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Proceeding Paper

Effect of the Partial Use of Potato Flour and Enhancers on the Rheological, Nutritional and Cooking Properties of Dried Noodles †

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Abstract: Wheat flour (WF) was replaced with potato flour (PF) at 10%, 20% and 30% (*w*/*w*) in combination with enhancers xanthan gum (XG) and wheat gluten (WG). The flour quality, rheological properties and noodle quality were analyzed. Increasing the PF substitution decreases the strength (S); the optimum cooked time (OCT) and water absorption slightly increased with increasing PF content. The best treatment to elaborate dry noodles was 20% of PF and application of WG6% + XG0.4%, while was significant ($p \geq 0.05$) on the antioxidant activity compared to the control. The techno-functional and nutritional characteristics of PF can be an alternative to replace to WF.

Keywords: dry noodles; potato flour; enhancers

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1. Introduction

Noodles or pasta are popular worldwide [1]. Potato (*Solanum tuberosum* L.) is one of the four most widely grown crops in the world, and from a nutritional point of view, it has mainly starch, which gives it important rheological properties, as well as low fat and protein content, and provides vitamins, minerals, fiber and other functional compounds [2]. Research has shown that Andean or native potatoes have a high content of phenolic compounds, the ones found in the highest proportion were chlorogenic acid, p-coumaric acid, caffeic acid, coumarin, ferulic acid and neochlorogenic acid, which have been studied and shown to have antioxidant properties and beneficial effects on health [3]. The substitution of wheat flour with other flours from tubers, pseudocereals, roots, legumes and local raw materials is a good strategy in developing countries to reduce dependence on wheat flour imports, due to the volatility of world prices, in addition to the nutritional improvement that can be achieved with substitution [4]. However, the substitution of wheat flour by other gluten-free flours can decrease the rheological properties of the dough; in that sense, hydrocolloids can provide an improvement in the functional properties, making the substitution suitable [5]. Therefore, the present study aimed to evaluate the effect of the enhancers xanthan gum (XG) and wheat gluten (WG) in the production of dried noodles with the partial replacement by potato flour (PF) and determine the treatment with the highest degree of substitution with a quality like the control based on a sensory analysis of the final product.

2. Materials and Methods

2.1. Materials

The native potato (*Solanum tuberosum*) used was of the Almonacid or Canchan variety, which was bought in a supermarket in the city of Lima, Peru. Wheat flour (WF) was provided by Molitalia S.A., obtained from Canadian prairie red spring wheat, also known as CPSR. The enhancers used in this study were wheat gluten (WG) and xanthan gum (XG), which were purchased from Bakery S.A.C and Ingredients & Solutions S.A.C., respectively.

2.2. Preparation of Potato Flour and Dry Noodles

The potato was boiled using distilled water at a ratio of 1:1.5 (w/w) raw material: water, for a total time of 15 min. The peel was then manually removed, and the pulp was placed in a hot air dryer tray at 50 °C for 8 h. The dried product was then ground using an IKA 11 basic mill, and finally the flour was sieved using a 0.5 mm sieve. The ingredients were mixed for 10 min, followed by a rest time of 30 min, then rolled and cut, and finally dried for 10 h at 45 °C; the dry noodle is a mixture of 30–33% water, 2.5% NaCl and 100% WF.

2.3. Flour Quality of Raw Materials

Humidity, ashes, damaged starch (Approved Methods of Analysis [AACC] Method 76-33.01); gluten (International Association for Cereal Science and Technology [ICC] Standard Method 155).

2.4. Rheological Properties of the Dough

Rheological analysis was performed using a Chopin Technologies NG Alveograph, according to ICC Standard Method No.121. The parameters were automatically recorded by means of a software program: tenacity (P), mass extensibility (L), curve configuration (P/L ratio) and strain energy (W).

2.5. Experimental Design

In the first phase, the flour quality of the raw materials was evaluated; the second phase included a Z_0 standard (100% WF) and three substitution percentages Z_1, Z_2 and Z_3, in which the WF was replaced by 10%, 20% and 30% with PF, respectively; the treatments considered were the application of the enhancers, grouped as follows: WG4% + XG0.2%, WG4% + XG0.4%, WG4% + XG0.6%, WG6% + XG0.2%, WG6% + CG0.4% and WG6% + XG0.6%, an evaluation was performed that consisted of a rheological analysis of the dough, then the samples similar to the Z_0 standard were chosen; in the third stage, the culinary evaluation of the samples selected in the previous stage was performed, finally the best sample was chosen taking the Z_0 standard as a reference.

2.6. Cooking Properties

The optimum cooking time was evaluated (OCT) according to the AACC method (22) with slight modifications, reported by [6].

2.7. Colour of Flours and Dry Noodles

A chroma meter (Konica Minolta, Tokyo, Japan) was utilized to measure the color of the noodle tests. L* is a measurement of brightness (0–100); a* represents the red–green facilitates (− is green, while + is red), whereas b* measures the blue–yellow arranges (− is blue, with + demonstrating yellowness) of a product [7].

2.8. Antioxidant Activity by DPPH Radical Scavenging Assays

The antioxidant capacity of each fraction (lipophilic and hydrophilic) was measured by 2,2-diphenyl-1-picrylhydrazyl free radical (DPPH) scavenging according to the method reported by Brand-Williams et al. (1995) [8] with some modifications.

2.9. Statistical Analysis

For Phase II, a multivariate statistical analysis of variance (MANOVA) and then a Tukey's test of comparison of means was applied at a significance level of 95% ($p < 0.05$). For Phase III, statistical analysis was carried out by means of the analysis of variance (ANOVA), and then a Tukey's test of comparison of means was applied, at a significance level of 95% ($p < 0.05$). This analysis was performed using Minitab 19 software. The evaluations were carried out in triplicate; the data mentioned represent the average of the given repetitions.

3. Results and Discussion

3.1. Phase I: Quality of the Flours

The physicochemical characteristics of the flours were evaluated, and the results are shown in Table 1. The final moisture content of the potato was reduced from 78% (wet basis) to 0.31% (dry basis) after drying. Damaged starch has an effect on the quality of the flours, and the granules can be damaged during milling, depending on the severity of the milling and the hardness of the wheat grain; if the damage is high, it can influence the mixing properties, dough-sticking and proneness to enzymatic hydrolysis, the obtained value of damaged starch in wheat flour is a value very respect to those reported in the literature that oscillate in the range from 6. 5% to 12.5% [9], and this may have an influence on the properties of the dough and the final product.

Table 1. Flour quality and protein analysis of samples Z_1, Z_2 and Z_3.

	Potato Flour	**Wheat Flour**	**Z_1 (10% PF+90WF)**	**Z_2 (20% PF+80% WF)**	**Z_3 (30% PF+70% WF)**
Humidity	6.7% (wb)	14.20% (wb)			
Ashes	3.15%	0.58%			
Damaged starch	-	20.9 UCD			
Gluten	-	DG: 11.9%			
	-	WG: 33.2%			
Crude protein	5.40%	12.07%	11,403%	10,736	10,069

DG: dry gluten; WG: wet gluten, wb: wet basis, PF: potato flour; WF: wheat flour.

The minimum gluten content of wheat flour should be 24% (wet) and 8% (dry); therefore, the values obtained for wheat flour are within acceptable values [10]. The literature reports protein content values of wheat flour for making noodles in the range of 11% to 14%; in our case, wheat flour is within acceptable values [11]. Table 1 shows the samples with three substitution levels: Z_1 = 10%, Z_2 = 20% and Z_3 = 30%, respectively; as can be seen, sample Z_1, Z_2 and Z_3 contain 10.70%, 11.18% and 11.24% less than the control sample respectively.

3.2. Phase II: Rheological Properties of the Dough

The multivariate analysis product of the interaction of strength, tenacity and extensibility, it was found that there was at least one significant difference between the treatments used ($p < 0.05$). Likewise, according to strength alone, it was found that there was at least one difference between each treatment ($p < 0.05$). Therefore, we proceeded to use Tukey's post-hoc tests. This test indicated that the treatments that have 10% potato flour + 90% CPSR with GL 6% + GX 0.4%, 20% potato flour + 80% CPSR with GL 6% + GX 0.4% and 20% potato flour + 80% CPSR with GL 6% + GX 0.6% had averages of strength significantly equal to the average of strength of the treatment with 100% wheat flour. For its part, the treatment with 10% potato flour + 90% CPSR with GL 6% + GX 0.6% had better performance in strength compared to the treatment with 100% wheat flour and all other treatments, as shown in Table 2.

Table 2. Multivariate analysis on the treatments for the formulations.

	Enhancers	Z_1 (10% PF + 90% WF)	Z_2 (20% PF + 80% WF)	Z_3 (30% PF + 7% WF)
Strength: W (10E-4J)	WG 4% + GX 0.2%	178.33 ± 2.08 ^{a}	152.00 ± 1.00 ^{a}	78.00 ± 1.73 ^{a}
	WG 4% + GX 0.4%	193.33 ± 1.15 ^{b}	180.67 ± 1.15 ^{b}	74.33 ± 2.08 ^{b}
	WG 4% + GX 0.6%	224.33 ± 0.58 ^{c}	223.33 ± 3.06 ^{c}	41.00 ± 1.00 ^{c}
	WG 6% + GX 0.2%	234.33 ± 4.04 ^{d}	206.67 ± 5.77 ^{d}	63.00 ± 1.00 ^{d}
	WG 6% + GX 0.4%	253.00 ± 1.00 ^{e}	248.67 ± 1.53 ^{e}	61.00 ± 1.00 ^{f}
	WG 6% + GX 0.6%	267.00 ± 4.58 ^{f}	254.67 ± 2.31 ^{e}	24.00 ± 1.00 ^{g}
	100% WF	252.00 ± 2.08 ^{e}	252.00 ± 2.08 ^{e}	252.00 ± 2.08 ^{e}
Tenacity: P (mmH_2O)	WG 4% + GX 0.2%	162.33 ± 0.58 ^{a}	124.33 ± 4.04 ^{a}	123.00 ± 2.65 ^{a}
	WG 4% + GX 0.4%	200.33 ± 0.58 ^{b}	122.33 ± 2.52 ^{b}	149.00 ± 1.00 ^{b}
	WG 4% + GX 0.6%	241.00 ± 1.00 ^{c}	142.67 ± 2.08 ^{c}	114.00 ± 1.00 ^{e}
	WG 6% + GX 0.2%	197.00 ± 1.00 ^{d}	171.00 ± 2.65 ^{d}	129.00 ± 1.00 ^{c}
	WG 6% + GX 0.4%	193.67 ± 0.58 ^{f}	140.00 ± 4.58 ^{f}	105.67 ± 4.04 ^{d}
	WG 6% + GX 0.6%	189.00 ± 2.65 ^{g}	244.00 ± 1.00 ^{g}	26.00 ± 5.29 ^{f}
	100% WF	118.67 ± 1.53 ^{e}	118.67 ± 1.53 ^{e}	118.67 ± 1.53 ^{e}
Extensibility: L (mm)	WG 4% + GX 0.2%	25.33 ± 0.58 ^{a}	33.33 ± 2.52 ^{a}	14.33 ± 0.58 ^{a}
	WG 4% + GX 0.4%	21.33 ± 0.58 ^{b}	50.67 ± 1.15 ^{b}	10.33 ± 0.58 ^{b}
	WG 4% + GX 0.6%	20.33 ± 0.58 ^{c}	53.00 ± 3.00 ^{c}	8.33 ± 0.58 ^{c}
	WG 6% + GX 0.2%	25.67 ± 1.53 ^{d}	34.67 ± 1.53 ^{d}	9.67 ± 0.58 ^{d}
	WG 6% + GX 0.4%	28.67 ± 0.58 ^{f}	45.33 ± 2.52 ^{f}	12.00 ± 1.00 ^{f}
	WG 6% + GX 0.6%	34.67 ± 0.58 ^{g}	22.67 ± 2.52 ^{g}	14.00 ± 1.00 ^{g}
	100% WF	71.33 ± 0.58 ^{e}	71.33 ± 0.58 ^{e}	71.33 ± 0.58 ^{e}

PF: potato flour; WF: wheat flour; WG: wheat gluten; XG: xanthan gum, n: determinations by treatments±standard deviation. Values with the same letters in the same column are significantly identical ($p \geq 0.05$).

3.3. Phase III: Dry Noodle Quality

The cooking properties are shown in Table 3. The water absorption and firing loss results obtained for all treatments are close to other investigations; the values reported for samples without substitution, 10% substitution, 20% substitution and 30% were 92.1–3.78%, 116.1–5.64%, 126.6–6.86% and 133.4–8.24% respectively, in general an increase in substitution increases water absorption and firing loss [12]. For dry noodles, the optimum cooking time has been determined by the disappearance of the white core; according to the results obtained, significant differences ($p \geq 0.05$). were found with respect to the control, being greater in the samples with substitution; however, according to similar studies, these are within an acceptable range of 13.6 to 16.2 min [11].

Table 3. Evaluation of noodles quality: cooking properties, antioxidant activity and color.

Type of Test	Control Sample	Treatment Z_1 WG 6% + XG 0.4%	Z_1 WG 6% + XG 0.6%	Z_2 WG 6% + XG 0.4%	Z_2 WG 6% + XG 0.6%
Optimum cooking time (min)	12.83 ± 0.29 ^{a}	15.00 ± 0.00 ^{b}	14.83 ± 0.29 ^{b}	14.17 ± 0.29 ^{c}	14.17 ± 0.29 ^{c}
Water absorption (%)	144.37 ± 0.52 ^{a}	162.42 ± 0.21 ^{b}	163.33 ± 0.87 ^{b}	156. 19 ± 0.25 ^{d}	150.38 ± 0.85 ^{c}
Cooking loss (g)	2.54 ± 0.01 ^{a}	2.09 ± 0.00 ^{b}	1.85 ± 0.08 ^{c}	2.69 ± 0.06 ^{a}	2.35 ± 0.09 ^{d}
Antioxidant activity (% inhibition)	HF: 5.87 ± 0.32 ^{a} HFO: 4.22 ± 0.10 ^{a}			HF: 9.73 ± 0.41 ^{b} HFO: 4.08 ± 0.12 ^{a}	

HF: hydrophilic fraction, HFO: hydrophobic fraction, n: determinations by treatments±standard deviation. Values with equal letters in the same row are significantly identical ($p \geq 0.05$).

Finally, significant differences ($p \geq 0.05$) were found in the antioxidant capacity of the control sample and the best Z_2 sample, which was higher by 1.66 times, indicating that substitution with native potato flour can improve the functional properties of the dried noodles.

4. Conclusions

The techno-functional properties and nutritional characteristics of PF, a good alternative substitute for cereals, could improve some quality characteristics, such as the nutritional, functional and technological characteristics of some finished products, such as dry noodles. Additionally, this could be a strategy for reduce dependence on the use of wheat flour.

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