Original article

Textural characterisation of lasagna made from organic whole wheat

Daniela F. Olivera,[1,2] & Viviana O. Salvadori,[1,2*]

1 CIDCA (Centro de Investigación y Desarrollo en Criotecnología de Alimentos), Facultad de Ciencias Exactas (UNLP) y CONICET, 47 y 116, B1900AAJ La Plata, Argentina

2 MODIAL – Departamento de Ingeniería Química, Facultad de Ingeniería (UNLP), 47 y 116, B1900AAJ La Plata, Argentina

(Received 14 February 2006; Accepted in revised form 2 March 2006)

Summary In the last years, trade of organic foods has risen significantly. Relevant quality studies for organic foods are generally related to environmental and health attributes/considerations. However, very few studies that analyse the traditional characteristics of food quality have been carried out. The importance of these studies is that they enable us to compare them with conventional food. Therefore, the objective of this article is to study the quality (texture and sensory properties) of lasagna prepared only with organic ingredients, without additives and through standard procedures of manufacture. Organic lasagna characteristics are compared with conventional white and whole wheat ones. The analysis of variance indicates the existence of significant differences in all the texture parameters, except for the cohesiveness. These differences show a possible interaction between the fibre and the gluten network. The relaxation curves show that conventional dough is more elastic than both the whole wheat samples; on the contrary, the viscous components are higher in whole wheat doughs, indicating the fibre–protein interaction. From the sensory analysis, the only parameter in which the organic pasta differed significantly from the conventional one was appearance. On the whole, these differences did not affect the acceptability of the product.

Keywords Lasagna, organic, sensory analysis, texture.

Introduction

In the previous years, international trade of organic foods has risen significantly, and this rise is expected to be even greater in the coming years. Currently, only 1–3% of the food market in developed countries is constituted by organic foods. However, the retail sales of organic products have grown 20% annually in the last 10 years and they can reach US$29–31 billion in 2005 (Kortbech-Olesen, 2002, 2003).

Organic agriculture has been practiced since the 1920s. Its development is the result of a trend to protect the environment, avoiding the use of synthetic agrochemicals and genetically modified species, and promoting health care.

In the beginning, organic foods were sold only in health food stores and specialty shops, comprising only primary products with minimal or no processing: vegetables, fruits, meat, eggs, tea, sugar, flour, jellies and fruit preserves. Nowadays, the list of organic products that can be found in any supermarket includes bread, cookies, frozen meals, pasta, sauces, cereals, milk, wine, etc.

Consumers of organic foods behave in a different way from other consumers when choosing their own food. Apart from the traditional quality aspects, organic consumers are concerned about ethical, environmental and health-related issues (Torjusen *et al.*, 2001).

At the time of buying a ready-to-serve meal, which has been industrially processed, these consumers need to be sure that both the product and the process are certified as organic. Besides, the meal has to look home-made. Therefore, the fact of counting with an objective and genuine proof, which guarantees that the organic food tastes better and is healthier, would be a very useful tool for the food industry. This justifies the necessity of doing deeper quality studies, as up to now there are only comparative studies of the different ways of obtaining the food or simple studies that compare organic and conventional products obtained from the local market (Harker, 2004).

The aim of this study is to analyse the quality attributes of a meal prepared only with organic certified ingredients (without additives and through standard procedures of manufacture) and to test the possible

*Correspondent: Fax: +54-221-4890741/4254853/4249287;
e-mail: vosalvad@ing.unlp.edu.ar

doi:10.1111/j.1365-2621.2006.01382.x

differences between the meals made from organic and non-organic ingredients.

Among the enormous varieties of ready-to-serve meals (refrigerated or frozen), which we can encounter in the market, pasta is a very popular food and has a high degree of acceptability. That is why we have chosen lasagna to perform this study.

Not only did we analyse the texture of the pasta sheets (before and after cooking), but we also analysed the sensory properties of lasagna with organic vegetable filling.

This work presents results from lasagna dough and cooked pasta. The behaviour of the dough is related to the preparation of the product. However, the final acceptability of the product is directly related to the textural characteristics of cooked product.

In order to perform the comparative analysis, two samples with conventional flours (white wheat flour and whole wheat flour) were also analysed. White wheat flour was used because regular lasagna is prepared with this flour. Regular whole wheat flour was used to analyse possible differences between the conventional food and its organic equivalent.

Materials and methods

Sample preparation

Lasagna dough

The dough was obtained with only two ingredients: flour and entire egg (yolk and white), according to the following recipes:

1 *Conventional sample 'C':* 62.5 g of 0000 commercial wheat flour (ANMAT, 2004) and 37.5 g of entire egg, both obtained from the local market.
2 *Whole wheat sample 'W':* 62.5 g of fine commercial whole wheat flour (ANMAT, 2004) and 37.5 g of entire egg, both obtained from the local market.
3 *Organic sample 'O':* 62.5 g of organic whole wheat flour (with fine bran particles) (Schatzi) and 37.5 g of organic entire egg (Ecovo).

Moisture, protein, ash and insoluble fibre of the three flours were determined in our laboratory following standard AACC methods, Systat Software Inc., Richmond, CA, USA (methods 44-15A, 46-11, 08-01 and 32-10, respectively).

Table 1 shows the composition of the flours. The high ash and dietary fibre contents of both whole wheat flours are expected to have a decisive impact on the textural and sensory qualities.

The three lasagna doughs were kneaded for 5 min in a home multifunction food processor Rowenta Universo (Rowenta France SA, Vernon, France) (700 W), at a constant speed equal to 960 r.p.m. Kneading is important for the development of the gluten network, which is crucial for textural attributes.

Table 1 Composition of flours used in the study

Flour	Moisture (%)	Protein (%)	Ash (%)	Insoluble fibre (%)	Total dietary fibre[a] (%)
Conventional	14.5	9.5	0.60	0.00	3.2
Whole wheat	14.0	10.5	1.35	0.80	Not available
Organic	14.2	12.0	1.46	0.88	9.1

[a]Data provided by manufacturer.

Dough discs of 4 cm diameter and 0.5 cm thick were cut to perform the measurement of the texture characteristics: texture profile analysis (TPA) and stress relaxation curves.

Cooked pasta

Dough sheets of 0.1 cm thick were obtained with a manual dough sheeter. Then, the sheets were cut into pieces of 4 cm × 10 cm × 0.1 cm. Pasta samples were cooked in abundant boiling water, using 300 mL of water for every 25 g of pasta sheets. Optimum cooking times were determined according to AACC 66-50 method (AACC, 1983). The measured times were 480 s for sample 'C' and 870 s for samples 'W' and 'O'. After being cooked during the respective time, each sample was drained and its surface was dried with paper towels. Prior to texture analysis, the samples were cooled until they reached ambient temperature. The entire sheets were used to perform TPA and stress relaxation curves.

Lasagna

Two sets of a traditional lasagna recipe, one conventional (C) and one organic (O) were prepared to perform sensory analysis. In this case, for the conventional sample, only white wheat flour was used, as the purpose of the test is to compare the organic product with the traditional, generally accepted one.

The cooked pasta sheets were alternated with a filling made with spinach and tomato sauce, top layer was sprinkled with grated cheese. The preparation was baked in a preheated oven (oven temperature equal to 210°C) for 10 min.

Small pieces of lasagna were cut and immediately served to the panellists for the analysis.

Texture analysis

Texture is 'the sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the senses of vision, hearing, touch and kinesthetics' (Szczesniak, 2002).

The texture parameters were measured with a TA.XT2i Texture Analyser (Stable Micro Systems Ltd., Godalming, UK), using a 75 mm flat-end aluminium compression disc (probe P/75). The data of the different texture analyses performed were acquired and

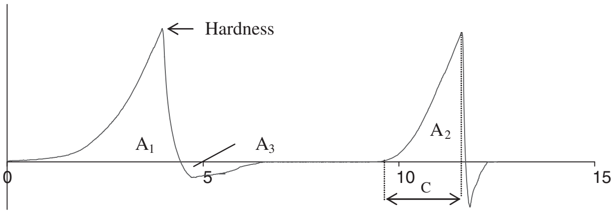


Figure 1 Texture profile curve of dough sample.

processed by means of Texture Expert Excede v. 1.0 (Stable Micro Systems).

Texture profile analysisThe same procedure was followed to analyse the just-made dough discs and the cooked pasta. One sample was placed on the base and was compressed twice to give a two complete compression–relaxation–tension profile curve. The settings of the experiments were the following: test speed, 0.5 mm s^{-1}; distance, 20% strain; data acquisition rate, 50 pps and load cell, 5 kg.

Figure 1 shows a typical TPA curve. From this curve and by means of the equipment software, the following parameters were obtained:

1 Hardness (peak force F_1)
2 Adhesiveness (area 3)
3 Cohesiveness (area 2/area 1)
4 Consistency (area 1 + area 2)
5 Springiness (s).

The five TPA parameters were tested using the general linear model analysis of variance (ANOVA) procedure of SYSTAT 10.0 (2000) to analyse differences attributable to the samples.

For each dependent variable (TPA parameters), the Bonferroni method was used to test pairwise differences in mean values. Six replicates per experiment were made.

Stress relaxation curves

The viscoelastic characteristics of dough and pasta were quantified from the relaxation curves. The procedure followed to analyse the just-made dough discs and the cooked pasta sheets was the same in both cases.

The sample was placed in the equipment platform, a fixed compression strain was set and the variation of tension with time was registered.

The settings of this analysis were the following: test speed 0.5 mm s^{-1}, compression strain 20% and time 600 s. Six replicates per experiment were made.

The observed behaviour was characterised by the Maxwell model (eqn 1), combining one elastic ideal element (string) in parallel with various composed Maxwell elements (a string element with a viscous element in series).

$$F(t) = F(t)/F_0 = A_\infty + \sum_{i=1}^{n} A_i \exp(-t/\tau_i) \qquad (1)$$

where F(t) is the instant force during relaxation test, F_0 the maximum value (before the beginning of tensile decay), A_i (dimensionless) the coefficient related to the material viscoelastic properties and τ_i (seconds) the relaxation time. The parameters were adjusted using a non-linear regression software (SYSTAT 10.0).

From the regression coefficients (A_i and τ_i), the rheological parameters, elasticity modulus (E_i) and viscosity (η_i), were calculated.

$$E_i = \frac{A_i F_0}{a\varepsilon}, \eta_i = E_i \tau_i (2)$$

Sensory analysis

In order to test the acceptability of the product, a sensory analysis was done using an unstructured hedonic scale (Mucci *et al.*, 2004), fixed in three points: 'dislike very much', 'neither like nor dislike' and 'like very much'; and focusing only on the pasta (not on the filling).

The samples of both organic and conventional pasta were given to the panellists immediately after being taken out of the oven, in individual dishes, and were placed and coded randomly.

A panel of 40 untrained consumers, some of whom had participated in previous acceptability studies of other food products performed in our laboratory, was recruited.

The tested attributes were the appearance (related to colour), flavour, consistency (related to hardness) and global acceptability. Each panellist received a form sheet (Fig. 2) to evaluate the mentioned attributes. The analysis was done in an isolate room with good illumination (normal white light and natural light) and natural ventilation.

For each descriptor (appearance, flavour, consistency and global acceptability), an ANOVA was performed to test significant differences ($P < 0.05$) attributable to samples (conventional and organic).

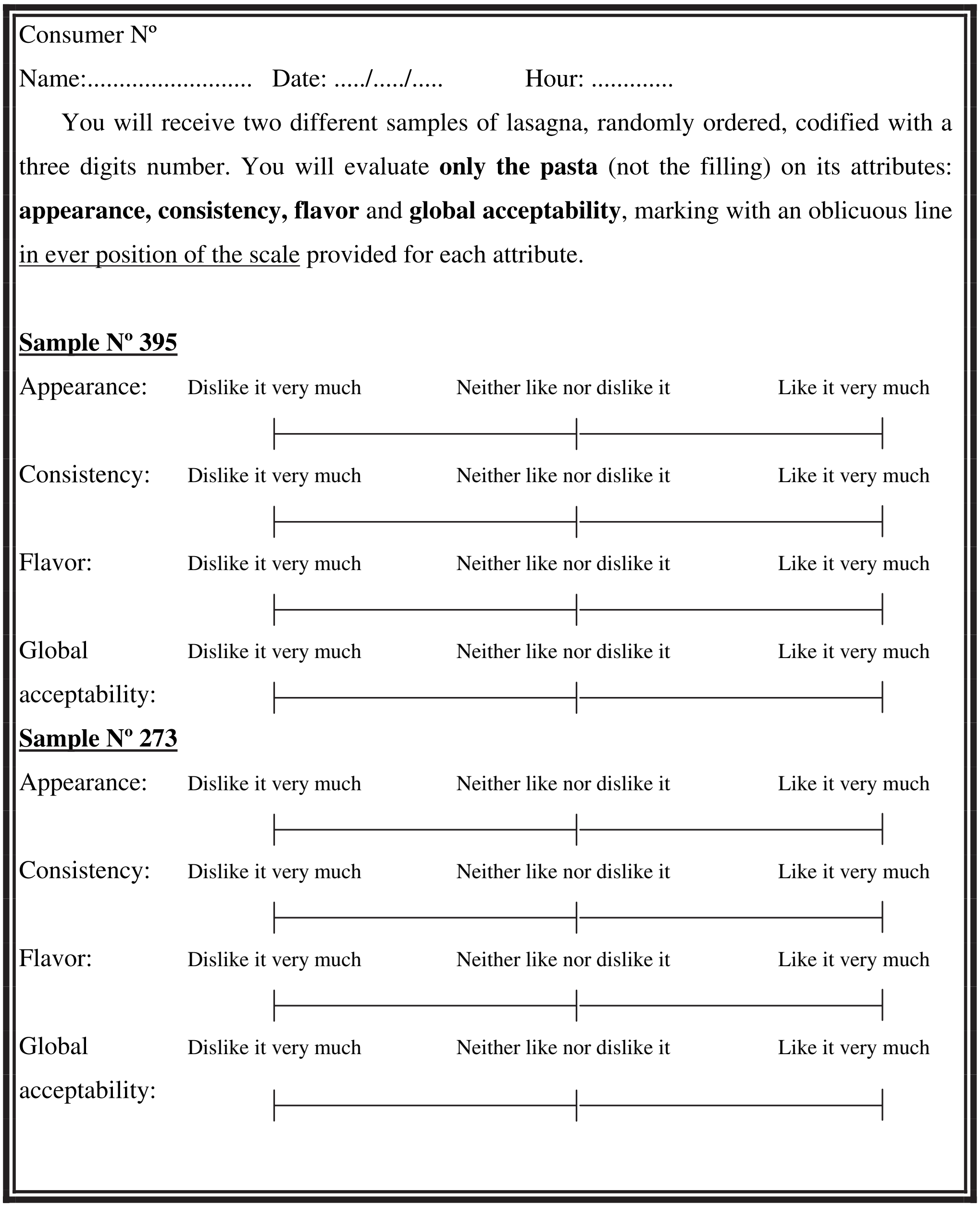
Results

Texture profile analysis

The textural characteristics of pasta play an essential role in determining the global acceptability of the food by consumers (Cole, 1991; Tudoricá *et al.*, 2002). A good quality pasta product may present certain degrees of firmness and elasticity and absence of stickiness (Edwards *et al.*, 1993).

Table 2 shows the results obtained with samples of raw dough, by means of the TPA. Table 3 shows similar results obtained with samples of cooked sheets of pasta.

These results can be related to the nature and arrangement of the structural elements that constituted the food. The main difference between the three


Consumer Nº

Name:......................... Date: ...../...../..... Hour: ....

You will receive two different samples of lasagna, randomly ordered, codified with a three digits number. You will evaluate **only the pasta** (not the filling) on its attributes: **appearance, consistency, flavor** and **global acceptability**, marking with an oblicuous line in ever position of the scale provided for each attribute.

Sample Nº 395

Appearance: Dislike it very much — Neither like nor dislike it — Like it very much

Consistency: Dislike it very much — Neither like nor dislike it — Like it very much

Flavor: Dislike it very much — Neither like nor dislike it — Like it very much

Global acceptability: Dislike it very much — Neither like nor dislike it — Like it very much

Sample Nº 273

Appearance: Dislike it very much — Neither like nor dislike it — Like it very much

Consistency: Dislike it very much — Neither like nor dislike it — Like it very much

Flavor: Dislike it very much — Neither like nor dislike it — Like it very much

Global acceptability: Dislike it very much — Neither like nor dislike it — Like it very much

Figure 2 Form sheet used for the sensory analysis.

analysed doughs is the structural characteristic of the flour. The conventional flour is white wheat flour, with a high degree of extraction and poor fibre content. Otherwise, the remaining two are whole wheat flours, with high fibre content. The moisture content of the organic dough differs significantly from the other two: 33.21% ± 0.82% in conventional dough, 32.82% ± 0.61% in whole wheat dough and 31.09% ± 0.83% in the organic sample (Olivera, 2005). The moisture content of the three cooked pasta do not differ significantly, because they were cooked at their optimum time: 60.10% ± 1.43% in conventional dough, 63.56% ± 1.96% in whole wheat dough and 62.97% ± 1.87% in the organic sample (Olivera, 2005).

The first parameter analysed is the hardness. It is a primary quality characteristic. Hardness (N) measures the force necessary to attain a given deformation (the first peak in TPA analysis) and is associated with the

Table 2 TPA results of raw dough

TPA parameter	Conventional	Integral	Organic
Hardness (N)	11.75 (1.38)[a]	27.82 (5.83)[b]	56.62 (5.40)[c]
Adhesiveness (N s)	−2.28 (0.40)[a]	−2.28 (0.90)[a]	−1.44 (0.28)[b]
Cohesiveness	0.58 (0.06)[a]	0.55 (0.07)[a]	0.59 (0.06)[a]
Consistency (N s)	31.11 (4.63)[a]	13.07 (3.66)[b]	120.53 (21.88)[c]
Springiness (s)	1.25 (0.36)[a]	0.80 (0.21)[b]	1.07 (0.24)[ab]

Values in parentheses are standard errors.
Mean values with the same superscript letters within columns are not significantly different ($P < 0.05$).

Table 3 TPA results of cooked lasagna

TPA parameter	Conventional	Integral	Organic
Hardness (N)	3.90 (0.82)[a]	6.19 (2.68)[b]	5.93 (0.47)[b]
Adhesiveness (N s)	−0.99 (0.23)[a]	−0.41 (0.26)[b]	−0.50 (0.11)[b]
Cohesiveness	0.58 (0.05)[a]	0.62 (0.05)[a]	0.57 (0.07)[a]
Consistency (N s)	5.83 (1.52)[a]	2.71 (1.47)[c]	8.55 (1.73)[b]
Springiness (s)	0.39 (0.04)[a]	0.39 (0.04)[a]	0.35 (0.04)[a]
Masticability	0.87 (0.23)[a]	1.49 (0.64)[b]	1.19 (0.20)[ab]

Values in parentheses are standard errors.
Mean values with the same superscript letters within columns are not significantly different ($P < 0.05$).

force required to compress a substance between molar teeth.

The hardness of the three lasagna doughs differs significantly. This fact may be due to the high fibre content of whole wheat flours and it is an evidence of a possible interaction between the gluten network and the fibre, which strengthens the dough, increasing its resistance to breakdown instead of weakening it (Chen *et al.*, 1988; Özboy & Köksel, 1997). The organic dough has the highest hardness, may be due to its lower water content and possible differences in protein quality because of organic agriculture. The hardness of both whole wheat cooked pasta is also significantly different from the conventional sample. Besides the higher fibre content, both whole wheat flours had higher gluten content than the conventional one as was measured in a previous work (Olivera, 2005); this fact may originate the higher hardness of the wholemeal samples in spite of the extra cooking time they were processed, as is confirmed in other works (Edwards *et al.*, 1993).

Adhesiveness (N s) is measured as the necessary work to overcome the attractive forces between the surface of the food and the plate of the instrument, and it is related to the force required to remove the food that adheres to the palate during eating. For doughs, this property is of vital importance, because it is related to handling properties and machinability, a low value of adhesiveness is appreciated. In addition, low adhesiveness is a desired attribute in cooked pasta. Raw organic doughs are significantly less adhesive than conventional ones (both white and whole flours); however, in cooked pasta both whole wheat flour samples adhesiveness are similar and different from the conventional.

Cohesiveness is the extent to which a material can be deformed before it breaks and it is related to the degree to which a food is compressed between the teeth. This parameter presents similar values for conventional, whole wheat and organic (dough and cooked pasta) samples.

Consistency (N s) sums the combined area of the two resistance peaks. The results shown in Tables 2 and 3 indicate that organic flour originates more consistent dough and, consequently, the organic pasta is more resistant to breakdown than the conventional one. The consistency differs significantly in the three doughs. In addition, the consistency of the three cooked samples is different. The behaviour of conventional and organic samples is similar to those observed with hardness, because of the interaction between fibre and gluten. These results refute the theory of dilution of the gluten network. However, regular whole wheat doughs are considerably less consistent than conventional and organic doughs, confirming the theory of dilution of the gluten network in fibre-enriched pasta.

Masticability is a derivate parameter (hardness × cohesiveness × springiness) and is associated to the energy required to swallow the food. This parameter is higher in organic pasta, indicating a significant impact of high fibre content.

Relaxation curves

The non-linear regression of the relaxation curves indicates that the viscoelastic behaviour of the dough was adjusted considering one simple element and two composed elements of the generalised Maxwell model, a typical behaviour in doughs (Dobraszczyk & Morgenstern, 2003).

From the results presented in Table 4, it can be concluded that the three doughs are similar in their relative components.

Table 5 shows the values of the elasticity and viscous components. It was observed that the F_0 value can be directly related to the flour's fibre content, therefore the rheological parameters elasticity modulus and viscosity are also directly correlated to fibre content.

The relaxation curves show that the viscoelastic properties of the doughs were all significantly different from each other: the conventional dough is the most elastic of the three samples; on the contrary, the viscous components are higher in whole wheat dough, because of the fibre–protein interaction. Different rheological studies show a similar trend in high-fibre-content foods (Edwards *et al.*, 1995).

Table 4 Parameters of Maxwell generalised model of doughs

Parameter	Conventional	Integral	Organic
A_∞	0.198 (0.002)	0.230 (0.002)	0.228 (0.002)
A_1	0.554 (0.017)	0.525 (0.017)	0.511 (0.015)
τ_1	5.545 (0.218)	3.245 (0.208)	4.658 (0.262)
A_2	0.223 (0.006)	0.203 (0.008)	0.225 (0.006)
τ_2	134.43 (6.240)	130.63 (5.840)	123.58 (5.630)
R	0.90	0.90	0.88

Values in parentheses are standard errors.
A_i (dimensionless), coefficient in eqn 1, related to the material viscoelastic properties; τ_i (seconds), relaxation time; r, correlation coefficient.

Table 5 Viscoelastic properties of doughs

Sample	F_0 (N)	E_1 (kPa)	E_2 (kPa)	η_1 (10^{-4} Pa s)	η_2 (10^{-4} Pa s)
Conventional	8.03	0.89	0.36	0.42	4.04
Whole wheat	30.41	4.93	1.23	1.60	15.84
Organic	50.34	8.13	3.18	3.44	39.81

F_0, maximum force; E_i, elasticity modulus; η_i, viscosity.

Table 6 Parameters of Maxwell generalised model of cooked pasta

Parameter	Conventional	Whole wheat	Organic
A_∞	0.133 (0.002)	0.137 (0.004)	0.134 (0.002)
A_1	0.648 (0.017)	0.562 (0.022)	0.650 (0.016)
τ_1	1.694 (0.089)	1.978 (0.089)	1.873 (0.092)
A_2	0.185 (0.005)	0.201 (0.005)	0.180 (0.005)
τ_2	67.130 (3.284)	55.601 (4.620)	68.098 (3.340)
R	0.95	0.92	0.96

Values in parentheses are standard errors.
A_i (dimensionless), coefficients in eqn 1, related to the material viscoelastic properties; τ_i (seconds), relaxation times; r, correlation coefficient.

Table 7 Viscoelastic properties of cooked pasta

Sample	F_0 (N)	E_1 (kPa)	E_2 (kPa)	η_1 (10^{-4} Pa s)	η_2 (10^{-4} Pa s)
Conventional	4.86	0.63	0.18	0.11	1.20
Whole wheat	6.62	0.75	0.26	0.15	1.48
Organic	6.08	0.79	0.22	0.15	1.48

F_0, maximum force; E_i, elasticity modulus; η_i, viscosity.

Tables 6 and 7 present the viscoelastic properties of the cooked lasagna. As for dough samples, the relaxation curves were adjusted with a simple elastic element and two composed elements. When comparing the maximum force values of cooked pasta (Table 7) with the correspondent values of dough (Table 5), a notorious decrease of F_0 in samples 'W' and 'O' was observed. This fact is due to the different cooking times each sample was processed. As a consequence, the three cooked samples presented similar elasticity and viscosity modules (Table 7).

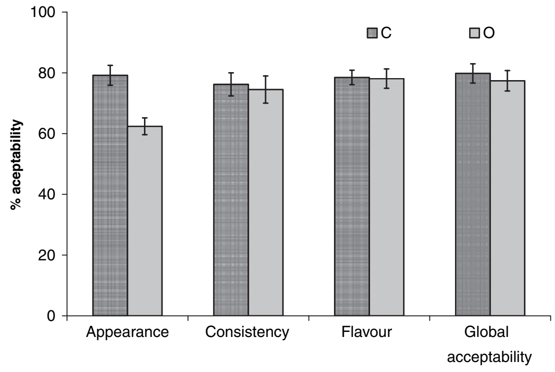


Figure 3 Results of the sensory analysis on acceptability of lasagna.

Sensory analysis

Results from the acceptability study are shown in Fig. 3. The values in this figure indicate the percentage of acceptability in each attribute: appearance, flavour, consistency and general acceptability, obtained from the measuring of the corresponding lengths marked by the panellists in the evaluation sheets.

The ANOVA confirms that the effect of sample (organic or conventional) was significant only on the appearance; differences among samples were not significant on flavour, consistency and global acceptability ($P < 0.05$).

Appearance is determined mainly by colour, an essential factor in assessing pasta quality (Feillet *et al.*, 2000). Organic samples have a brownish colour, because of the whole wheat used in its formulation.

From the consumer standpoint, flavour seems not to be as important as texture or appearance in the overall quality of pasta (Cole, 1991).

In spite of the differences in the texture parameters observed by objective instruments, the consistency of both samples tested have the same level of acceptability.

Conclusions

The texture of a new organic product has been tested objectively, quantifying the effect of the high fibre content of the organic flour, by the chosen quality indicators.

The ANOVA indicates the existence of significant differences in all the evaluated parameters, except for the cohesiveness. These differences (found both in the dough and in the cooked pasta) show a possible interaction between the fibre and the gluten proteins.

The high value of hardness and consistence, which appear in the organic dough, are unwanted characteristics. However, the pasta is slightly firmer and less adhesive, which are good attributes for the cooked pasta.

The results of the relaxation studies show a good correlation with the hardness measured by TPA profiles and with the fibre content of the flour. Therefore, both texture analyses had demonstrated to be complementary techniques to investigate the effect of bran particles in pasta behaviour.

According to the ANOVA of the result of sensory analysis, there were no significant differences in relation to consistence, flavour and global acceptability. The only parameter in which the organic pasta differed significantly from the conventional one was appearance ($P < 0.05$). On the whole, the differences found between the texture of organic pasta and the one existent in the market did not affect the acceptability of the product.

To summarise, this study has proved that, despite the objective differences between the organic and the conventional (white and whole wheat) dough and pasta, the organic product not only has a good acceptability but also has some benefits related to the high content of dietary fibre.

Acknowledgments

This research was supported by grants from CONICET, ANPCyT (PICT 99/09-7134) and Universidad Nacional de La Plata from Argentina.

References

AACC (1983). *Approved methods of the AACC. Methods 08-01, 32-10, 44-15A, 46-11 and 66-50. 8th edn.* St Paul, MN: American Association of Cereal Chemists.

ANMAT (2004). *Código Alimentario Argentino [Argentine Food Code, chapter IX, arts. 661 and 662].* Available at: http://www.anmat.gov.ar/codigoa/CAPITULO_IX_Harinas_actualiz_06-03.pdf (accessed 15 June 2005).

Chen, H., Rubenthaler, G.L. & Schanus, E.G. (1988). Effect of apple fiber and cellulose on the physical properties of wheat flour. *Journal of Food Science*, **53**, 304–305.

Cole, M.E. (1991). Review: prediction and measurement of pasta quality. *International Journal of Food Science and Technology*, **26**, 133–151.

Dobraszczyk, B.J. & Morgenstern, M.P. (2003). Rheology and the breadmaking process. *Journal of Cereal Science*, **38**, 229–245.

Edwards, N.M., Izydorczyk, M.S., Dexter, J.E. & Biliaderis, C.G. (1993). Cooked pasta texture: comparison of dynamic viscoelastic properties to instrumental assessment of firmness. *Cereal Chemistry*, **70**, 122–126.

Edwards, N.M., Biliaderis, C.G. & Dexter, J.E. (1995). Textural characteristics of wholewheat pasta and pasta containing non-starch polysaccharides. *Journal of Food Science*, **60**, 1321–1324.

Feillet, P., Autran, J.C. & Icard Vernière, C. (2000). Pasta brownness: an assessment. *Journal of Cereal Science*, **32**, 215–233.

Harker, F.R. (2004). Organic food claims cannot be substantiated through testing of samples intercepted in the market place: a horticulturalist's opinion. *Food Quality and Preference*, **15**, 91–95.

Kortbech-Olesen, R. (2002). Crece demanda de productos orgánicos en los Estados Unidos. *Forum de Comercio Internacional*, **2**, 27–31.

Kortbech-Olesen, R. (2003). Overview on World Trade in Organic Food Products, the US Market and Recent Trends. Nuremberg, Germany: BioFach Congress. Available at: http://www.intracen.org/mds/sectors/organic (accessed 20 June 2005).

Mucci, A., Hough, G. & Ziliani, C. (2004). Factors that influence purchase intent and perceptions of genetically modified foods among Argentine consumers. *Food Quality and Preference*, **15**, 559–567.

Olivera, D. (2005) *Desarrollo de lasagna orgánica. MS Thesis*. La Plata, Argentina: Facultad de Ingeniería, Universidad Nacional de La Plata.

Özboy, Ö & Köksel, H. (1997). Unexpected strengthening effects of a coarse wheat bran on dough rheological properties and baking quality. *Journal of Cereal Science*, **25**, 77–82.

Systat 10.0 (2000). SPSS Inc., Systat Software Inc., Richmond, CA, USA.

Szczesniak, A.S. (2002). Texture is a sensory property. *Food Quality and Preference*, **13**, 215–225.

Torjusen, H., Lieblein, G., Wandel, M. & Francis, C. (2001). Food system orientation and quality perception among consumers and producers of organic food in Hedmark County, Norway. *Food Quality and Preference*, **12**, 207–216.

Tudoricá, C.M., Kuri, V. & Brennan, C.S. (2002). Nutritional and physicochemical characteristics of dietary fiber enriched pasta. *Journal of Agricultural and Food Chemistry*, **50**, 347–356.