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Technological and nutritional assessment of dry pasta with oatmeal and the microalga *Spirulina platensis*

Avaliação tecnológica e nutricional de massa alimentícia seca enriquecida com farinha de aveia e microalga Spirulina platensis

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Summary

Wheat flour is the most important raw material in the production of pasta. The production process consists of mixing water and flour, kneading, extrusion and drying. Oats and the microalga *Spirulina platensis* play a physiological role in the growth, development and maintenance of the human organism due to their high nutritional value. The aim of this study was to assess the technological and nutritional properties of dry pasta prepared with the addition of oatmeal and *Spirulina platensis*. The wheat flour was characterized and the effect of partial replacement by oatmeal and *Spirulina platensis* (*Arthrospira platensis*) was evaluated using response surface methodology (RSM). The mixtures were analysed for moisture, protein, ash, colour, particle size, falling number and alveography. The formulated pastas were dried and evaluated for moisture, colour, cooking test, acidity, proximate composition and amino acids. Generally, the addition of *Spirulina platensis* influenced the soluble solids content and colour of the pasta, while the oatmeal mainly affected the acid content. The oatmeal increased the values of crude protein and total dietary fibre (13.06%) when compared with the commercial pasta (2.40%) and may be considered as a source of fibre.

Key words: *Avena sativa; Spirulina plantensis; Triticum aestivum; Amino acid composition; Dietary fibre.*

Resumo

A farinha de trigo é a matéria-prima mais importante para a elaboração de massas alimentícias. O processo de produção de massas consiste na mistura de água e farinha, amassamento, extrusão e secagem. Aveia e microalga *Spirulina platensis* desempenham um papel fisiológico no crescimento e manutenção do organismo humano devido ao seu elevado valor nutricional. Com base nisso, o objetivo deste trabalho foi estudar as propriedades nutricionais e tecnológicas de massa seca enriquecida com farinha de aveia e microalga *Spirulina platensis*. A farinha de trigo foi caracterizada e o efeito da substituição parcial por aveia e *Spirulina platensis* (*Arthrospira platensis*) foi avaliado utilizando-se metodologia de superfície de resposta (MSR). As misturas foram analisadas quanto a umidade, proteínas, cinzas, cor, tamanho de partícula, número de queda e alveografia. As massas formuladas foram secas e avaliadas quanto a teor de umidade, cor, cozimento, acidez, composição centesimal e perfil de aminoácidos. De maneira geral, a adição de *Spirulina platensis* influenciou o teor de sólidos solúveis e a cor da massa, enquanto que a farinha de aveia afetou os teores de acidez. A farinha de aveia aumentou os valores de proteína bruta e de fibra dietética total (13,06%), quando comparados com os da massa comercial (2,40%), e pode ser considerada como uma fonte de fibra.

Palavras-chave: *Avena sativa; Spirulina plantensis; Triticum aestivum; Composição em aminoácidos; Fibra alimentar.*

1 Introduction

Pasta is made from wheat flour (*Triticum aestivum* L and/or other species of the Genus *Triticum*) and/or other cereals, legumes, roots and tubers, resulting from the process of hand and/or mechanical kneading, and pressing, without fermentation. The pasta can be made dry, fresh, precooked, instant or ready for consumption, with different shapes and fillings (BRASIL, 2005a). According to the Brazilian Association of Manufacturers of Pasta and Bread & Cakes Processed (ABIMAPI), the consumption in 2013 was 0.9, 0.3 and 4.8 kg / capita for dry, instantaneous and fresh pasta, respectively (ABIMAPI, 2013).

The pastas are foods that can be used to incorporate additives due to their simple manufacturing process, low cost, nutritive value and finally due to their high acceptance (LEMES et al., 2012). A market survey on the consumption of pastas, in which 100 individuals were interviewed, indicated that pastas were consumed frequently consumed by 97% of the people interviewed (SILVEIRA and BADIALE-FURLONG, 1998).

The possibility of producing new types of unconventional pasta has increased the interest in using other raw materials that are widely available and underused such as oats, rice, microalgae or a mixture of these. Due to their metabolic and physiological role in the growth, development and maintenance of the human body, oats and *Spirulina platensis* are characterized as foods of high nutritional value (COLLA et al., 2007a; WEBER et al., 2002). The white oat (*Avena sativa* L.) is a cereal of excellent nutritional value with high levels of protein and dietary fibre and an adequate amino acid composition according to FAO (Food and Agriculture Organization) (SIMIONI et al., 2007). As a functional food, oats can be used in commercial products with low caloric value and as a source of dietary fibre (BUTT et al., 2008; GUTKOSKI et al., 2009; COLUSSI et al., 2013). It can also be used as a thickener due to its good stability against retrogradation (GALDEANO et al., 2009). The microalga *Spirulina platensis* (Arthrospira platensis) has high levels of protein (64 to 74%), polyunsaturated fatty acids and vitamins, also contains antioxidant compounds and is classified as GRAS (Generally Recognized as Safe) by the FDA (Food and Drug Administration), so it can be used in foods without any risks to the health (COLLA et al., 2007b). The digestibility of its crude protein is an important criterion for the use of this microalga as a supplement in food products (FIGUEIRA et al., 2011). The amino acid composition showed that the proteins in *Spirulina platensis* are a source of methionine, cystine and possibly of lysine and histidine (COLLA et al., 2007a).

The texture and appearance of the pastas during and after cooking is the most important quality parameter for consumers. In addition to the flavour and odour, the following are included in these parameters: cooking time, quantification of the water absorbed, rheological properties of the pasta and the surface characteristics (ORMENESE et al., 2004; LEMES et al., 2012; CASAGRANDI et al., 1999).

This study investigated the technological and nutritional properties of dry pasta prepared with the addition of oatmeal and *Spirulina platensis*.

2 Material and methods

2.1 Raw material

This study was carried out at the University of Passo Fundo, Brazil, using the ingredients: wheat flour, oatmeal, *Spirulina platensis*, distilled water, egg and sodium stearoyl-2-lactylate (SSL).

2.2 Characterization of the wheat flour

The wheat flour was characterized with respect to moisture using the 44-15A method (2000); and protein and ash using reflectance spectroscopy (NIRs) and the Fartam calibration curve according to the AACC methods 46-13 and 08-01 (AACC, 2000), respectively. The luminosity (L*) and colour chromaticity coordinates a* and b* were determined according to AACC method 14-22 (AACC, 2000) using a diffuse reflectance spectrophotometer (Hunter Lab, ColorQuest II model, USA). The falling number was determined in a Falling Number apparatus (Perten model, Sweden), according to AACC method 56-81B (AACC, 2000). The rheological properties were measured using a NG model Chopin alveograph (Villeneuve-la-Garenne Cedex, France), according to AACC method 54-30 (AACC, 2000), obtaining the following parameters: tenacity (P, mm), extensibility (L, mm) and general gluten strength (W x 10^{-4} J).

2.3 Experimental design

The study used a central composite design applicable to response surface methodology (BARROS NETO et al., 2003) to study the combined effects of the independent variables, oat meal content (%) and *Spirulina platensis* content (%), which were used to partially replace the wheat flour in the pasta formulations. The variables were set at five levels, coded as $-\alpha$, -1, 0, +1, + α (Table 1) and the design used four factorial experiments, four axial experiments and three replicates at the centre point, totalling 11 experiments.

2.4 Rheological properties of the mixtures

The rheological properties of the mixtures of wheat flour, oatmeal and *Spirulina platensis* were determined using a Chopin alveograph, as described in item 2.2.

Table 1. Levels of the independent variables in the 2^2 central composite design applicable to response surface methodology.

Independent variables	Levels of variation				
	$-\alpha$	–1	0	+1	$+\alpha$
Oatmeal content (%)	0.0	7	25	43	50
Spirulina content (%)	0.0	0.6	2.0	3.4	4.0

2.5 Dry pasta processing

The pasta was produced using 1 g of SSL, 50 g of egg (% w/w) and the quantities of oatmeal and *Spirulina platensis* defined in the experimental design shown in Table 1. Sufficient distilled water was added to obtain 1000 g of pasta with a final moisture content of 35%. The ingredients (wheat flour, oat flour and SSL) were mixed for 15 min in a vertical mixer (Kitchen Aid, USA) together with the whole egg and *Spirulina platensis*, diluted in distilled water at 50°C. The mixture was processed in a Pastaia II extruder (Italvisa, Brazil) to obtain a screw-type shape.

The pasta was dried conventionally in a tray dryer fitted with steam injection and instrumentation to control and record the relative humidity and air velocity. For each experiment, four perforated trays were used with dimensions of 0.7 × 0.45 and a capacity for 438 g fresh weight of pasta.

Air was circulated horizontally at a velocity of 1.0 m s^{-1}. The process sequence and operating conditions in terms of residence time and relative humidity were carried out according to Leitão et al. (1990), with 0.5 h at Ts = 25°C (RH = 70%); 3 h at Ts = 48°C and Tu = 46°C (RH = 89%); interruption of heating for 0.5 h to allow the Ts to drop to 45°C; and finally 3 h at Ts = 45°C and Tu = 42°C (RH = 82%). At the end of the sequences described above, the heating system was turned off, and the product was dried for 12 h. The end point of drying occurred when the pasta reached 13% moisture content.

2.6 Analyses of the dry pastas

The moisture content and colour were determined according to AACC (2000), methods 44-15A and 14-22, respectively. The cooking test was carried out in duplicate, according to AACC method 16-50 (AACC, 2000), assessing the parameters of cooking time, increase in weight of cooked product, loss of soluble solids to the cooking water and increase in volume. The cooking time was determined using 10 g of sample in 140 mL of boiling distilled water until the appropriate visual quality was achieved, as a result of starch gelatinization throughout the pasta cross-section. This final point was determined by compressing cooked samples of the product between two flat glasses every minute after the first five minutes of cooking, until the central axis disappeared.

The weight increase of the cooked product was measured by weighing the sample before and after cooking, using the ideal time for each sample. The weight increase value is the ratio between the weights of the cooked pasta and the raw pasta (10 g), expressed as a percentage (%). The amount of soluble solids lost was determined by evaporating 25 mL of cooking water to constant weight in a 105°C oven. The volume increase was determined by using 140 mL of hexane in a 250 mL beaker. The ratio between the volumes of solvent displaced by the raw pasta (10 g) and by the cooked pasta, expressed as a percentage, served as a parameter to determine the volume increase.

The titra acidity of the supernatant was determined according to the AOCS Ca 5a-40 method (FIRESTONE, 2004) dispersing the sample in 95% ethanol for 24 h and titrating the supernatant with 0.01 M NaOH.

The proximate composition was obtained by determining the moisture, ash, lipid and protein contents according to AACC (2000) methods 44-15A, 08-01, 30-20 and 46-13, respectively. The total dietary fibre content was determined using AOAC method 994-43 (CUNNIFF, 1997), and the carbohydrate content estimated by difference. The metabolizable energy was calculated from the proximate composition data, in agreement with RDC 360 of the National Agency for Sanitary Surveillance, Ministry of Health (BRASIL, 2003). Conversion factors of 4 kcal g^{-1} for carbohydrates and protein and 9 kcal g^{-1} for lipids were used in the calculations, and the values were expressed in kcal g^{-1}.

The quantitative amino acid composition was measured using the Spackmann method (SPACKMANN et al., 1958), hydrolysing the sample in 6 M HCl in sealed ampoules under vacuum and maintaining at 110°C for 22 h. The amino acid profile was obtained in duplicate using a high performance liquid chromatograph in a third-party laboratory, and expressed as g of amino acid per 16 g N. To calculate the chemical score (CS), the ratio was calculated for each of the crude protein amino acids, comparing with the reference values for each amino acid for children from 2 to 5 years old according to FAO (1985). The ratios indicate the order of limiting amino acids and the value found for the most limiting amino acid is an estimate of the biological value of the protein in the study and indicates the CS.

2.7 Statistical analysis

The results were analysed using response surface methodology (BARROS NETO et al., 2003), and the significance of the model was tested by an analysis of variance (F test). Non-significant variables were eliminated from the adjusted models, only those that were significant at the 5% probability level remained in the final equation.

The experimental data for the proximate composition were subjected to an analysis of variance (ANOVA) and in the means in the significant models compared using the Tukey test ($p < 0.05$).

3 Results and discussion

3.1 Characterization of wheat flour

The moisture content of the wheat flour was 13.36%, which conforms with the standard value (up to 15%) (BRASIL, 2005b). The falling number of the wheat flour was 418 s. Values above 400 s are recommended for pasta, because low enzymatic activity reduces darkening of the pasta and loss of solids in the cooking water (DICK and YOUNGS, 1988).

The alveographic parameters were used to predict the quality of the flour for pasta production because there is a correlation with baking quality (D'EGIDIO et al., 1990). In this study, the gluten strength (W) was 315×10^{-4} J with a tenacity/extensibility (P/L) ratio of 3.1, indicating tenacious gluten. Chang and Flores (2004) found values for W and the P/L ratio of 258 J $\times 10^{-4}$ and 2.49, respectively, lower than the values found in the present study. The precise balance of the viscoelastic properties is an essential factor for determining the end use of wheat flour, and tenacious gluten is recommended for the production of dry pasta (SISSONS, 2008).

According to many authors, the protein content is the principal indicator of the quality and end use of a flour (EL-DASH et al., 1982). The protein content showed a value of 11%, lower than that recommended for pasta. The differences observed in the proximate compositions were generally not significant, but the differences could have resulted from a lack of homogenization during the processing and to analytical inaccuracies, such as the ingredients not being from the same batch (LEMES et al., 2012).

A higher percentage of ash indicates the presence of unwanted material such as bran, which results in a final product of inferior texture with poorer sensory characteristics. The ash content was 0.63% (dry basis), which conforms with Instruction No. 8, Ministry of Agriculture, Livestock and Supply (BRASIL, 2005b) for type I wheat flour.

The wheat flour had a uniform particle size, with 99.28% passing through a n° 80 Tyler sieve, which is a smaller opening than the required n° 60 Tyler sieve (BRASIL, 2005b). Pasta that is produced with an uneven wheat flour particle size can show white patches due to variations in the rate of water absorption, which is faster for fine particles.

The colour of the flour is evaluated by measurements of luminosity and yellow chromaticity, which is influenced by the bran content, while the yellowness is related to the amount of carotenoid pigments (MAILHOT and PATTON, 1988). The luminosity (L*) was 92.72, below that recommended for dry pasta, which is 94.00 (ORMENESE, 2002). The yellow chromaticity (+ b*) had a value of 9.83, which is above the minimum required for pastas (8.5). A similar value (9.86) was found by Chang and Flores (2004) who studied the technological quality of fresh pasta. It should be noted that the flour used was mixed with oats and microalgae, an ingredient with a green pigment, so that the ash content and luminosity would not be a problem for the quality of the final product.

3.2 Technological and functional properties of dry pasta

The gluten strength (W) of the mixtures ranged between 78×10^{-4} and 281×10^{-4} J (Table 2), which enables one to assess the ability of the flour to withstand the mechanical treatment when mixed with water. The regression model for W was significant at 5% probability with R^2 equal to 0.9803. The fitted first-order model for gluten strength is shown in Equation (1), where x_1 corresponds to the oat contents used in the formulations.

$$W = 161.3 - 142.3\, x_1 \qquad (1)$$

Of the factors studied, the oat content significantly affected this component (W), and an increase in the oat concentration reduced the gluten strength of the formulations. *Spirulina platensis* did not significantly ($p < 0.05$) influence the W value of the formulations (Figure 1a). These values were due to the fact that oats do not have the ability to form gluten, which is a characteristic unique to wheat flour. However, its use in formulations is recommended, due to its functional properties and the quality of its proteins, which are appropriate from a nutritional standpoint (GUTKOSKI and PEDÓ, 2000).

The regression model was not significant at a 5% probability for the tenacity/extensibility (P/L) ratio of the formulations containing wheat flour, oat flour and *Spirulina platensis* (Figure 1b). The mixtures had P/L values greater than 2.5, suitable for the preparation of pasta because this indicates tenacious gluten (high P and low L) (ORMENESE et al., 2004). However, this parameter must be associated with the W value of the mixtures, which decreased with the addition of oats and *Spirulina platensis*.

The fitted model for the parameter L* (luminosity) of the colour of the raw product was significant at 5% probability. The percentages of oats and *Spirulina platensis* significantly affected this parameter, and higher levels of *Spirulina platensis* in the mixture reduced the luminosity of the raw pasta, characterizing darker samples

Table 2. Experimental design with coded and real values and responses for the analyses of gluten strength (W) and the tenacity/ extensibility ratio (P/L) for the mixtures of wheat flour, oatmeal and *Spirulina platensis*.

Assay	x_1 (%)*	x_2 (%)*	W (10^{-4} J)	P/L
1	–1 (7)	–1 (0.6)	281	2.75
2	1 (43)	–1 (0.6)	90	6.08
3	–1 (7)	+1 (3.4)	209	3.76
4	1 (43)	+1 (3.4)	102	7.55
5	–1,42 (0)	0 (2.0)	269	3.61
6	+1,42 (50)	0 (2.0)	78	8.76
7	0 (25)	–1,42 (0.0)	152	3.23
8	0 (25)	+1,42 (4.0)	153	4.86
9 (C)	0 (25)	0 (2.0)	158	3.72
10 (C)	0 (25)	0 (2.0)	176	5.15
11 (C)	0 (25)	0 (2.0)	150	6.12

*Coded and real values for oats (x_1) and *Spirulina platensis* (x_2); C= central point.

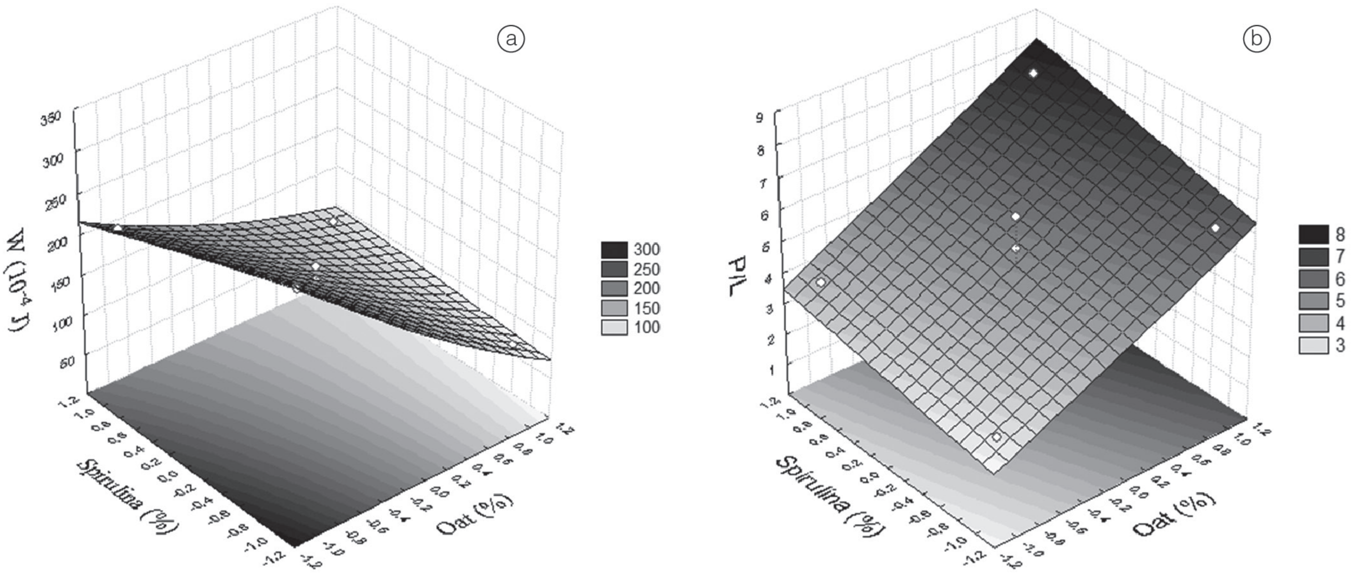

Figure 1. Response surfaces showing the influences of the oats and *Spirulina platensis* concentrations on (a) gluten strength (W, 10^{-4}J) and (b) tenacity/ extensibility (P/L).

(Figure 2a). The regression coefficient (R^2) was 96.6%, indicating a good fit to the data, which ensures the validity of the model. The fitted first-order model for luminosity is shown in Equation (2) where x_2 corresponds to the *Spirulina platensis* content used in the formulations.

$$L^* = 73.66 + 4.85x_1 - 11.32\,x_2 \quad (2)$$

The results of the response surfaces for the influence of the oats and *Spirulina platensis* concentrations on the L* parameter of the dry pasta colour demonstrated that the addition of *Spirulina platensis* had a greater influence on the results than the oatmeal, because the optimal region was obtained with smaller amounts of microalga.

The model fitted for the colour chromaticity coordinate a* was significant ($p < 0.05$). The oats and *Spirulina platensis* percentages significantly affected this component, but the *Spirulina platensis* intensified the green colour of the pasta when this ingredient was increased (Figure 2b). The regression coefficient (R^2) was 94.8%, which indicates a good fit of the model to the data, thereby ensuring the validity. The fitted first-order model for the a* colour component is shown in Equation (3).

$$-a^* = 73.66 + 4.86x_1 - 11.32\,x_2 \quad (3)$$

The response surfaces for the chromaticity coordinate a * indicated that the greater the amount of *Spirulina platensis* used in the dry pasta formulation, the greater the intensity of green (–a*). Teimouri et al.

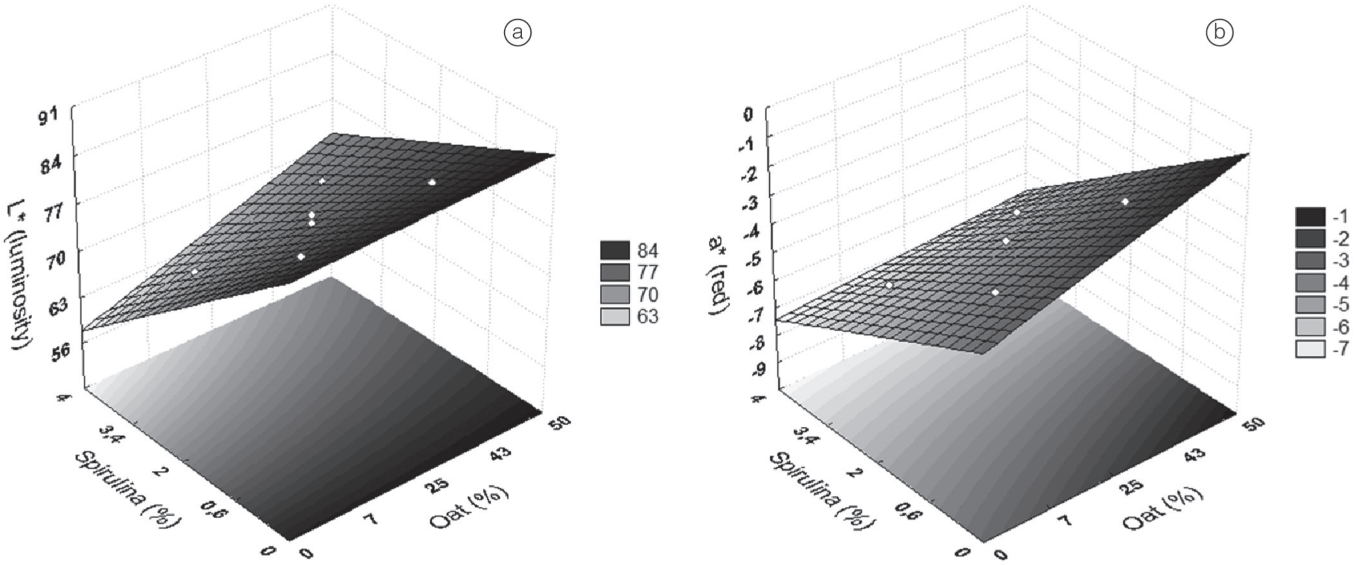

Figure 2. Response surfaces showing the influences of the oats and *Spirulina platensis* concentrations on: (a) L* parameter and (b) chromaticity coordinate a* of the dried pasta.

(2013) included 10% *S. platensis* as a natural pigment source, resulting in the highest carotenoid deposition in fish tissues. The highest values for a* (redness) and b* (yellowness) were observed in fillets from fish fed with10% *S. platensis*. The chromaticity coordinate b* of the dry pasta experiments pasta ranged between 10.06 and 14.18. The regression model for the chromaticity coordinate + b* (yellow) was not significant ($p < 0.05$) within the range studied.

The cooking test provided information about the behaviour of the product during cooking and the texture of the cooked product (Table 3). A loss of solids of up to 6%, an increase of 100% in the minimum weight and a volume in the range from 200% to 300% are characteristics of good quality pastas (ORMENESE et al., 2004). The weight increase ranged from 140.5% and 173.3% and the loss of solids was less than 6.5% for all treatments. The volume increase was less than 200% for all samples, but this result did not alter the quality parameters due to the influence of the shape of the pasta. The regression models for the responses of weight gain, volume increase and loss of solids were not significant within the range studied ($p < 0.05$).

The acidity of the dry pasta ranged between 0.97 and 1.87 mL of NaOH 100 g^{-1}, and the oats and *Spirulina platensis* significantly affected ($p < 0.05$) this value. The regression coefficient (R^2) was 99.9%, which indicates that the model was suitable to represent the response within the range studied (Figure 3). The fitted first-order model for acidity is shown in Equation (4).

$$Acidity = 1.42 + 0.74x_1 + 0.11x_2 \quad (4)$$

The amount of *Spirulina platensis* added to the pasta was not sufficient to reduce the acidity, suggesting

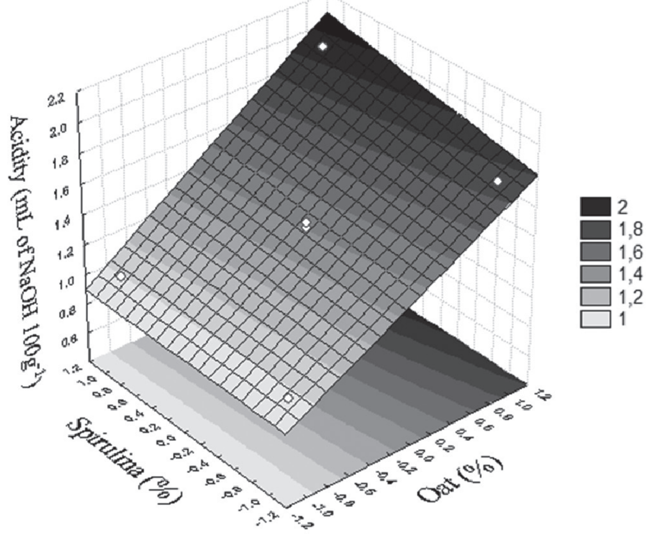

Figure 3. Response surface showing the influence of the oats and *Spirulina platensis* concentrations on the acidity of the dry pastas.

that further studies should be carried out with the addition of larger amounts of the microalga to the mixtures.

3.3 Chemical composition of the dry pastas

The chemical compositions of assays T6, T8, Central point and control (pasta without added oats and microalga) are presented in Table 4. The criteria for choosing these trials was based on the maximum value for the addition of the variables, where T6 had the largest amount of oatmeal (%) and T8 the largest amount of microalga (%).

Table 3. Parameter L * (luminosity), Chromaticity coordinate a* (green) and chromaticity coordinate + b* (yellow), acidity (mL NaOH 100g^{-1}), increase in mass (%), increase in volume (%) and loss of soluble solids (%) of the dry pastas.

Assay	Independent variables		Colour and acidity of the raw product				Cooking test		
	x_1*	x_2*	L*	–a*	b*	Acidity	WI**	VI**	LS**
1	–1	–1	78.0	–3.47	11.24	0.98	157.09	175	4.90
2	1	–1	81.4	–2.40	10.06	1.75	173.33	170	4.40
3	–1	+1	66.1	–6.08	10.41	0.99	153.00	160	6.52
4	1	+1	71.7	–5.67	11.62	1.96	165.62	150	5.94
5	–1.4	0	69.3	–6.06	10.56	1.02	148.22	150	4.74
6	+1.4	0	76.6	–4.55	10.84	1.87	169.99	160	4.62
7	0	–1.4	83.8	–0.24	10.74	1.41	140.53	150	4.09
8	0	+1.4	67.1	–6.27	10.54	1.55	143.09	150	5.02
9 (C)	0	0	72.1	–3.86	13.44	1.43	162.56	185	5.28
10 (C)	0	0	75.0	–4.34	10.30	1.39	169.96	180	5.18
11 (C)	0	0	74.0	–4.87	10.56	1.43	151.12	170	5.29
Control***	0	0	86.3	–0.62	14.18	0.82	162.06	170	5.94

*Coded and real values for oats (x_1) and *Spirulina platensis* (x_2); C = central point; **WI = Weight increase; VI= Volume increase. LS = Loss of solids; Control***: pasta without enrichment with oatmeal and *S. platensis*.

Table 4. Chemical composition of treatment 6 (T6), treatment 8 (T8), central point (C) and the controls (pasta not enriched with oatmeal and *S. platensis*).

Determination	T6	T8	C	Control
Oatmeal (%)	50	25	25	-
S. platensis (%)	2.0	4.0	2.0	-
Moisture (%)	13±0.14^a	13±0.19^a	13±0.2^a	13.2±0.04^a
Crude protein (%)	13±0.01^a	12.9±0.03^a	12.2±0.1^b	10.7±0.11^c
Lipids (%)	3.6±0.02^a	2.1±0.01^b	2.6±0.04^b	1.9±0.21^c
Ash (%)	1.3±0.01^a	1.4±0.17^a	1.2±0.02^a	0.50±0.07^b
Total Dietary Fibre (%)	13.1±0.14^a	7.7±0.17^b	7.6±0.09^b	2.4±0.11^c
Carbohydrates (%)	56.5±0.12^c	62.8±0.09^b	63.1±0.2^b	71.3±0.15^a
Metabolizable energy (kcal 100g^{-1})	308.8±0.18^c	325±0.24^b	323.3±0.2^b	345.1±0.28^a
Chemical score (%)	-	-	36.00±0.8	-

Results are the mean of three repetitions ± standard deviation. Means followed by different lowercase letters present significant differences according to the Tukey test (p> 0.05) amongst the lines.

The moisture content of the pastas was determined to monitor the efficiency of the drying process and assess whether the product has good storage characteristics (ORMENESE, 2002). Thus, moisture values always below 13% were expected. In this range the product is theoretically free of microbiological problems. The pastas in this study were within this safety range, and the control pasta had a slightly higher moisture content than desired (13.%). Although moisture content is the first control analysis carried out, the possibility of high internal residual moisture during the drying process exists. Therefore the determination of acidity tends to complement the results for moisture content in the evaluation of the drying efficiency and quality of the pasta.

The addition of *Spirulina platensis* changed the protein content of the pasta with a gradual increase as the microalga concentration was raised. The protein content did not vary significantly between the treatments, but when compared to the control, it was approximately 20% higher.

The lipid contents ranged between 1.9% and 3.6%, with a higher value in the trial with the addition of 50% oat flour (T6). Lipids are nutritionally important, but when combined with hydrolytic enzymes can accelerate degradation and reduce the storage stability of cereals and their derivatives (LIUKKONEN et al., 1992).

The Total Dietary Fibre concentration increased as the oatmeal concentration increased, when compared with the control pasta, with the highest value at 50% concentration (130%). In addition to the increase in protein, this product can be classified as a fibre-rich food and increasing amounts of total dietary fibre resulted in a reduction in the metabolizable energy.

The first limiting amino acid in the pasta was lysine, with a chemical score of 36% followed by threonine. To be considered to have a high-protein nutritional value the chemical score should be higher than 1.0 for all the essential amino acids, but when there is one amino acid with a chemical score below 1.0, it is considered to be limiting (PIRES et al. 2006). The sulphur amino acid content (methionine + ½cystine) was 1.63 mg amino acid 100 g^{-1} protein, while the level recommended by FAO is 2.5 mg amino acid 100 g^{-1} protein.

4 Conclusions

The addition of *Spirulina platensis* influenced the soluble solids level in the cooking water and the colour of the unconventional pasta, while the oatmeal influenced the acidity. The amount of *Spirulina platensis* used in the formulations (0-4%) did not cause changes in the functional properties of the unconventional pasta. The addition of oat flour increased the crude protein from 10.7% to 13% and the total dietary fibre from 2.4% to 13.1%, and may be considered as a fibre source.

Oatmeal and *Spirulina platensis* could be used as ingredients in the preparation of commercial unconventional dry pasta that show acceptable technological characteristics.

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