



CARACTERIZACIÓN DEL ESPASMOGÉNICO OBTENIDO A PARTIR DE TUNA: INFLUENCIA DEL PROCESO DE SECADO

CHARACTERIZATION OF THE SPASMOGENIC OBTAINED FROM TUNA: INFLUENCE OF THE DRYING PROCESS

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RESUMEN

El uso de aditivos naturales en la industria alimentaria ha cobrado relevancia debido a la creciente demanda de productos más saludables y sostenibles. Este estudio se centró en la caracterización de un espesante natural obtenido a partir de *Opuntia ficus-indica* (tuna), evaluando la influencia del proceso de secado y el uso de solventes en su extracción. Se utilizaron tres variedades de cactáceas: *Echinopsis pachanoi* (San Pedro), *Neoraimondia arequipensis* (Ulluquite) y *Opuntia ficus-indica* (tuna), sometidas a diferentes temperaturas de secado. El etanol se seleccionó como solvente principal debido a su alta efectividad en la extracción de pectina, logrando un rendimiento de 1.5166 g por cada 300 g de tuna procesada. Los resultados mostraron que la temperatura de secado de 40°C durante 70 minutos preservó mejor las propiedades bioactivas del espesante, mientras que temperaturas más altas degradaron la pectina. El pH del espesante fue de 6.68, lo que demuestra que el uso de etanol no afectó negativamente las propiedades químicas del producto. En comparación, las variedades *Echinopsis pachanoi* y *Neoraimondia arequipensis* presentaron menores rendimientos. Este trabajo concluye que el etanol es el solvente más adecuado para la extracción de pectina de *Opuntia ficus-indica*, y que el secado a temperaturas moderadas es clave para preservar las propiedades funcionales del espesante, ofreciendo una alternativa y eficiente a los espesantes sintéticos, contribuyendo al desarrollo de productos más naturales y saludables. La implementación de estos procesos puede mejorar la competitividad de las empresas alimentarias que buscan innovar en sus formulaciones utilizando ingredientes de origen vegetal con beneficios funcionales y tecnológicos.



Palabras clave

Espesante, cactácea, natural, métodos

ABSTRACT

The use of natural additives in the food industry has gained relevance due to the growing demand for healthier and more sustainable products. This study focused on the characterization of a natural thickener obtained from *Opuntia ficus-indica* (prickly pear), evaluating the influence of the drying process and the use of solvents in its extraction. Three varieties of cacti were used: *Echinopsis pachanoi* (San Pedro), *Neoraimondia arequipensis* (Ulluquite) and *Opuntia ficus-indica* (prickly pear), subjected to different drying temperatures. Ethanol was selected as the main solvent due to its high effectiveness in pectin extraction, achieving a yield of 1.5166 g per 300 g of processed prickly pear. The results showed that the drying temperature of 40°C for 70 minutes best preserved the bioactive properties of the thickener, while higher temperatures degraded the pectin. The pH of the thickener was 6.68, showing that the use of ethanol did not negatively affect the chemical properties of the product. In comparison, the varieties *Echinopsis pachanoi* and *Neoraimondia arequipensis* presented lower yields. This work concludes that ethanol is the most suitable solvent for the extraction of pectin from *Opuntia ficus-indica*, and that drying at moderate temperatures is key to preserve the functional properties of the thickener, offering a viable and efficient alternative to synthetic thickeners, contributing to the development of more natural and healthy products. The implementation of these processes can improve the competitiveness of food companies seeking to innovate in their formulations using plant-based ingredients with functional and technological benefits.

Keywords

Thickener, cactus, natural, methods

INTRODUCTION

The use of food additives is an essential practice in modern industry, since they allow modifying and improving the sensory and technological properties of foods. One of the most important additives in this category are thickeners, which can come from both natural and synthetic sources. Thickeners are responsible for providing specific textures to a wide variety of products, adjusting their viscosity and solubility depending on the proportions used. Among the most prominent natural thickeners are pectins, which are commonly extracted from plant tissues and used in the formulation of products such as jams, sauces and dressings (1).

The food industry seeks natural additives such as thickeners to improve the sensory and technical properties of products. Among them, the nopal (*Opuntia ficus-indica*) stands out for its potential due to its low cost and high content of bioactive compounds. The process to achieve this thickening involves the operation of the unit, with drying being the most important as it affects the quality of the final product. This study investigated



the acid removal efficiency of cactus solutions and the effect of yield, pH, solubility and drying on thickener quality.

The growing demand for more natural and healthy foods has highlighted the importance of developing food additives that not only meet technological requirements, but are also sustainable and safe for human consumption. In this context, special attention has been paid to cacti, specifically prickly pear (*Opuntia ficus-indica*), as a viable source for obtaining natural thickeners. The prickly pear is a plant that has shown great potential due to its abundance, low production cost and the amount of bioactive compounds present in its tissues, which can be used for the food industry (2).

The process of obtaining thickeners from prickly pear, as with other plant products, involves various unit operations. One of the most critical factors in this process is drying, since time and temperature conditions have a significant impact on the final quality of the product. Although drying at elevated temperatures can accelerate the extraction process, there is a risk that poor management of these parameters will lead to the loss of the thickening properties of the product (3).

The food industry has focused on the development of additives that improve the organoleptic and technological properties of food products, and thickeners play a fundamental role in this task. Traditionally, synthetic thickeners have dominated the market, due to their relatively low cost and effectiveness in improving texture. However, the long-term use of synthetic thickeners has raised concerns among both consumers and food safety experts, as some studies suggest that their excessive consumption may be linked to decreased nutritional quality of foods (4).

Faced with this problem, natural thickeners, derived from plant sources, have emerged as a viable and healthier alternative. Prickly pear, in particular, has been widely investigated for its nutritional properties and its ability to produce polysaccharides with high thickening power (5). The drying process is a key step in obtaining these compounds, since it allows solids to be concentrated and humidity reduced, obtaining a thick powder with functional properties that can be used in various food applications.

Despite the advances in the use of prickly pear as a source of natural thickeners, there are important challenges associated with controlling the drying process. The relationship between drying time and temperature is essential to ensure that the final product maintains its technological and functional properties. If drying conditions are not adequate, there is a risk that the thickening properties of the product will be compromised. This study seeks to investigate how different drying conditions influence the quality of the thickener obtained from prickly pear (6).

The general objective of this study is to analyze the efficiency of the acid extraction method with the use of different solvents in obtaining thickeners from cacti, specifically from the variety *Opuntia Ficus* (prickly pear). The aim is to evaluate the yields, pH, and solubility properties of the thickener obtained. Among the specific objectives, it is proposed to determine the extraction yields using ethanol as a solvent, in comparison with other solvents, for three varieties of cacti: *Echinopsis pachanoi* (San Pedro), *Neoraimondia arequipensis* (Ulluquite), and *Opuntia Ficus* (prickly pear). In addition, it is intended to evaluate the influence of ethanol on the pH of the thickener, analyzing



how this solvent impacts its chemical properties. On the other hand, the effect of temperature and drying time on the quality of the thickener will be investigated, particularly on its solubility and gelatinization capacity, essential to guarantee its application in the food industry.

MATERIALS AND METHODS

This study was based on an applied research that included a literature review and the execution of experimental processes with the objective of obtaining a thickener from prickly pear (*Opuntia ficus-indica*), varying the time and temperature conditions to evaluate the quality and quantity of extracted pectin. The procedures carried out are described below.

Raw material

The raw material used was the fruit of the prickly pear, sold in the markets of the city of Riobamba, Ecuador. Fruits were selected in optimal ripening conditions and without visible damage to guarantee the quality of the final product.

Sample preparation

The prickly pear fruits were subjected to a washing process to eliminate impurities and residues, followed by manual selection to ensure the homogeneity of the material. Subsequently, the fruits were cut into 4 mm thick slices to facilitate the dehydration process (7).

Drying

The drying of the prickly pear slices was carried out with three different treatments to evaluate the best performance in obtaining pectin:

T1: Drying at 90 °C for 15 minutes

T2: Drying at 65 °C for 30 minutes

T3: Drying at 40 °C for 70 minutes (8).

The drying process was essential to reduce the moisture content of the fruit and prepare the sample for pectin extraction. After drying, the sheets were processed in a mill until obtaining a fine powder, which was used in the subsequent stages of the research (9).

Pectin extraction

Pectin extraction was carried out in the food science laboratory of the Faculty of Livestock Sciences (FCP) of the Higher Polytechnic School of Chimborazo (ESPOCH), following the AOAC 923.03 method. This method is suitable for the extraction of pectin from plant matter, and was used to ensure the quality and consistency of the final product (10).



The powder obtained from the grinding process was subjected to acid hydrolysis using 0.1 N citric acid at a temperature of 90 °C for 90 minutes. The pectin was then precipitated using 96% ethanol, as described in the relevant literature.

Thickener characterization

To evaluate the quality of the thickener obtained, instrumental tests were carried out that included the measurement of the pH and the thickening capacity of the final product. The pH was measured using a potentiometer, following the quality standards described in previous studies. The results showed that the thickener obtained from prickly pear with ethanol had an average pH of 6.68 ± 0.03 (11).

To carry out the measurements and analyzes that appear in the table of cactus extraction yields, the following methods and instruments could have been used:

- **Analytical balance:** It was used to measure the precise amounts of stalk (g), solvent (mL), filtered solution (g) and the catalyzed thickener (g). It is essential to ensure precision in the weights of the solids and liquids involved.
- **Liquid chromatography:** This instrumental method could have been used to verify the composition of the extracted components, such as the purity of pectin in the thickener obtained, or to separate different components present in the final solution.
- **Potentiometer:** This instrument would be essential to measure the pH of solutions during or after the extraction process, especially if an acidic solvent or ethanol is being used, which can alter the pH of the final product.
- **Refractometer:** Could have been used to measure the concentration of soluble solids in the filtered solution before precipitation of the thickener, providing information on the density of the dissolved solids.
- **UV-Visible Spectrophotometry:** This instrument could have been used to analyze the concentration of pectins or other soluble components in the filtered solution. Helps determine the presence of specific compounds based on light absorption.
- **Desiccator with temperature control:** It would have been used for the precise drying of the stalks and the products obtained, controlling temperature variations during the dehydration process (12).

RESULTS

The results based on the yields obtained through the acid extraction method are shown in Table 1, following a detailed process that is based on the use of different solvents, it was obtained thanks to the drying and solvent solution to obtain pectin having an estimated $0.6546 \pm 0.0246\%$ extracted with ethanol, according to (10) this method is the one with the best performance, after having gone through grinding and being sieved on



a mesh #325, yields of 2.5% are obtained for the variety (*Opuntia Ficus*) prickly pear, however this solvent extraction method allows us to largely eliminate some components of the stalks or cladodes of cacti, hence the yield achieved in this research is lower than the process carried out in the bibliographic review, it should be noted that the use of different solvents can lead to an increase or decrease in the obtaining of pectin since this is a factor that must generally be carried out. in the processing and grinding of raw materials.

Table 1. Cactus extraction yields

Variety	Penca (g)	Filtered juice (mL)	Solvent (mL)	Filtered Solution (g)	Catalyzed thickener (g)			%Yield (g of thickener/g of cactus)		
					R1	R2	R3	x	±	Yes
Solvent					Ethanol					
<i>Echinopsis pachanoi</i> (San Pedro)	300	300	600	300	0.7560	0.8236	0.7702	0.2602	±	0.0128
<i>Neoraimondia arequipensis</i> (Ullquite)	300	300	600	320	0.4511	0.5230	0.4333	0.1564	±	0.0158
<i>Opuntia Ficus</i> (Prickly Pear)	300	300	60	300	1.5166	1.6203	1.5827	0.5244	±	0.0175

In relation to these yields we must take into account that in a certain way the solvent solution in this case ethanol presents better results, since when going through the optimal sieving process the raw material was better used, for the variety proposed in this research, it presents significant differences with regard to the use of different solvents taking into account certain considerations such as sieving and drying at different times and temperatures (13).

For the definition and assessment of the pH, the lowest values were taken into account, unlike the other cacti, taking into account that with the use of ethanol in the extraction of the prickly pear thickener, the following data were taken as a reference (14).

Table 2. Estimated pH of the prickly pear-based thickener using ethanol

Thickener pH			
Solvent	Opuntia Ficus (Prickly Pear)		
Ethanol	x	±	Yes
	6.68	±	0.03

Taking into consideration the measurement parameters since solvents such as water were also used, however, this did not provide the specific requirements for each prickly pear sample, determining in the same way that the use of ethanol as a solvent is the best alternative for this type of procedure.



One of the factors that must be taken into account is the solubility temperature according to (15), gelatinization is due to the starch content in the thickener naturally, however the extraction procedure is ruled out since this solubility temperature is natural, that is, it is based on the natural composition of the starch itself, in this case derived from prickly pear, thus referring to the internal collapse of the granules when subjected to heat in the presence of water (16).

DISCUSSION

The present study on the characterization of the thickener obtained from *Opuntia ficus-indica* (prickly pear) revealed significant observations related to the optimal drying conditions and the effectiveness of ethanol as a solvent in pectin extraction. These results not only confirm previous findings on the use of ethanol, but also provide new knowledge about the influence of drying time and temperature on the quality of the thickener obtained.

One of the key aspects of this study was the choice of ethanol as a solvent. The yield obtained, 1.5166 g of thickener per 300 g of processed prickly pear, is consistent with previous research that indicates ethanol as the most effective solvent for pectin extraction. (17), for example, observed that ethanol was superior to other solvents such as water and methanol in the extraction of pectin from gulupa shell, confirming its ability to precipitate pectins more efficiently than other solvents. This behavior can be explained by the ability of ethanol to dehydrate pectin compounds, facilitating their recovery at high concentrations.

In comparison with other studies, such as that of (18), who evaluated the extraction of pectin from orange peels using methanol, it was found that, although methanol has a certain degree of efficiency, the yields obtained with ethanol are significantly higher, which reaffirms the value of ethanol in this type of processes. This finding is also consistent with the results obtained by Sabir et al. (19), who pointed out that ethanol is ideal for preserving the bioactive properties of pectin and reducing the presence of impurities during the extraction process.

Another fundamental factor that was investigated was the effect of drying temperature on the quality of the thickener. In our study, the ideal drying temperature to obtain a high-quality thickener was 40°C for 70 minutes. Although higher temperatures could accelerate the drying process, temperatures above 65°C for prolonged periods were observed to negatively affect the structural and functional integrity of pectin. This finding is supported by previous studies that indicate that the bioactive properties of plant extracts must be preserved by moderate temperatures to avoid the degradation of polysaccharides (20).

The study of (21), which explored the different types of food thickeners and critical processing parameters, emphasized that maintaining controlled temperature conditions is crucial to ensure the quality of the final product. This aspect is particularly important in the case of pectins, since excessive temperatures can destroy the structures of the polysaccharides, reducing their thickening capacity. Likewise, in studies related to the extraction of pectins from other plant sources, such as guava and carrot, it was also



concluded that higher temperatures affect the functionality of the extracted products (22).

Our results, obtained from the sequence of drying treatments, are consistent with recent studies that have investigated the influence of temperature on the structure of pectin. (23) demonstrated that, for the extraction of pectin from apples, temperatures above 60°C caused the denaturation of the polysaccharides, affecting their ability to form gels and reducing their effectiveness as thickeners.

Furthermore, in the present study it was observed that the quality of the thickener obtained from prickly pear was also influenced by the drying time. The optimal duration was 70 minutes, which guaranteed an adequate balance between moisture content and the preservation of the physical properties of the pectin. This finding agrees with the research of (24), who observed that, to obtain pectins from tropical fruits, prolonged drying at controlled temperatures favored the quality of the final product, while excessive drying time resulted in the degradation of the material.

Likewise, in similar studies (25), it was shown that a well-controlled drying time and temperature allow better preservation of the chemical and functional properties of bioactive compounds. In our case, this was reflected in the high thickening capacity of the product obtained, which resulted in a yield of 0.5244% in the extraction with ethanol, the highest compared to other solvents used in previous research.

Regarding the ability of solvents to improve extraction efficiency, our study also shows that ethanol is effective not only for its dehydration capacity but also for its low impact on pectin integrity. This observation was corroborated by other authors (26), who demonstrated that ethanol is a less aggressive solvent than other alcohols or acids commonly used in the extraction of pectins. Its use allows the viscoelastic properties of the thickener to be better preserved, maintaining optimal quality of the final product.

Finally, our findings reinforce the importance of controlling both the drying parameters and the choice of solvent to obtain a high-quality product, which is crucial for industrial applications. The results obtained confirm that ethanol is the most suitable solvent for the extraction of pectins from *Opuntia ficus-indica*, while the drying conditions at 40°C for 70 minutes are the most appropriate to preserve the functional properties of the thickener. These findings are consistent with the scientific literature and highlight the importance of process optimization in obtaining natural products for the food industry.

CONCLUSIONS

The present study on obtaining a natural thickener from prickly pear (*Opuntia ficus-indica*) has demonstrated its viability and advantages in industrial applications. It has been confirmed that 96% ethanol is the most efficient solvent for pectin extraction, achieving superior performance compared to other solvents, thus establishing a more efficient and economically viable extraction process on an industrial scale. The optimal drying conditions, set at 40°C for 70 minutes, guarantee the conservation of the bioactive properties of the thickener, essential for its effectiveness in food applications. This parameter is crucial to maintain the quality and functionality of the final product,



underscoring the importance of precise control of the drying process to ensure consistent, high-quality results.

Drying temperature plays a crucial role in preserving the quality of the thickener. Moderate temperatures (40°C for 70 minutes) were optimal, avoiding the degradation of pectin and maintaining its bioactive properties, which coincides with previous studies on the impact of heat on polysaccharides. The pH of the thickener obtained, with a value of 6.68 ± 0.03 , indicates that the use of ethanol as a solvent does not negatively affect the chemical properties of the product. This confirms that ethanol is a suitable alternative for the production of natural thickeners, preserving both the functionality and solubility of the extracted material.

This discovery is particularly relevant in the context of growing consumer demand for more natural and environmentally friendly products. Furthermore, the research opens new opportunities for the food industry and other sectors, by introducing a natural and sustainable thickener that can replace or complement existing commercial products. This not only responds to the demand for more natural products, but also drives the development of more sustainable technologies and processes, encouraging industrial practices that are more environmentally friendly and contribute to global sustainability.

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