

# Perception of the use of agro-industrial by-products as ingredients for food product development: a qualitative study

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## Abstract

**Introduction/Objective:** The purpose of the study is to qualitatively evaluate the perception of the use of by-products as an ingredient in food processing and its effect on human health. **Methods:** The study was descriptive and observational to determine the perception of the use of food by-products (FBP) for food processing and its impact on health, using a questionnaire in Google Forms format. The survey was applied to people in seven municipalities of Nayarit: Acaponeta, Compostela, San Blas, Santiago Ixcuintla, Xalisco, Tecuala and Tepic. **Results:** 56% of the respondents answered that by-products are feasible for reuse in the development of new food products. Of the volunteers who were in favor, 33% agreed and only 9% strongly agreed. Seeds (42%) and husks (33%) are the main by-products that respondents noted as potential ingredients. The processes where by-products can be implemented the most are fermentation processes (25%), juices or nectars (18%) and bakery products (17%). **Conclusions:** Perceptions are associated with culture and health, so it is important to analyze the criteria between the relationship with nutritional and functional health attributes so that by-products are accepted in the daily diet.

**Keywords:** Foods. By-products. Perception. Nayarit. Human health. Food processing.

## Introduction

The prevalence of excess weight in the Mexican population has been steadily increasing over the last ten years, caused by the access to industrialized food consumption, which has been transferred to all people regardless of age, race, gender, place of residence and/or socioeconomic level<sup>1</sup>. In this sense, it represents a multifactorial situation, caused by two factors related to nutrition and lifestyle, which are internal or personal and external (socio-educational)<sup>2</sup>. Personal factors include psychological factors (knowledge, attitudes, behaviors, skills or emotions) and biological factors (genetic, metabolic), while external factors refer to the influence of lifestyles ranging from an immediate level

(family, school environment, work environment, groups of friends, media, information and communication technologies, etc.) to a broader level of the environment (social, values and beliefs) that influence the individual<sup>2-3</sup>. Of course, social representations only manifest themselves as beliefs; therefore, it is important to identify the beliefs and perceptions that people have about food by-products (FBP)<sup>3</sup>. According to FAO, FBP are those food losses and/or wastes that occur in the production, post-harvest and processing stages of the food supply chain; as well as the behavior of retailers and consumers<sup>4</sup>. BP are not usually useful as raw material for the production chain, but they can be used to obtain another product with economic, commercial or social

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Date of reception: 04-04-2023

Date of acceptance: 12-07-2023

DOI: 10.24875/HGMX.23000024

Available online: 29-09-2023

Rev Med Hosp Gen Mex. 2023;86(4):135-140

www.hospitalgeneral.mx

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value, such as food for animals and humans, composting process and impact on the environment (bioethanol, biodiesel, biogas, biomass)<sup>5</sup>.

Faced with this reality, today multiple strategies have been added and tried in an integral way to control and/or reduce the by-products (BP) of different food matrices that can be given an added value to be considered as ingredients in the development of different more natural foods and reduce those components that harm your health (colorings, flavorings, preservatives, among others) and become part of eating habits<sup>6,7</sup>. Studies have also shown that BP can provide equal or higher nutritional content compared to foods traditionally sold on the market. The chemical composition of by-products can vary greatly as a result of different materials, processing methods<sup>8</sup>. Due to their high nutritional composition, they could be considered as “emerging raw materials” for the development of other products<sup>5,9,10</sup>.

However, some studies have shown a high failure in the introduction and acceptance of novel foods by consumers (>70%) and they disappear from the market shortly after their introduction<sup>6-8</sup>. Given that consumer decisions and knowledge of consumer preferences are fundamentally complicated, this has led researchers to focus on the factors mentioned above. Therefore, it is necessary to have a holistic view of people in order to understand the generalized conceptions about FBP and their relationship with health and nutrition. In this sense, the objective of this research was to qualitatively evaluate the perception of the people of the State of Nayarit on the use of FBP, their application in food development and their positive effect on human health.

## Methods

### Sample and study design

The research was a descriptive and observational study that made it possible to analyze the perception of the use of FBP for food development as well as the impact they have on their health. For this purpose, a questionnaire was elaborated in Google Forms format with fifty items divided into three blocks. The first block addresses the confidence and nutritional composition of the FBP, the second the perspective and type of use for food development. Finally, the third block of the benefits and contributions of the FBP on health. The content validity of the questionnaire was evaluated by experts (10 food and research professionals) independently, who were offered an open opinion about the instrument and offered suggestions and/or modifications to each

item for its better understanding and the need to eliminate them for a better concordance with reality. They were asked to determine the consistency, clarity and relevance of the instrument using a scale of 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree). Applicable, 2. Applicable after correction or 3. Not applicable) and the degree of agreement for each item by means of the Interclass Correlation Coefficient (ICC), which could be moderate (ICC: 0.5-0.75), good (ICC: 0.75-0.90) or excellent (ICC > 0.90)<sup>11,12</sup>. Some of the questions included in the questionnaire were: 1) How much do you agree with using waste as an ingredient in the elaboration of food? 2) In what type of food do you think agroindustrial waste can be used? 3) Would you consume food elaborated with any type of agroindustrial waste? 4) If you started to see food elaborated with agroindustrial waste, would you continue buying those that dominate the market? 5) Where do you think the sale of agroindustrial waste would be appropriate?

The questionnaire was disseminated through social networks and emails to family, friends and even encouraging participants to send the survey to as many people as possible. The survey was open during the months of July to September 2022. The municipalities of Nayarit that supported in answering the questionnaire were Acajoneta (103), Compostela (112), San Blas (108), Santiago Ixcuintla (114), Xalisco (125), Tecuala (131) and Tepic (143), with a total of 836 questionnaires received. Based on the data evaluated in the Microsoft Excel program, an analysis of the response items was carried out and a pattern of null non-response was observed. Therefore, it was not considered appropriate to make an exclusion criterion for the questionnaires.

The inclusion criteria were people between 18 and 40 years of age, who lived in the municipalities of the State of Nayarit and who were not familiar with the topic of analysis (professionals and specialists in the area of health and food). The questionnaire included items that automatically excluded any participant who was not from Nayarit, infants, and health and food professionals and specialists. It was not necessary to have ethical approval because the questionnaire did not harm people's morals/privacy and did not include compromising questions. Within the questionnaire there was an informed consent form for the participant to voluntarily choose to participate, answering Yes/No to accept what was established.

### Statistical analysis

The data were analyzed with Statistica version 10 software. The Shapiro-Wilk and Kurtosis test was used

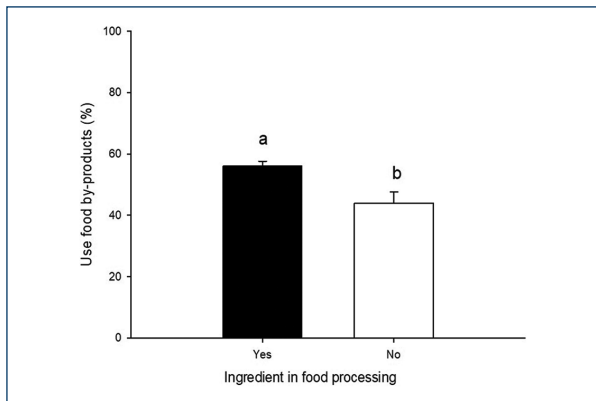


Figure 1. Consideration for the use of food by-products.

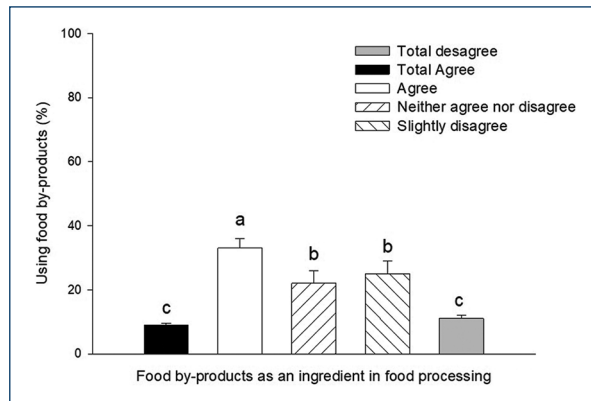


Figure 2. Confidence level for the use of by-products as ingredients in food development.

to evaluate the normal distribution of the data. After verifying the normality of the data, a descriptive study was carried out by calculating percentages and absolute frequencies with their corresponding standard deviations. All data were analyzed using one-way analysis of variance (ANOVA). Tukey's multiple range test at a significance level of  $P \leq 0.05$  was used to identify significant differences in the means of the measured parameters.

## Results

This section describes the results obtained from the participants who were surveyed. Nayarit is a state where the traditions of food handling and preparation are preserved, so when evaluating their perception of the use of BP, they called their attention to the opportunities to reuse them. Figure 1 shows the consideration of using by-products as an ingredient to produce some type of food product. In this figure it can be seen that 52.8% responded that by-products are feasible to be used. In this sense, people's interest led them to ask about the opportunities that BP can be used in their face, either in the preparation of food or to apply it in their garden for their plants. For this reason, 33% agree to use them while 22% neither disagree nor agree to the use of BP (Fig. 2). Interesting data we could obtain (Fig. 2) that only 9% of the surveyed population totally agrees in implementing BP as ingredients in the food process and 11% totally disagrees in not using them. It should be noted that some people found it strange to give it a reuse because they prefer to give it to homeless animals as leftovers instead of throwing it away. While others (bone, peel, seeds) knew that they could be used as fertilizer for their plants. Figure 3 shows the

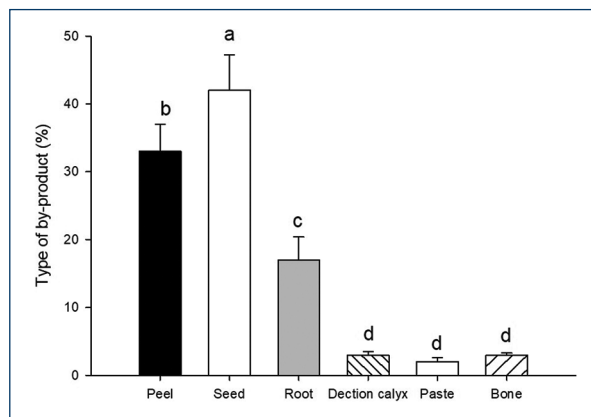


Figure 3. Perspective of the type of food by-products that can be used in the processing of food products.

type of by-products that people think can be implemented in the development of other food products. Seeds had a better option (41.7%) to be implemented as an ingredient, followed by husk (33.3%) and root (16.7%) (Fig. 3). However, the majority of respondents are not confident in consuming a food with these added BP (59.5%) and only 22% are confident in consuming them, as shown in Table 1. Thus, confidence is divided between strongly agree (22%) and neither confidence nor distrust (26%) (Table 1). This may be due to the fact that the majority of people (52.8%) do not know the nutritional composition of the BP (Table 2). Forty-two percent of people think that BP contain dietary fiber; while 19% consider that they contain oils and fats, vitamins and antioxidants (11% for both). For this reason, thirty-six percent of people know that BP can help reduce body weight (Table 3) and few people think that they can help the respiratory system (14%) and the

**Table 1.** Level of people’s confidence in the consumption of food by-products (FBP)

Would you consume food made with any type of FBP?	Analysis (%)
Yes	40.6 <sup>b</sup>
No	59.4 <sup>a</sup>
Would you trust FBP for consumption?	
Totally confident	22 <sup>a</sup>
Moderately confident	28 <sup>a</sup>
Neither trust nor distrust	26 <sup>a</sup>
Slightly distrustful	11 <sup>b</sup>
Total distrust	3 <sup>c</sup>

Data expressed as mean ± SD. Different superscript letters within same row denote a significant difference (p < 0.05).

**Table 2.** Nutritional contribution of food by-products (FBP)

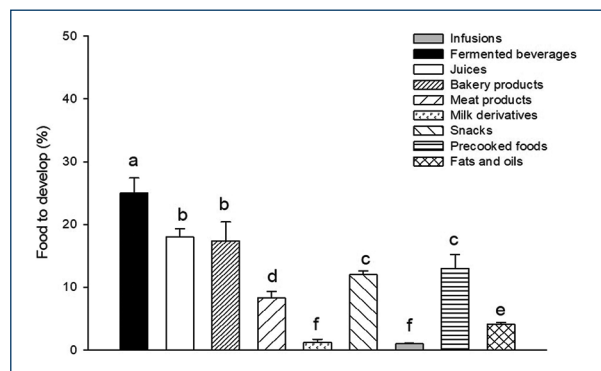
Do you know that FBP provide nutrients as well as the ingredients commonly used in the production of foods you see in the market?	Analysis (%)
Yes	47.2 <sup>b</sup>
No	52.8 <sup>a</sup>
What is the component you have heard or read about most often in FBP?	
Dietary fiber	42 <sup>a</sup>
Minerals	8 <sup>c</sup>
Oils and fats	19 <sup>b</sup>
Vitamins	11 <sup>b</sup>
Antioxidants	11 <sup>b</sup>
Proteins	3 <sup>c</sup>
Carbohydrates	6 <sup>c</sup>

Data expressed as mean ± SD. Different superscript letters within same row denote a significant difference (p < 0.05).

**Table 3.** Knowledge of the health benefits of food by-products (FBP)

Did you know that FBP has health benefits for people?	Analysis (%)
Yes	22 <sup>c</sup>
No	42 <sup>a</sup>
No idea	36 <sup>b</sup>
Benefits contributed by FBP	
Weight	36 <sup>a</sup>
Immune system	8 <sup>c</sup>
Respiratory system	14 <sup>b</sup>
Urinary system	13 <sup>b</sup>
Reduces carbohydrate absorption	7 <sup>c</sup>
Anticarcinogenic	7 <sup>c</sup>
Anti-aging	4 <sup>c</sup>
Anti-inflammatory	7 <sup>c</sup>
Reduces cholesterol	4 <sup>c</sup>

Data expressed as mean ± SD. Different superscript letters within same row denote a significant difference (p < 0.05).



**Figure 4.** Frequency of development of foods from food by-products.

urinary system (13%). These results below 50% are due to the fact that people were unaware that they could be manipulated and reused for medicinal purposes, especially in diseases that some people suffer from, or in the elaboration of certain products. Therefore, most people prefer by-products to be used for the development of fermented beverages (25%), followed by juices and bakery products with 18 and 17.4%, respectively (Fig. 4). Estos resultados por debajo del 50% se debe que las personas desconocían que se podrían manipular y reutilizarlos en la elaboración de ciertos productos

## Discussion

The presentation of the results is going to start with a brief descriptive presentation of the socio-demographic characteristics of the respondents according to their

gender, more than 70% of the sample are women, aspect that women generally acquire food for the household<sup>13</sup>. The average age of the two genders is in the range of 20-29 (83.3%) and the social class is in the middle level (83.3%), in which the resistance of the perceptions of food neophobia and in the willingness to accept new and unfamiliar foods is high<sup>14-16</sup>. It should be remembered that food neophobia is characterized by the rejection of foods that are new and unfamiliar, limiting the variety of people’s diets<sup>13</sup>.

Studies show a negative correlation between food neophobia and the willingness to consume or purchase novel foods, with those with high levels of food neophobia being less likely to accept and consume foods they are not used to<sup>17-19</sup>. This is evidenced by our results, where >50% of the respondents do not have full

confidence in FBP to be used as an ingredient (Fig. 2). It should be noted that culture is an important factor in the perception and acceptance of FBPs, followed by economic aspects, age, gender, education, and family and social background, which can affect the scores given to novel foods in social acceptance tests<sup>13,20</sup>. In this sense, Nayarit is a state that presents heterogeneous socioeconomic and cultural conditions: 28% of the population is in moderate poverty, 5.9% in extreme poverty, and 35% do not suffer from poverty but have certain social deprivations, this is generated by the geographic distribution of the state, which includes mountainous territory with difficult access, inhabited by different ethnic groups. On the other hand, over 30% represent a nonpoor and nonvulnerable population, with a middle or upper-middle social class<sup>21,22</sup>. Conversely, in Europe, specifically in northern countries, the choice of foods developed with FBP is continuously increasing due to their critical approach to the process and development of this type of products, in comparison with U.S. consumers<sup>10,14</sup>. Likewise, perception is even more influential when there is substantial empirical evidence of new feeding technologies<sup>13,20,23</sup>. In this sense, there is currently extensive evidence of the implementation of BP in the food technological process. Therefore, perceptions of risk and concerns associated with food innovations and one's own health status may enable information strategies that influence consumer attitudes and provide real health benefits<sup>14,24</sup>.

Health has been acquiring an important role in food consumption because consumers today are interested in feeling good, and based on this interest, the market has reacted by offering foods that go beyond just feeding people<sup>14-15</sup>. Therefore, people's beliefs about the health benefits of FBP are an important factor affecting the acceptance of these products. Therefore, people concerned about their health should be more interested in the development of functional foods<sup>25</sup>. Functional food has been shown to successfully support one or more target functions in the body for improved health and well-being and/or reduced risk of disease<sup>26,27</sup>. Therefore, people are increasingly informed about the impact of FBP on weight control, immune system, urinary system and may even help against cancer (Table 3). It is important to raise awareness and build trust with people about the impact of PBF and their role in reducing disease risk<sup>28,29</sup>. Therefore, the incorporation of new food components into traditional raw materials is of vital importance, as consumers are looking for food products that have been modified to fulfill physiological functions beyond the provision of simple

nutritional requirements<sup>30,31</sup>. In this context, the present work sheds light on previous studies by considering how people's criteria influence their willingness to choose FBP and, specifically, how their healthy lifestyle influences them. In more concrete terms, FBP promise better health, improved well-being or better functioning of physiological processes<sup>28,29</sup>. In this sense, the food industries have assumed an important role in generating changes in the food process, although the scientific literature considers a low innovative intensity in the food industry<sup>15,26</sup>.

The industry can adopt an innovative attitude and be more related to the financial structure, employing activities capable of improving its processes by combining with suppliers and customers, which confirms that the technological changes in this sector are mainly related to the possibilities of investing in new technologies through investments in equipment and capital goods<sup>15,32-34</sup>. However, companies must have the ability to integrate socio-economic changes to detect, identify, capture and manage people's perception of the FBP in the innovation process<sup>28,35</sup>. Therefore, perception represents one of the main points to consider in adopting the FBP approach to food innovation in order to offer customers a range of increasingly new and cutting-edge products in healthcare<sup>35</sup>.

## Conclusion

From the results obtained on the perception of by-products, it can be concluded that the decision to accept them presents an important emotional dimension, since they do not only include the reevaluation of their nutritional attributes, but also incorporate other types of trust attributes. This fact implies that the perception of by-products is undergoing an evolution towards greater complexity in the decision process. Therefore, knowing and understanding how consumers derive a sense of self-confidence is of great importance for use in food product development. For the future, these findings generate interesting opportunities that could be used as tools to expand the knowledge of perception to other entities in Mexico as another territory to corroborate the results of this study and develop campaigns related to food innovation models, in order to introduce by-products in the consumer's diet.

## Acknowledgements

We thank all volunteer participants for contributing to the experimental part of the study.



## Funding

The authors declare that there was no funding for this article.

## Conflicts of interest

The authors declare that they have no conflicts of interest.

## Ethical disclosures

**Protection of humans and animals.** The authors declare that no experiments on humans or animals have been performed for this research.

**Confidentiality of data.** The authors declare that no patient data appear in this article.

**Right to privacy and informed consent.** The authors declare that no patient data appear in this article.

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