using the equation:

$$\text{Gluten Index (\%)} = \frac{\text{Total wet gluten weight} \\ \text{- Gluten remaining on the centrifuge sieve}}{\text{Total wet gluten weight}} \times 100$$

Pasta preparation

Semolina and water were mixed in a Storci mixer (Parma, Italy) at a speed of 60 rpm for 10 min to facilitate uniform distribution of water. The amount of water added was calculated to achieve a dough with moisture 31 g/100 g on a wet weight basis.

The mixed dough was transferred to a pasta machine (Storci, Parma, Italy), and extruded with a pressure of 40 bar at a speed of 23 rpm. A temperature drying procedure was applied in two steps (75°C for 4-7min and at 68°C for 4 h) using a Storci Drier (Parma, Italy). After the drying process, pasta samples were allowed to cool at room temperature and then packed in oriented polypropylene packaging and stored at room temperature until needed.

Pasta quality evaluation

Pasta morphometry

In order to detect any morphometric abnormalities, lengths and widest, thickness of 100 g of pasta were measured with a digital caliper (TACTIX).

Pasta colour

Dried Farfalle pasta (100 g) was milled (Bühler crushing mill, Miag MLI-204, Switzerland); values of surface colour of raw pasta were measured in the same way as for semolina.

Pasta cooking quality

Optimal cooking time (OCT)

A modified method of Schoenlechner *et al.*(2010) was used to determine the cooking time. One hundred grams of pasta were put into a beaker containing 1 L of boiling water (without salt addition). Every minute, some pieces were taken out and pressed between two glass plates (2.5 cm × 2.5 cm). The optimal cooking time (OCT) corresponded to the disappearance of the white center core (Schoenlechner *et al.,* 2010).

Water uptake

Water uptake was determined according to the method described by (Petitot *et al.*, 2010). Dry pasta samples were weighed before and after cooking at an optimal cooking time. Water uptake was calculated using the equation:

$$\text{Water uptake} = [(\frac{\text{Weight of cooked pasta}}{\text{Weight of dry pasta}}) - 1] \times 100$$

Pasta cracking rate and manufacturing defect

Malformation and cracking occurrence were investigated at the end of each phase of experimentation; 250 g of Farfalle pasta were observed individually for cracking and manufacturing defects. Results were expressed as the percentage (%) of the product mass.

Pasta ash content

The value of ash content of dried pasta was measured in the same way as for semolina.

Moisture content

The value of moisture content of dried pasta was measured in the same way as for semolina.

Sensory analysis

Evaluation of the sensory quality is a subjective operation because it focuses on the following characters: appearance, texture, consistency and flavour, which are the properties of pasta. These depend on many physical properties and technological factors.

Based on the procedure of Seczyk, Swieca & Gawlik-Dziki (2016), Farfalle pasta was evaluated each month by a consumer panel consisting of 35 members (17 male, 18 female, aged 23-51 years, all academic or scientific staff and PhD students from Guelma University). Before testing, all participants were enquired for possible food allergies to wheat or wheat components. Pasta (500 g) were cooked freshly in water (5 L) for 8-9 min, rinsed and cooled in water at 20°C for 2 min. Cooked pasta was placed in plastic cups and presented to the panelists.

Participants were instructed to rinse their mouth with tap water (20°C) before they began testing and between samples. Pasta samples were evaluated for their colour, smell, taste, texture, and overall quality. Sensory attributes were evaluated using a nine-point hedonic scale with values ranging from 1 to 9: (1) extremely unpleasant, (2) very unpleasant, (3) moderately unpleasant, (4) slightly unpleasant, (5) neither pleasant nor unpleasant, (6) slightly pleasant, (7) moderately pleasant, (8) very pleasant, and (9) extremely pleasant (Seczyk *et al.*, 2016).

Statistical analysis

The results were expressed in the form of the mean ± SD (standard deviation). All parameters were measured in triplicates.

The analysis of variance (Anova) was carried out with respect to each physic-chemical parameter measured in semolina or Farfalle pasta; the effect of time was assessed according to a completely randomised design (with 3 repetitions). Mean discrimination was performed applying the Tukey test; statistically significant differences were determined at the probability level $p<0.05$.

Sensory analysis was analysed using ANOVAs, and the experimental design was built to allow the estimation of main effect (time and sex) and interaction "sex x time". Significant effects were reported. Significance was considered at $p< 0.05$ using MiniTab software [Minitab, Ltd, United Kingdom (Version 16)].

Ethical approval

The research protocol for the sensory study was developed and validated by the ethics committee of the University of Guelma-Algeria.

RESULTS

Physical and chemical analyses of semolina are shown in Table 1. Particle size distribution was carried out to check the coarseness or fineness of the semolina. Raw material used for pasta preparation retained on 450, 355, 250, 200 and 150 µm sieves was 1.28±0.35%; 37.48±2.81%; 52.92±1.81%; 7.16±1.16%; 0.68±0.31% respectively.

The lightness L* value of semolina samples was 84.95±0.39. The a* value (red-green) and b* value (yellow-blue) was: -3.43±0.08 and 37.30±0.57 respectively. As shown in Table 1, results from moisture, ash content, and index gluten were as follows: 14.46±0.36; 0.68±0.04; 83.75±1.5 respectively.

Physico-chemical and stability analysis of Farfalle pasta

Pasta morphometry

The results of morphometric analysis evaluated with a digital caliper (length, width and thickness) are presented in Figure 2A. The Farfalle pasta length and width varied between 30 to 40 mm and 20 to 30 mm respectively. The thickness was less than 5 mm.

The same graph shows that variation (standard deviation) is very small (ex: SD=0.33; 0.08; 0.02 for length, width and thickness respectively from the 1st month).

Also, the manufacturing process was found to be stable throughout the period of the experiment (from 1st to 3rd month).

Pasta colour

Figure 2B shows the results of staining of Farfalle pasta; it was amber-yellow, with lightness L*value 79.94±2.44. The a* value (red-green) and b* value (yellow-blue) were -1.87±0.65 and 35.70±0.25 respectively (example from the 1st month).

In relation to stability in the manufacturing process, despite a slight increase in b* value (yellow index) in the 2nd month, no significant difference was recorded (Figure 2B).

Pasta cooking quality

Optimal cooking time (OCT)

Figure 2C reports the pasta OCT values evaluated in this study. Results varied between (8-9 min). Also, there was no variation as a function of time for the period of our experimentation (Figure 2).

Table 1. Physical and chemical analysis of semolina

	Semolina	*Granularity or Particle size distribution (PS) (%)*							*Color*					
		600 µm	*500 µm*	*450 µm*	*355 µm*	*250 µm*	*200 µm*	*150 µm*	*L^* value*	*a^* value*	*b^* value*	*Moisture content (%)*	*Ash content (%)*	*Gluten index (%)*
1st Month	n=3	0	0	1.3	36.3	54.3	6.9	0.5	84.67	-3.37	37.43	14.88	0.690	85
	n=2	0	0	1.4	40.7	51.4	5.8	0.5	85.13	-3.34	36.49	14.61	0.730	83.9
2nd Month	n=3	0	0	0.9	34.3	54.7	9	0.6	84.58	-3.43	37.08	14.56	0.630	83
3rd Month	n=3	0	0	1.8	40.2	50.6	6.8	0.5	85.54	-3.47	37.49	14.36	0.640	82
	n=2	0	0	1	35.9	53.6	7.3	1.3	84.84	-3.54	38.05	13.89	0.720	85
	Mean	0	0	1.28	37.48	52.92	7.16	0.68	84.95	-3.43	37.30	14.46	0.68	83.75
	SD	0	0	0.35	2.81	1.81	1.16	0.31	0.39	0.08	0.57	0.36	0.04	1.5

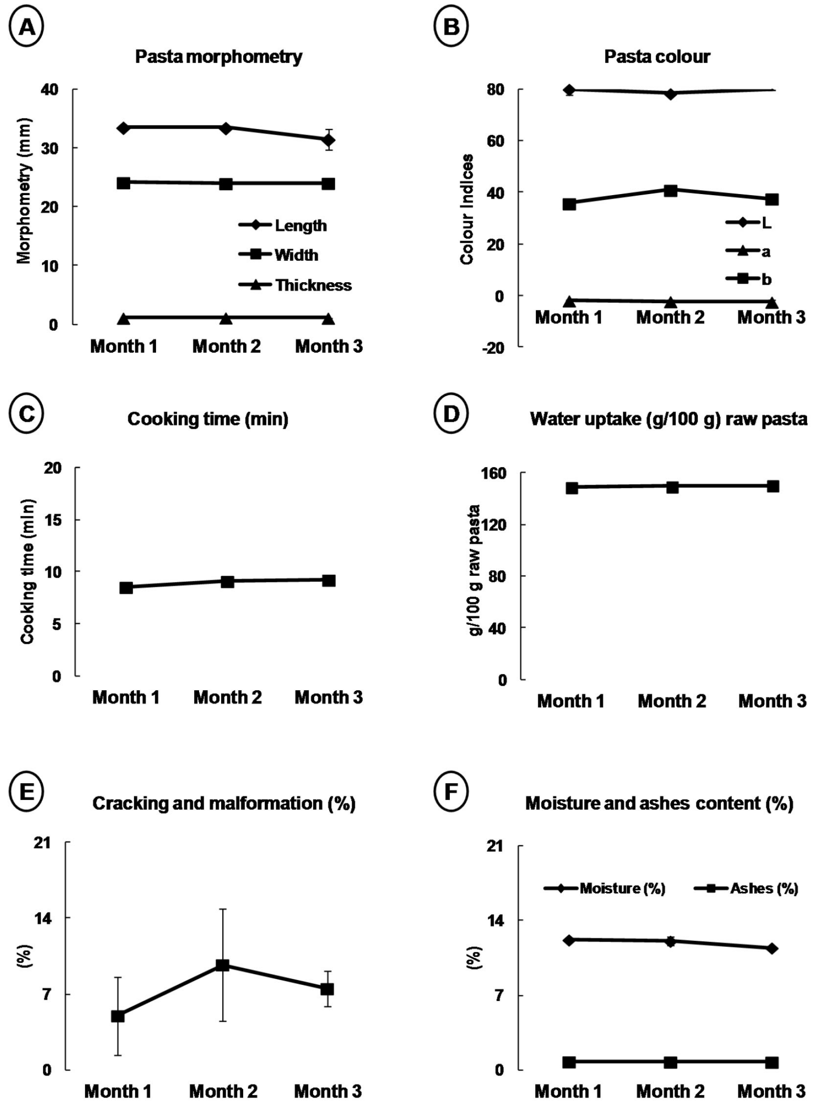

Figure 2. Physical and chemical analysis of Farfalle pasta over a period of three months.

Water uptake

As shown by the results (Figure 2D) water uptake after cooking pasta from the period of our experimentation (3 months) varied between (148.9 ± 2.82; 149.45 ± 2.34; 150.33 ± 2.08 g/100 g of raw pasta) respectively, however these results were not significant.

Cracking rate and manufacturing defect

Figure 2E shows the results in (%) which varied from 5.00±3.61 to 9.70±5.14. No variation was noticed during the duration of the experiment.

Moisture content
The moisture content is the water content in the pasta and it was measured continuously over several production line points. Figure 2F shows the results of the moisture content of the end-product.

These rates varied between 11-12%, the moisture content is stable, this means stability in the manufacturing process. No significant differences were recorded.

Ash content
Ash rates ranged from 0.65% to 0.75%. Our results show that despite a slight drop in the second month of study, the ash content was stable. This implies stability in the manufacturing process (Figure 2F).

Sensory analysis of Farfalle pasta
Averaged results of sensory evaluation attributes of pasta are summarised in Figure 3. The sensorial attributes of cooked pasta colour and smell were perceived by men rather than women, whereas taste, texture and overall quality were perceived by females rather than men (Figure 3).

Pasta samples scored higher than 5 for each evaluated characteristic. Also, results

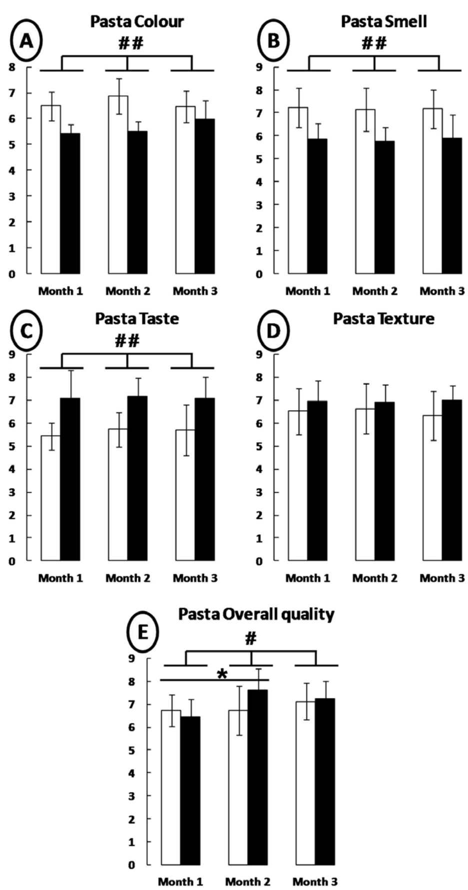

Figure 3: Sensory evaluation of Farfalle pasta; results are mean values ± SD of panelist (n = 17-18/ sex/group). * indicates a significant difference between: Month 1st, 2nd and 3rd, for both gender. # # indicates significant sexual dimorphism in the men group and women group (main gender effect) (ANOVA; p<0.05). # indicates strong tendency for significant sexual dimorphism in □Men ■Women

showed that none of the changes affected the colour, smell, taste and texture (Figure 3A, B, C, D).

However, the overall quality of Farfalle pasta was disrupted (Figure 3E) with a significant effect in the second month (p=0.04).

Also, significant sex dimorphism occurred for colour, smell, taste (p<0.001), and a tendency to differ in overall quality perception between males and females (p=0.09) (Figure 3).

Significant "gender time" interaction was not found, either for colour or for smell, taste, texture or overall quality.

DISCUSSION

The results of all analysis (from semolina and pasta) met the standards according to international and Algerian regulations (JORF, 1957; JORADP, 1997; JORADP, 2007) [Moisture (≤14.5%); Ash content (≤0.80% ± 0.05); Gluten index (≥ 65%); semolina colour (L *: 82 minimum, a *: -2.5 minimum, b * 34 minimum); > 50% semolina particle size varies between 2000 μm and 250 μm].

Also, as colour is the first parameter perceived by the consumer, it plays a very important role in the general perception of the product. The bright yellow colour is one of the desirable attributes for pasta quality (Petitot *et al*., 2010). The L* and b* values are considered more important as colour attributes at higher levels (Rayas-Duarte, Mock & Satterlee, 1996). In this study, the b* value was higher and this contributed to the yellowness of the pasta; this can be due to the amount of carotenoid pigment and to enzymatic reactions (Acquistucci, 2000).

In the same way, the moisture of samples remained within the safety limits of around 12-13%. The values were similar to those recorded by Petitot *et al.* (2009). All others parameters (pasta morphometry, pasta cooking quality [OCT and water uptake], pasta ash and moisture contents) were in accordance with the literature (Gull, Prasad & Kumar, 2015).

Also, the study confirms the absence of variation during the whole duration of the experiment, which proves stability in the process of manufacturing, and the absence of differences between the average spreads obtained by several operators (Lacroix, 2015).

The sensory analysis did not reveal any significant variation throughout the duration of the experiment except between the 1st and the 2nd months in relation to overall quality of pasta. However, gender differences (differences between man and women subjects) in colour, smell and taste perceptions of pasta were registered. These differences may be due to the effects of sex hormones on food choice in a general way and pasta perception in a more specific manner.

According to previous studies, gender differences and menstrual cycle-related changes in basic measures of human sensory function have been reported for every major sensory system, including vision and colour influences (Rodriguez-Carmona *et al*., 2008; Gupta *et al*., 2005; Giuffre, Di Rosa & Fiorino, 2007), smell (Doty & Cameron, 2009) and also taste (Doty, 1978; Sato, Endo & Tomita, 2002; Frye & Demolar, 1994; Kuga, Ikeda & Suzuki, 1999; Than, Delay & Maier, 1994).

Also, even in the animal model, several studies show that response to sweet taste (carbohydrates which are the more important constituent of pasta), responses were stronger in male than females, due to the action of sex hormones (estrogens and androgens) on brain response to sweet taste. In the animal model, the sex differences in sweet intakes have been described by several authors (Curtis, Stratford & Contreras, 2005; Boudalia *et al*., 2014).

In summary, the physico-chemical properties and sensory qualities of Farfalle pasta were found to be stable throughout the duration of the experiment, which reflects reproducibility in manufacturing operations. Also, results from this study showed that semolina and pasta meet the standards according to international and Algerian regulations. For sensorial analysis, gender differences were registered for colour, smell and taste (p<0.05), and a strong tendency (p=0.09) for sexual dimorphism was observed for overall quality.

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Conflict of interest
None

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