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USE OF AGAVE *ANGUSTIFOLIA HAW* BAGASSE PULP AS AN ADDITIVE POWDER FOR BAKING FLOUR

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ABSTRACT

Objective: The main objective of this study was to determine the conditions under which the pulp of Agave Angustifolia Haw bagasse fibers should be processed to obtain a good quality bread in terms of texture, emulsion, and crumb formation.

Theoretical Framework: Agro-industrial residues have become in recent years alternative raw materials for different production processes, however, they must present conditions that allow food fortification, as is the case of agave residues whose nutrient content has evidence in the literature.

Method: The methodology used in this study is experimental and applied in stages, 10 kg of agave bagasse were collected and processed; different proportions of agave flour were established in bread recipes to test the ideal fermentation for baking.

Results and Discussion: The results obtained revealed that the fine residues obtained from the process of solar drying and grounding of agave bagasse pulp increase high-water absorption capacity, therefore this property favors the hydration of bakery products.

Implications of the research: It is concluded that these residues in a lower concentration combined with flour can be used for the elaboration of bakery products with nutritional value.

Originality/value: This study contributes to reduce agro-industrial waste contamination by transforming them into functional food, which represents a contribution to food security programs and social impact.

Keywords: Agave Angustifolia Haw, Bread Flour, Bagasse Residues, Functional Food.

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UTILIZAÇÃO DA POLPA DE BAGAÇO DE AGAVE *ANGUSTIFOLIA HAW* COMO ADITIVO EM PÓ PARA FARINHA DE PANIFICAÇÃO

RESUMO

Objetivo: O principal objetivo deste estudo foi determinar as condições em que a polpa de fibra de bagaço de Agave *Angustifolia Haw* deve ser processada para obter um pão de boa qualidade em termos de textura, emulsão e formação de miolo.

Estructura teórico: Os resíduos agro-industriais têm-se tornado nos últimos anos matérias-primas alternativas para diferentes processos produtivos, no entanto, devem apresentar condições que permitam a fortificação de alimentos, como é o caso dos resíduos de agave cujo teor de nutrientes tem evidência na literatura.

Método: A metodologia utilizada é experimental e aplicada em etapas, 10 kg de bagaço de agave foram coletados e processados; diferentes proporções de farinha de agave foram estabelecidas em receitas de pães para testar a fermentação ideal para panificação.

Resultados e Discussão: Os resultados obtidos revelaram que os resíduos finos obtidos a partir do processo de secagem solar e esmerilhamento da polpa de bagaço de agave aumenta capacidade de absorção de água, pelo que esta propriedade favorece a hidratação dos produtos de panificação.

Implicações da investigação: Conclui-se que estes resíduos em menor concentração combinados com a farinha podem ser utilizados para a produção de produtos de panificação com valor nutricional.

Originalidade/valor: Este estudo contribui para a redução da poluição dos resíduos agro-industriais, transformando-os em alimentos funcionais, o que representa uma contribuição para programas de segurança alimentar e impacto social.

Palavras-chave: Agave *Angustifolia Haw*, Farinha De Pão, Resíduos De Bagaço, Alimentos Funcionáis.

APROVECHAMIENTO DE LA PULPA DE BAGAZO DE AGAVE *ANGUSTIFOLIA HAW* COMO POLVO ADITIVO PARA HARINA PANIFICABLE

RESUMEN

Objetivo: El objetivo principal de este estudio fue determinar las condiciones en las cuales se debe procesar la pulpa de las fibras de bagazo de Agave *angustifolia Haw* para obtener un pan de buena calidad en cuanto a textura, emulsión y formación de miga

Marco Teórico: Los residuos agroindustriales se han convertido en los últimos años en alternativas de materias primas para diferentes procesos de producción, no obstante deben presentar condiciones que permitan la fortificación de los alimentos, como es el caso de los residuos de agave cuyo contenido de nutrientes tiene evidencia en la literatura.

Método: La metodología empleada es de corte experimental aplicada por etapas, se recolectaron y procesaron 10 kg de bagazo de agave; se establecieron diferentes proporciones harina de agave en recetas de pan para probar la fermentación idónea para la panificación.

Resultados y Discusión: Los resultados obtenidos revelaron que los residuos finos obtenidos del proceso de secado solar y molienda de la pulpa de bagazo de agave aumenta la capacidad de absorción de agua, por tanto esta propiedad favorece la hidratación de productos panificables.

Implicaciones de la investigación Se concluye que estos residuos en una concentración menor al combinarse con harina pueden ser utilizados para la elaboración de productos panificables con valor nutrimental.

Originalidad/Valor: Este estudio contribuye a disminuir la contaminación por residuos agroindustriales transformándolos en alimento funcional, esto representa una contribución para programas de seguridad alimentaria e impacto social.

Palabras clave: Agave *Angustifolia Haw*, Harina Panificable, Residuos de Bagazo, Alimento funcional.

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1 INTRODUCTION

In recent years, there has been a growing interest in the search for sustainable and economically viable alternatives in the food industry. In this context, the utilization of agricultural by-products for food processing has emerged as a promising line of research. Zainudin et al. (2022) and Romero-Sáez (2022) agree that agro-industrial residues have become raw material alternatives for different food industries; these are obtained from the food production process in its different stages (from cultivation to the final product), of which there is evidence that the residues of this process such as molasses, husks, pulp, bagasse, stubble among others that are categorized as residues are used (Zainudin et al., 2022).

However, these wastes are not fully utilized and contribute to environmental pollution originated by processes of companies' activities, Cury et al. (2017) point out that agro industries are currently not only valued for their productivity and economic performance but also for their impact on the environment, which can be a factor that influences their permanence in the market, since consumers are increasingly aware of the damage that a company can cause to the ecosystem, so this same factor can represent an advantage for the company if its planning includes environmental protection programs in all its processes, including waste disposal.

Mexico generates a large amount of agro-industrial waste from three economic sectors, the main ones being the livestock sector, the food industry and the beverage industry; Rioja-Scott (2018), points out that "all alcohol distillation processes produce a relevant amount of residual by-product in the process. As is the case of the beer industry that generates approximately 20 kilos of bagasse and 3 kilos of spent yeast for each hectoliter of beer, in the process 8% of the components comes from the grain and 92% from waste, with this concern for the impact to the environment the life Brewery project was initiated which is an initiative of the LIFE program of the European Union (Interempresas, 2021).

Within the beverage industry there is one that is representative of the State of Oaxaca, the mezcal industry, which despite the fact that its processes are artisanal in nature, is not far from this problem, since in order to meet market demands the mezcal palenques have increased their production and with it the waste that the activity generates: vinasse and bagasse.

In Oaxaca the trend in the production of maguey mezcal and mezcal is upward, since according to data from the Agri-food and Fisheries Information Service (SIAP, 2024) from 2017 to 2022, the volume of production, almost tripled, in addition there is an intention to harvest in 2024 of 375,377.66 tons, representing an increase of 436% in 7 years. Likewise, mezcal production, according to Mexican Regulatory Council of Mezcal Quality (COMERCAM), reported increased by 74.89% nationally, with Oaxaca being the producer of just over 91% of national mezcal, and although a decrease in national production is shown in COMERCAM's 2024 report, production in both years exceeds 11 million liters in Oaxaca.

1.1 USE AGRO-INDUSTRIAL WASTE

According to Flores et al. (2020), an average of 5.63 kg of bagasse (wet basis) is generated per liter of mezcal from maguey espadín (Agave angustifolia *Haw*), which has represented approximately between 81 and 86% of the maguey used in the last two years (COMERCAM, 2024) in national production; therefore, the generation of more than 59 thousand and 53 thousand tons of bagasse from maguey espadín in 2022 and 2023 respectively in the state of Oaxaca could be estimated.

Due to the impact on the environment when discarding these slow degradation wastes, the search for strategies for their valorization as MDF agglomerates, biofuels, biohydrogen, enzyme production for industry, inulin, cellulose nanoparticles, feed for ruminants and substrate for plants, among others, has been chosen (Kumar and Ram, 2021; Escudero et al., 2023).

Munasinghe (2009), argues that the environmental function comprises the symmetrical relationship between agriculture and the biophysical conditions of the environment to maintain the viability and overall health of ecosystems, as well as knowledge about the rational use of natural resources in obtaining food raw materials of agricultural origin. The residues of some food products contain compounds with nutritional value (Gondim et al., 2005). The processing of these residues into flour turns it into a safe product with nutritional capacity because by reducing the moisture content, it reduces chemical and microbiological reactions, increases its nutritional value, and is a source of fiber and minerals (Izidoro et al., 2008), in this sense Romero-Saenz (2022) points out that for agro-industrial residues to be used for food purposes, they must have a physicochemical composition that allows for the fortification and improvement of other foods.

Therefore, the objective of this work was to determine the conditions under which the pulp of agave *Angustifolia* Haw bagasse fibers should be processed to obtain the formulation of a flour

fortified with agave that allows the elaboration of a good quality bread in terms of texture, emulsion and crumb formation.

2 MATERIALS AND METHODS

2.1 RAW MATERIAL SELECTION AND PREPARATION

A total of 10 kg of agave (*Angustifolia*) bagasse was collected from “El Cortijo” palenque located in Santiago Matatlán, Oaxaca.

The pulp was dried in an unbranded hybrid solar dryer for 7 days to ensure complete drying. The residual pulp was separated from the fiber by manual friction and then milled with a Carejoy UYIO Pulvex mill for size reduction and sieved on a 100 mesh to obtain a particle size of approximately 149 µm, which gives it a grain size similar to wheat flour whose range is 125-250 µm.

The yield of the residual agave pulp flour was determined: weight of agave flour obtained in relation to the weight of bagasse used.

2.2 SUBJECTIVE WATER ABSORPTION CAPACITY OF THE AGAVE FLOUR

The methodology described by Flores-Farias et al. (2002) was used to meter water absorption capacity or the amount of water absorbed by the flour to obtain a dough of appropriate consistency. Ten g of flour were weighed, and water was added gradually, performing a gentle manual kneading until a dough of good consistency was obtained. The amount of water added was recorded as the water absorption capacity of the flour in ml of water / 100 g of flour.

2.3 FORMULATION OF FLOUR FORTIFIED WITH RESIDUAL AGAVE PULP

The fortified agave flour was formulated using as a base 1 kg of wheat flour with agave residual pulp flour, in concentrations: 10, 20 and 30 % (% agave flour/kg wheat flour).

2.4 BAKING OF " CONCHA" TYPE BREAD

Baking tests were carried out with the formulated flours, in this process " concha" type sweet bread with fortified flour, sugar, water, oil, piloncillo, agave honey, butter and egg. The

processing of the dough consisted of weighing the liquid and solid ingredients on a Just Home scale with a 10 kg capacity. The solid ingredients were mixed gradually incorporating the liquid ingredients, kneaded until an elastic and manageable dough was obtained, and left to rest at room temperature.

A second kneading with rest at room temperature was then applied to achieve a first fermentation. The dough was sectioned for rounding and rested for a second fermentation. After the second fermentation, the shell topping was placed on top of the bun. The concha topping was made with flour, powdered sugar, butter and vanilla.

The breads were baked in a San-Son convection gas oven for 15 min, taking care to rotate on the oven to ensure good baking.

The percentage of water required for hydration of flour during kneading, the effect of concentration on fermentation time and the visual properties of the final product were evaluated.

3 RESULTS AND DISCUSSIONS

3.1 AGAVE FLOUR YIELD

Of the 10 kg of dehydrated agave bagasse, 3 kg of dehydrated residual pulp were obtained, therefore the yield of agave flour (Figure 1) per kg of agave bagasse corresponds to 30 % (w/w). The yield of agave flour is sufficient for wheat flour fortification and according to Almaraz (2016) under the right conditions it can be an excellent support or substrate for solid state fermentation, therefore the use of this residue decreases the environmental impact.

Figure 1

Processing of residual agave pulp flour: 1. dehydrated bagasse, 2. ground pulp, 3. agave flour.



1 2 3

3.2 WATER ABSORPTION CAPACITY

The water absorption capacity obtained by agave flour was 2.5 (25 ml of water/ 10 g of flour), which indicates that it is above the water absorption capacity of wheat flour with a capacity of 1.92 and very close to quinoa flour with a capacity of 2.31 as reported by Rodriguez et al, (2010), which considers that water absorption capacity is a parameter that shows the interaction between starch chains within the amorphous and crystalline sections that are affected by the amylose/amylopectin ratio in terms of weight/distribution, degree, length and conformation of the chain and therefore, water absorption capacity is a quality index of a baking flour.

3.3 BAKING OF "SHELL" TYPE BREAD

Table 1 shows the percentage of water required for hydration of flour fortified with residual agave pulp. It is observed that increasing the percentage of residual agave pulp flour requires a higher % of water. In the case of 30% flour, a ratio of 100% water per weight of flour is required, i.e. for every 100 g of flour, 100 g of water are required. Agave flour provides a greater water absorption capacity to wheat flour and therefore facilitates its kneading.

Table 1

Percentage of water required for the hydration of flour fortified with residual agave pulp.

Wheat flour (%)	Agave residual pulp flour (%)	Water for hydration (%)
90	10	80
80	20	90
70	30	100

During the first fermentation it was observed that the doughs containing 20 and 30 % agave flour required a fermentation time of 35 min, for the dough with 10 % agave flour the fermentation time was 25 min, all the doughs presented good humectation, in this first fermentation the dough leavened was minimal. The coloration of the dough is slightly yellowish.

In the second fermentation it was observed a change of color to brown color of the dough being evident in doughs with higher concentration of agave flour, nevertheless the wettability was lost since they presented cracks, low elevation and a fermentation time of 25 min. In the dough with 10 %, the fermentation time was 15 min, good moistening and doubled laudation. The baking time for the bread was 15 minutes at 180°C (Figure 2).

Figure 2

Concha bread before and after baking.



The baked "concha" bread showed the following physical characteristics: at 30% agave flour, the browner coloration, however, there is no good crumb formation with caking of material; with 20% flour, the bread shows better crumb formation, less intense brown coloration, greater softness and less caking; with 10% flour, there is no caking, a slightly caramel coloration, greater crumb formation, and the bread is very soft. In the breads obtained, a slight aroma of cooked agave was detected and a tendency to brown color was observed according to the concentration of agave flour used (Figure 3).

Figure 3

Crumb formation in concha bread according to agave flour concentration 1.10%, 2. 20%, 3. 30% concentration agave flour



1 2 3

4 CONCLUSIONS

The separation of residual pulp from agave bagasse is possible through the use of simple mechanical processes, reducing the load of organic material in the residue leaving cleaner fibers, its use has an economic, social and the risk of public health, environmental impact for the population dedicated to mezcal production. It also represents an alternative for circular economy models and social impact due to the fact that mezcal production in Oaxaca takes place in rural communities.

The flour obtained from the residual agave bagasse pulp is a product that can be combined with wheat flour for its fortification, it has a high-water absorption capacity that favors the flours used for baking.

The 10% concentration of agave flour is optimal for the fortification of wheat flour, since it facilitates kneading, dough moistening, better crumb formation, and generates a better-quality baked product.

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