Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias

Ciba

ISSN: 2007 - 9990

https://doi.org/10.23913/ciba.v10i20.109

Artículos científicos

Efecto de la adición de harina del hongo Pleurotus columbinus en la composición químico proximal y física de una pasta para la elaboración de sopas

Effect of the Addition of Flour of the Fungus Pleurotus Columbinus in the Proximal Chemical Composition and Physical of a Paste for the Preparation of Soups

Efeito da adição de farinha do fungo Pleurotus columbinus na composição proximal e físico-química de uma massa para preparo de sopas

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Resumen

Las sopas son uno de los alimentos más importantes para los mexicanos. Sin embargo, por su alto contenido de carbohidratos, poca fibra y proteína, se caracterizan por estar desbalanceadas nutrimentalmente. El hongo *Pleurotus* incrementa la calidad nutricional de los alimentos (sopa de vegetales, *snacks* y pan de caja, por ejemplo). Las pastas son de bajo valor biológico por carecer de lisina; en cambio, *Pleurotus columbinus* posee aminoácidos esenciales, por lo que, al elaborar una pasta en combinación con este hongo, se obtendría una mayor calidad nutricional. Este trabajo muestra que la proteína de las pastas se incrementó en porcentajes de 32.15 % hasta 79.27 %, no hubo cambio en las propiedades físicas (tiempo de cocimiento y absorción de agua), a excepción de la desintegración, que se incrementó de 6.4 % hasta 8.5 %. La harina del hongo incrementa la cantidad proteínica de la pasta, lo cual ayudaría a mejorar la alimentación de la población.

Palabras clave: calorías, hongos comestibles, nutrientes, proteínas.

Abstract

Soups are one of the most important foods for Mexicans. However, due to their high carbohydrate content, little fiber and protein, they are characterized by being nutritionally unbalanced. The *Pleurotus* fungus increases the nutritional quality of food (vegetable soup, snacks, and box bread, for example). Pasta is of low biological value because it lacks lysine; on the other hand, *Pleurotus columbinus* has essential amino acids, which is why, when making a pasta in combination with this fungus, a higher nutritional quality would be obtained. This work shows that the protein of the pasta increased in percentages from 32.15 % to 79.27 %, there was no change in the physical properties (cooking time and water absorption), except for disintegration, which increased from 6.4 % to 8.5 %. The flour of the fungus increases the protein amount of the pasta, which would help improve the diet of the population.

Keywords: calories, mushrooms, nutrients, proteins.

Resumo

As sopas são um dos alimentos mais importantes para os mexicanos. Porém, devido ao alto teor de carboidratos, pouca fibra e proteína, caracterizam-se por apresentarem desequilíbrio nutricional. O fungo Pleurotus aumenta a qualidade nutricional dos alimentos (sopa de legumes, salgadinhos e pão embalado, por exemplo). As pastas são de baixo valor biológico porque carecem de lisina; Por outro lado, Pleurotus columbinus possui aminoácidos essenciais, por isso, ao fazer uma pasta em combinação com este fungo, seria obtida uma qualidade nutricional superior. Este trabalho mostra que a proteína do macarrão aumentou em percentuais de 32,15% para 79,27%, não houve alteração nas propriedades físicas (tempo de cozimento e absorção de água), exceto para a desintegração, que passou de 6,4% para 8,5%. A farinha do fungo aumenta a quantidade de proteína da massa, o que ajudaria a melhorar a dieta alimentar da população.

Palavras-chave: calorias, cogumelos comestíveis, nutrientes, proteínas.

Fecha recepción: Diciembre 2020 **Fecha aceptación:** Julio 2021

Introduction

According to the report of the Food and Agriculture Organization of the United Nations [FAO], the Financial Institutions for Development [IFD], the United Nations Fund for Children [UNICEF], the World Food Program [WFP] and the World Health Organization [WHO] (2020), in the last five For years, hunger among the population has worsened: tens of millions of people have suffered from chronic malnutrition. In 2019, nearly 690 million people went hungry, 10 million more than in 2018. In fact, since 2014, 60 million people have joined the ranks of the hungry. Asia has the highest number of undernourished people (381 million), Africa is second (250 million), followed by Latin America and the Caribbean (48 million).

Unfortunately, people in low- and middle-income countries are highly dependent on food based on plant products and some derived from grains. These foods are characterized by having a low percentage of proteins and lacking essential amino acids such as lysine, methionine and tryptophan, which are essential for good physical and mental development in children and to maintain good performance in adults (FAO, IFD, Unicef, WFP and WHO, 2020).

In Mexico, a large percentage of the population largely consumes foods that, although they are usually cheap, or precisely because they are cheap, are quite caloric, made from cereals, roots, tubers and bananas, and in smaller quantities, foods expensive like meat and dairy (compared to vegetables that are safer for proper nutrition). In the particular case of Mexico, there is a decrease in the consumption of fruits and dairy products as the severity of food insecurity increases (FAO, IFD, Unicef, WFP and WHO, 2020)

However, recently, due to their variety in preparation and their low cost, soup pastas have become a classic in most Mexican homes (Cardinale et al., 2005; Laboratorio Profeco Reporta, 2017). According to the La Moderna pasta factory (October 1, 2019), the consumption of this food in Mexico is 3.2 kg per person per year.

As we well know, pasta provides a good amount of complex carbohydrates such as starch, which gives it a low glycemic value due to its slow absorption in the digestive tract. Furthermore, its protein is considered to be of low biological value due to its deficiency in lysine. And if that weren't enough, it has a low content of dietary fiber. In short, it is an unbalanced food (Araya, Park, Vera and Alviña, 2003). For this reason, various studies have been carried out aimed at improving the nutritional quality of pasta. One of them is that of Acosta (2007), who made pasta with semolina from different varieties of barley, because it provides a higher content of lysine compared to wheat semolina. While Astaíza, Ruiz and Elizalde (2010) made pasta from quinoa and carrot in different proportions with wheat semolina, thanks to which they obtained a product of higher nutritional quality and good acceptance. Thus, based on this formula, Astaíza et al. (2010) recorded an increase in protein and fiber and a notable decrease in carbohydrate content.

Another alternative that would improve the nutritional quality of pasta in particular, and in general of any other food, are edible mushrooms of the genus Pleurotus, since they are a good source of protein (11-42 g / 100 g) containing all the essential amino acids, including leucine, valine, lysine, isoleucine, threonine, tyrosine, methionine, and phenylalanine. They are rich in dietary fiber made up of chitin that varies between 11 and 31 g / 100g. They contain scarce lipids, they have essential fatty acids, such as oleic and linoleic acid; B vitamins, and with regard to minerals, phosphorus, potassium, iron, calcium, magnesium, manganese and copper have been found, as well as a low energy value. In addition, they have polysaccharides of 36 to 60 g / 100 g, including alpha and beta-glucans, which have been shown to have immunomodulating effects (Asaduzzaman and Mousumi, 2012; Rampinelli et al., 2010; Vega and Franco, 2012).

Pleurotus columbinus is cultivated in various regions of Mexico (Guzmán et al., 2008; Soto and Arias 2004) and is commercialized in supermarkets, markets and flea markets, so it has a very high potential to be used as a food fortifier, such as and as has been demonstrated with vegetable soup, snacks, cookies and box bread (Ghorai et al., 2009; Lavelli, Proserpio, Gallotti, Laureati and Pagliarini, 2018; Parab, Dhalagade, Sahoo and Ranveer, 2012; Proserpio, Lavelli , Laureati and Pagliarini, 2019; Ng, Wan Amir Nizam and Wan Rosli, 2017). Locally, Soto et al., (2005) carried out a study regarding its nutritional quality and found protein values of 29.93 g / 100 g., 15 essential amino acids, fiber 11.7 g / 100 g, lipids 1.43 g / 100 g and ash of 8.94 g / 100 g. Hence, in this work, the incorporation of flour from the fructifications of this fungus into a noodle-type soup paste is proposed, as it is a food popularly consumed by the majority of the population. The aim of this work is to obtain a food of better nutritional quality and more than anything protein that in the long run prevents diseases, such as cardiovascular disease, obesity, type two diabetes and cancer.

Materials and method

The present study was developed in the Laboratory for the Cultivation of Edible Mushrooms of the Department of Botany and Zoology of the University of Guadalajara. The pasta was made in accordance with the official Mexican standard NMX-F-023-NORMEX-2002 (Ministry of Economy, September 23, 2002), type III classification: wheat or semolina flour pasta with vegetables for soup (noodles) . And in this case, Pleurotus columbinus (HPc) flour was used.

The semolina (S) was provided by the company La Moderna, S. A. de C. V., from Zapopan, Jalisco. The fresh fructifications of P. columbinus were harvested from a maize stubble substrate, as described by Soto and Arias (2004). These were dehydrated in a wood dryer designed for this purpose, at a temperature of 40 ° C. Once dry, they were pulverized in a Cyclone Mill (Retsch Twister X 100) with a 0.3 mm sieve.

Both types of flour, S and HPc, underwent chemical-proximal analyzes in accordance with the provisions of the Official Association of Analytical Chemistry [AOAC, for its acronym in English] (1990). Said analyzes were carried out in the Bioengineering Laboratory of the Department of Cellulose Wood and Paper of the University of Guadalajara. The determinations of ash (AOAC 7-010 / 70), crude fiber (FC) and ether extract (EE) (AOAC 7-048 / 70) were made. Regarding crude protein (PC), the Microkjeldahl method (AOAC 42-

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014 / 70) was used. The total nitrogen value obtained was multiplied by the correction factor of 5.75, in the case of S, and for the HPc the correction factor of N × 4.38 was used (Lau, 1983; Soto, Serratos, Ruiz and García, 2005). The nitrogen-free extract (ELN) was determined by the difference between the total solids and the sum of the previous determinations. Finally, the kcal / 100 of each ingredient of S were calculated: PC × 4, ELN × 4 and EE × 9. In the case of HPc, the factors proposed by Mattila, Salo, Konko, Aro y Jalava (2002): PC × 2.62, EE × 8.37 y ELN × 3.48.

The pastes were made in the following proportions (S: Pc): 100: 00, 90:10, 85:15, 80:20 and 70:30. The flours were stirred by hand until a homogeneous mixture was obtained. Subsequently, drinking water was added to each sample until obtaining a mass with the adequate consistency of kneading. Kneading was carried out manually and the mass obtained was left to rest at room temperature for about 50 minutes. Using an Olimpia Luso model 150 machine, the dough was shaped into a laminar shape until a sheet thickness of ± 1 mm was obtained, characteristic of a noodle. Said sheet was cut with the help of a roller with blades belonging to the machine to obtain the final noodles.

The drying of the noodles was carried out in three stages with the aim of reducing the moisture content to less than 12%. The first step consisted of pre-drying during which the noodles were kept for two hours at a temperature between 30 and 40 ° C, in order to reduce the microbiological or enzymatic activity, harden the peripheral gluten, fortify the structure of the pasta and reduce the time of the final drying period.

The next step was pasteurization: the noodles were kept at 60 ° C for 30 minutes. The objective of this stage was to achieve a moisture balance between the interior of the paste and its surface, since in pre-drying the moisture moves away from the interior of the paste through the capillaries in the same proportion in which the moisture evaporates of the surface, but then this proportion decreases and the humidity begins to concentrate around the center of the pasta, which makes it necessary to balance the interior and exterior humidity.

The final drying stage was at a temperature between 45 and 55 ° C for four hours. During this period, an attempt was made to eliminate as much water as possible to obtain a product with a maximum of 12% humidity. Finally, the paste was left at room temperature for 12 h, to later be packed in polypropylene bags for use in the following analyzes. It is considered that approximately half of the water is absorbed by the protein. The latter is more difficult to remove, hence the long drying periods.

Representative samples of the pastes were taken, which were pulverized with the help of an electric mill to allow the passage of the pulverized through a 1 mm sieve. Subsequently, the following determinations were made: ash, FC, EE, PC and ELN, according to the methods described above. Likewise, the analysis was carried out on a commercial pasta (Rex) type noodle, without egg, as a control. Once the determinations were obtained, the energy content was calculated as previously described.

The physical properties of a pasta make it possible to define its characteristics to establish a quality judgment, so the following physical analyzes were carried out on the noodles, following here Acosta (2007):

- Volume of raw pasta: 100 g of sample was weighed and placed in a fine mesh cylinder, which was introduced into a 1000 ml cylinder with approximately 800 ml of water and the dislodged liquid was measured.
- Cooking time: to one liter of boiling water, 100 g of sample and 10 g of sodium chloride were added and the time required for cooking the pasta was measured.
- Weight of the cooked pasta: once the cooking time had been obtained, the pasta was drained for 10 minutes using a funnel and then weighed wet.
- Degree of water absorption: it is the difference obtained between the weight of cooked pasta and the weight of raw pasta, a minimum increase of 150 g was established.
- Volume in cooked pasta: as for the volume in raw pasta, the cooked pasta was placed in a fine mesh cylinder, placed in a 1000 ml measuring cylinder with 800 ml of water and the increase in water volume was measured .
- Percentage of increase in cooked pasta with respect to raw pasta: for this determination the following calculation was made: $V1 - V2 / V2 \times 100$, where: $V1$ = volume of cooked pasta and $V2$ = volume of raw pasta

The percentage of sedimentation or disintegration was carried out with 100 g of pasta, which was cooked in 1000 ml of water for 10 minutes, the liquid was drained and the paste was placed in a 1000 ml cylinder. The sediment formed was measured in milliliters and calculated as a percentage. A maximum of 20% sedimentation was established.

Experimental design

In all cases, a completely randomized design was followed with a 6 × 6 arrangement with three replications for the treatments. Thus, six types of pasta and six nutritional determinations were considered. A single factor analysis of variance (Anova) was applied to the results to determine if there were significant statistical differences. For the separation of groups, the Tukey test was used with a $p < 0.05$ and 95% confidence level.

Results and Discussion

Proximal chemical analysis

The proximal chemical analyzes carried out on the raw materials for the preparation of the pasta in this study, S and HPc, are presented in table 1. The PC that was determined for the S was 11.34% and for the flour of the fungus it was 30.1 %. The EE with 0.93 and 1.8% for S and HPc, respectively. The FC found in the S was 0.26% and 10.4% in the mushroom flour. The percentage of ashes in the S corresponded to 0.6% and for the HPc 10%. Finally, the nitrogen-free extract found in the S is 86.87% and 47.7% in the HPc. It should be noted that table 1 also presents the data obtained in the commercial Rex paste used as a control.

Tabla 1. Análisis químico proximal de los ingredientes utilizados para hacer los tallarines y comparados con una pasta comercial. Valores promedio ($N = 9$)

Nutrimento (%)	Semolina	Harina de *P. columbinus*	Pasta comercial (Rex)
Proteína cruda	11.34	30.1	9.61
Extracto etéreo	0.93	1.8	1.66
Fibra cruda	0.26	10.4	0.09
Cenizas	0.6	10	0.8
Extracto libre de nitrógeno	86.87	47.7	87.84
Kcal/100	401.21	260	404.74

Fuente: Elaboración propia

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Table 2, on the other hand, shows the results obtained from the proximal chemical analyzes of the noodles made based on the mixtures of S and HPc, as well as those determined in a commercial pasta (Rex) type noodle, without egg. There it is observed that, as the amount of HPc increases, the amount of PC increases: from 10.95% (S) to 19.63% with the 70:30 mixture (+79.27%) ($p > 0.05$). Likewise, it should be noted that the energy content was very similar in the mixtures with the control sample.

Tabla 2. Se muestran los análisis de las diferentes proporciones de las mezclas de S y H*Pc*, así como la pasta control y el testigo comercial. Valores promedio ($N = 18$)

		Proporciones: S:H*Pc*				
Nutrimento %	Pasta Rex	S	90:10	85:15	80:20	70:30
Proteína cruda ($N \times 5.76$)	9.61^{e}	10.95^{d}	14.47^{c}	16.70^{b}	17.50^{b}	19.63^{a}
Extracto etéreo	1.66^{ns}	0.90^{ns}	1.06^{ns}	1.05^{ns}	1.16^{ns}	1.26^{ns}
Fibra cruda	0.09^{b}	0.20^{a}	0.093^{b}	0.21^{a}	0.21^{a}	0.21^{a}
Cenizas	0.80^{d}	0.65^{d}	2.33^{c}	2.75^{b}	2.86^{b}	3.06^{a}
Extracto libre de nitrógeno	87.84^{d}	87.3^{d}	82.04^{c}	79.29^{b}	78.30^{b}	75.84^{a}
Kcal/100	404.74^{ns}	401.1^{ns}	395.58^{ns}	389.33^{ns}	383.8^{ns}	393.22^{ns}
Nota: letras distintas en la misma fila indican diferencias estadísticamente significativas.						

Fuente: Elaboración propia

Figure 1 indicates the percentages of CP found in each of the mixtures. In the 90:10 mix, it was 14.47%; in that of 85:15, 16.70%; at 80:20, 17.50%, and at 70:30, 19.63%. The pasta made only with S had a PC percentage of 10.95% and the commercial pasta had a value of 9.61%. Soup pastas generally have around 10-15% crude protein. With the addition of the flour of the fungus, a considerable increase in the protein content of the pasta was observed: from 32.15% to 79.27% in the proportion 90:10 and 70:30, respectively. If it is taken into

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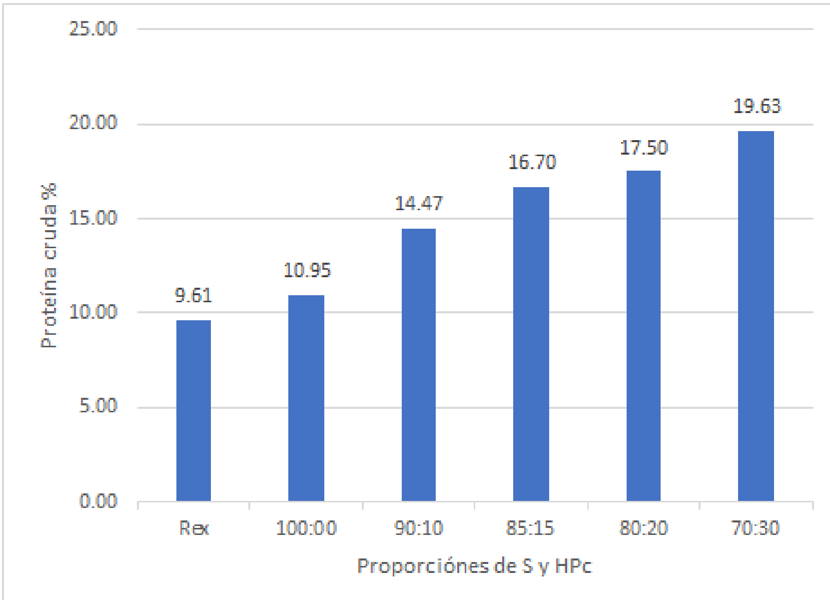
account that an adult requires a daily consumption of 75 g of protein (Serralda, Meléndez & Pasquetti, 2003), a diet with HPc-fortified pasta could cover 50% to 100% of the daily requirements. On the other hand, it is proven that most cereals, and particularly wheat, are deficient in the amino acid lysine, so the addition of HPc to soup pasta would substantially increase the content of this and other amino acids. (Soto *et al*., 2005).

Figura 1. Se esquematizan los resultados de PC encontrados en las mezclas de S y H*Pc*. Se observa un incremento marcado cuando se añade más harina de hongos



Fuente: Elaboración propia

With the protein data that was determined in all samples, a positive correlation was found between the addition of HPc and the amount of protein obtained, as shown in Figure 2.

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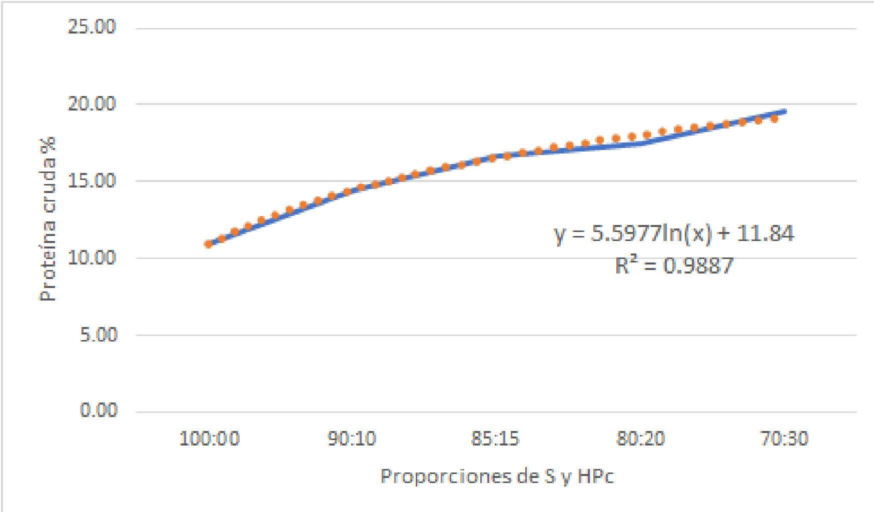
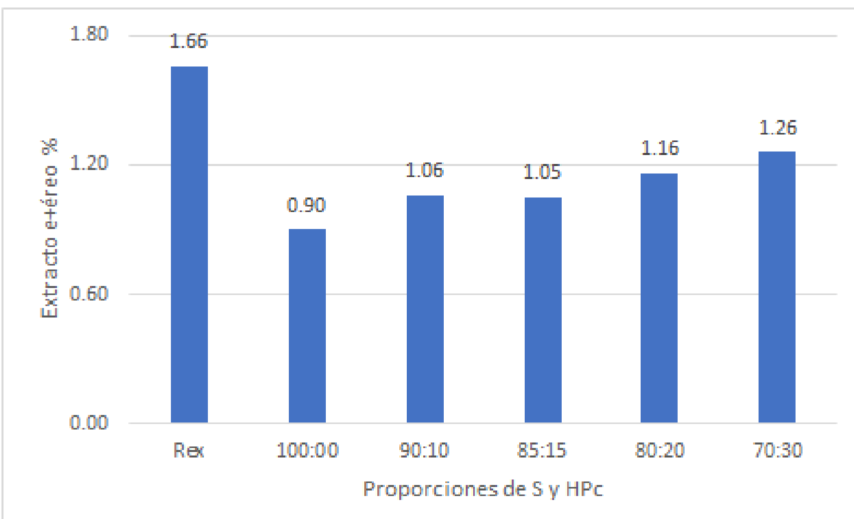
Figura 2. Indica la relación positiva que tiene la adición de H*Pc* a la S para el incremento de la proteína de las pastas elaboradas con estos ingredientes



Fuente: Elaboración propia

The determination of EE of the pastes is observed in figure 3. In general, the percentages obtained ranged between 1.26% and 1.05% for all the mixtures of S and HPc. Commercial pulp and S pulp had 1.66% and 0.9%, respectively. The EE in the mixtures was determined in a range of 1.06% (90:10) and 1.26% (70:30).

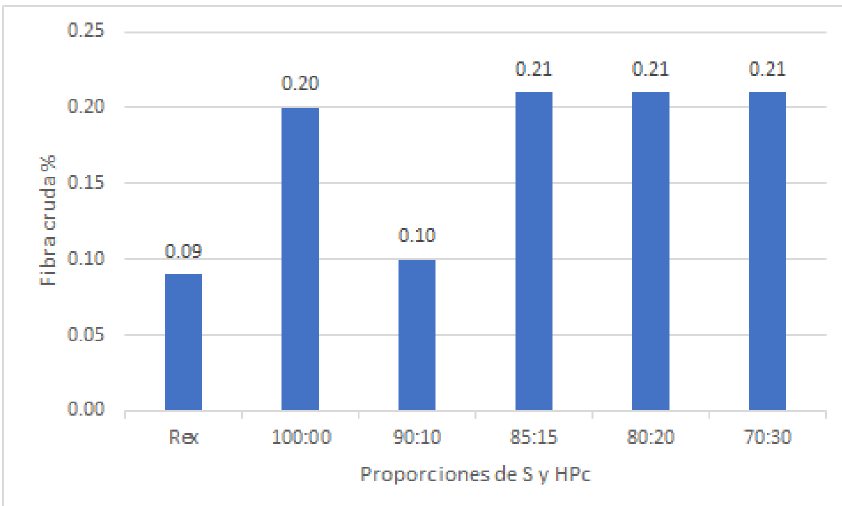
Figura 3. Los valores de EE permanecieron sin mucha alteración comparados con la pasta Rex y la S



Fuente: Elaboración propia

Regarding the FC content in the 90:10 mixture, it was 0.10%; in the remaining samples (85:15, 80:20 and 70:30) of 0.21%. In the pasta made with S it was 0.2% and the commercial pasta 0.09% (figure 4). Regarding the crude fiber content, the pasta made from 100% S and the commercial pasta had very low values, 0.09%, not the pasta made with mixtures of the flours, whose value was statistically different with 0.21%.

Figura 4. Se indican las determinaciones para el contenido de FC. Los valores fueron muy semejantes entre la muestra testigo y la S, pero diferentes en relación con las pastas adicionadas con harina del hongo

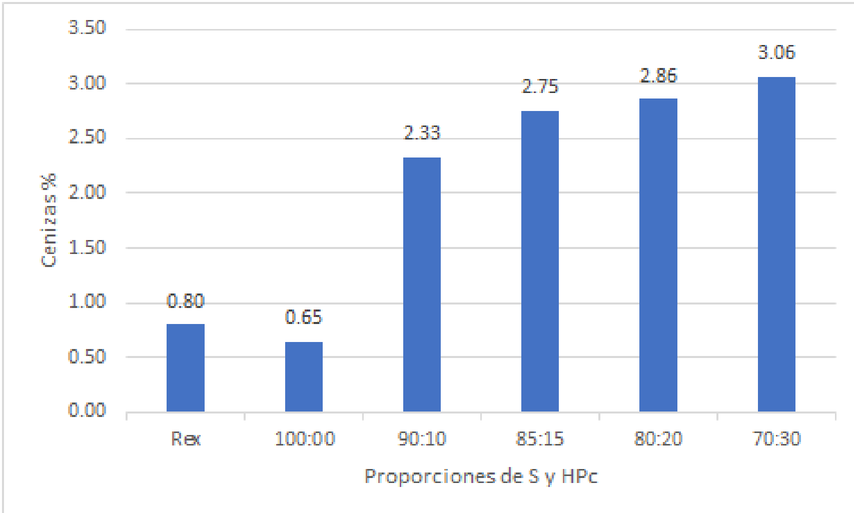


Fuente; Elaboración propia

The percentages of ashes determined in the samples are shown in Figure 5. In general, percentages of around 2.33% and 3.06% were found in the mixtures. In the 90:10 paste, the percentage was 2.33%; at 85:15, from 2.75%; in 80:20, of 2.86%, and of 3.06% in the proportion 70:30. In the pasta made with S a value of 0.65% was obtained and in the commercial pasta of 0.8%. It was found that HPc increases the amount of ash (258.2% to 371%) as it mixes with S.

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
ISSN: 2007 - 9990

Figura 5. Las cenizas tuvieron un aumento en las pastas elaboradas con H*Pc* en relación con la pasta Rex y de S



Fuente: Elaboración propia

The ELN had high values in all the samples studied. Figure 6 shows these results. In the 90:10 mixture, a percentage of 82.04% was obtained. With the mixture of 85:15, 79.29% was found. In the 80:20, 78.3% and 75.84% in the 70:30. In the S pulp it was a percentage of 87.3% and with the commercial pulp it was determined 87.84%. However, the ELN content decreased (-14.10%) as the inclusion of the fungus flour increased. This can be important from a nutritional point of view, since this decrease in carbohydrates represents a decrease in calories, which is beneficial for a better use of proteins.

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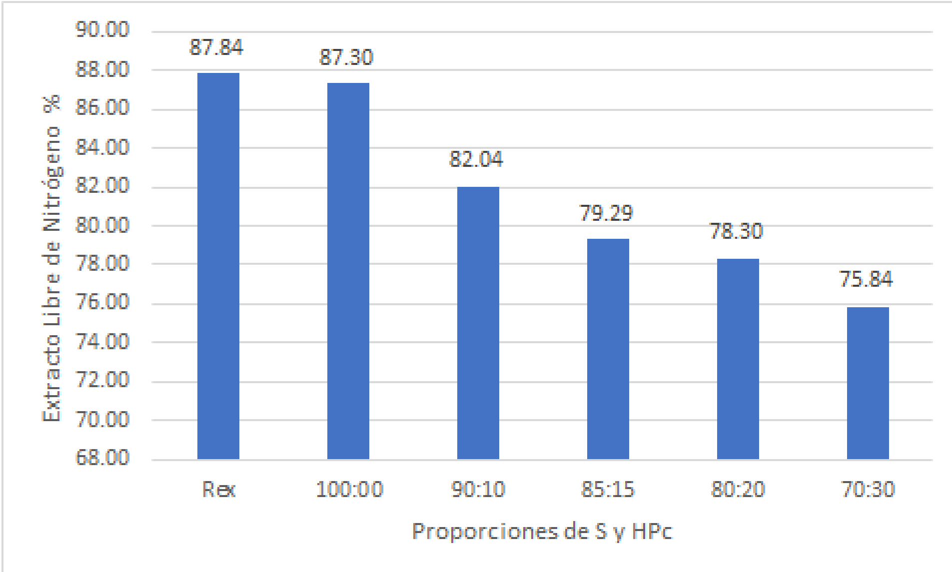
Figura 6. El ELN en las pastas Rex y semolina poseen un mayor porcentaje de solubles que las elaboradas con H*Pc*



Fuente: Elaboración propia

Physical tests

Table 3 shows the weight of the pasta once it was cooked for 10 minutes in boiling water. The pasta made with 100% S had a final weight of 230 g, which indicates that it absorbed 130 g of water and a weight increase of 2.3 times. The commercial Rex paste weighed 249 g, of which 149 g corresponded to absorbed water, that is, an increase of 2.49 times. The pasta made based on S and HPc had a lower water absorption, for example, the mixture 90:10 and 85:15 had a weight of 180 g, which indicates a water retention in the cooked pasta of 80 g (1.8 times). The 80:20 mixture in cooked pasta weighed 187 g, of which 87 g corresponded to absorbed water (1.87 times). The 70:30 ratio in cooked pasta weighed 193 g, where 93 g were absorbed water, with a 1.93-fold increase in weight. According to the quality standards of pasta for soups, the flour of the mushroom did not affect the cooking time, since, in general, only 10 minutes were enough for the softening of the pasta. The same cooking time was observed with pasta made with pure S and commercial pasta.

For a pasta to be considered of good quality, it needs to increase twice its weight once cooked. Table 3 shows that only S and commercial pasta increased twice in weight; none of the pasta made with the flour mixtures doubled its weight, although their difference is only 0.20 and 0.07 units, so this lack was considered insignificant.

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Regarding the degree of water absorption (table 3), the pasta made with the flour mixtures had a lower absorption in relation to those of S and the commercial pasta. However, neither S nor commercial pasta reached the minimum quantity of 150 g, as established by official standards. In this aspect, the flour of the fungus does negatively affect the absorption of water.

Tabla 3. Se indica el aumento de peso de la pasta cocida en relación con la pasta cruda, así como el agua absorbida. Valores promedio (*N* = 15)

Pasta S:H*Pc*	Peso en pasta cruda (g)	Peso en pasta cocida (g)	Aumento de peso (g)	Tiempo de cocción (min)	Agua absorbida (g)
100:00	100	230 [b]	2.30	10	130 [a]
90:10	100	180 [d]	1.80	10	80 [d]
85:15	100	180 [d]	1.80	10	80 [d]
80:20	100	187 [cd]	1.87	10	87 [cd]
70:30	100	193 [c]	1.93	10	93 [c]
Rex	100	249 [a]	2.49	10	149 [b]
Nota: letras distintas en la misma columna muestran diferencias estadísticamente significativas.					

Fuente: Elaboración propia

As for the increase in volume that is considered as a norm, it should be three to four times the original. Table 4 shows the increase in volume of raw pasta with respect to cooked pasta. None of the pasta made with flour mixtures achieved this increase. Similarly, S pulp and commercial pulp did not get that volume. The latter only lacked 0.20 units.

Another factor that is considered important in the quality of a paste is the amount of sedimentation or disintegration which, according to the regulations, is set at a maximum of 20%. In table 4 it can be seen that in none of the cases is the permitted limit exceeded, although, as the amount of HPc in the mixture was increased, the percentage of sediment increased.

It should be noted that there are commercial soup pastes to which some type of adhesive is added to keep the level of disintegration low, such as, for example, egg white. In the case of the pastes in this study, no additives were added, so it would be convenient to use one of them to eliminate this problem.

Table 4 shows the results in relation to the volume in raw pasta, cooked pasta and the percentage of increase, as well as the percentage of disintegration of the pasta under study. The pasta made with 100% S had a percentage increase of 137.5%; however, the commercial pasta had it of 182%. In the S and HPc mixes, the percentage increase in the 90:10 mix was 114.2% and in the 85:15 mix it was 106.2%. The 80:20 and 70:30 mixes had the same 112.5 percent increase.

Regarding the percentage of sedimentation or disintegration of the pulps, it was found that the S pulp and the commercial pulp show about 5% disintegration. The pastes with flour mixtures presented a higher percentage of disintegration, from 6.4% to 8.5%, as the amount of HPc increased.

Tabla 4. Se muestran los resultados del aumento de volumen de la pasta cruda y la cocida, así como el porcentaje de sedimentación. Valores promedio (*N* = 15)

Pasta S:H*Pc*	Volumen (100 g) pasta cruda (mL)	Volumen pasta cocida (mL)	Aumento de volumen (veces)	Aumento (%)	Sedimentos (%)
100:00	80	190 ^{b}	2.4	137.5	5 ^{e}
90:10	70	150 ^{d}	2.1	114.2	6.4 ^{cd}
85:15	80	165 ^{c}	2.0	106.2	6.8 ^{bc}
80:20	80	170 ^{c}	2.1	112.5	7.5 ^{ab}
70:30	80	170 ^{c}	2.1	112.5	8.5 ^{a}
Rex	78	220 ^{a}	2.8	182	5.5 ^{de}
Nota: letras distintas en la misma columna muestran diferencias estadísticamente significativas					

Fuente: Elaboración propia

An aspect that was not mentioned in the results, but that must be taken into account, is the color change of the pastes. S and commercial pastes are yellowish white; On the other hand, the pastes made with S and HPc gradually, as the inclusion percentage increases,

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change from yellowish white to light brown. Said color change could affect the acceptability and preference of these pastas in people's taste, therefore, as a follow-up to this study, it would be convenient to carry out sensory analyzes and studies of acceptability of these noodles. Said studies would entail making protein isolates from the fungi, to include them in the pastes, as well as previously decolorizing and deodorizing the HPc.

Conclusion

It can be said that HPc increases the percentage of protein in pasta in relation to those made with semolina. Likewise, the FC, ELN and ash have a significant increase. The lipids and kilocalories did not show changes in relation to the control and the control. On the other hand, the physical properties are little altered in relation to commercial pastes, with the exception of the color change as the percentage of inclusion of HPc increases. Acceptability studies are necessary.

Future lines of research

Edible Pleurotus mushrooms have potential as food fortifiers, so it is essential to continue with this study regarding the nutritional quality of soups added with flour from this fungus. The next and short-term step is to determine the essential amino acids that were integrated into this pasta. In addition, a sensory study is necessary to determine the degree of acceptability of this food, taking as a starting point the color change of the pasta. On the other hand, seek to link this product to the pasta production industry in order to be able to offer this idea.

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