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Article

Effect of frying on pork rinds quality

Efecto del freído en la calidad del chicharrón de cerdo

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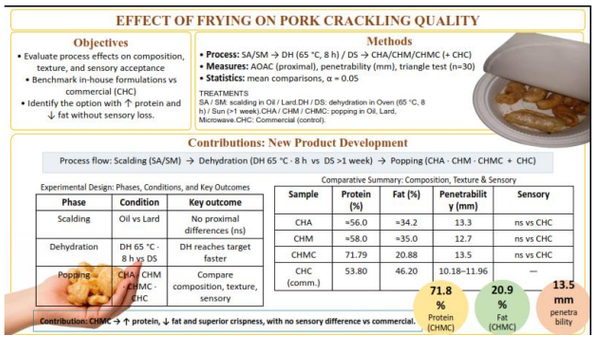
Abstract

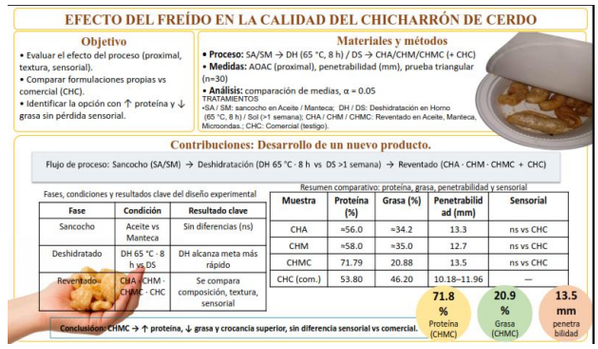
Saturated fatty acids (SFA) are endogenously synthesized and necessary for some physiological and structural functions, while trans fatty acids (TFA) are almost always derived from the ingestion of hydrogenated foods and have no health benefits. The alteration of the lipid profile is a risk factor for cardiocerebrovascular diseases. Reducing their consumption may present a protective effect for cardiovascular events (Cabezas et al., 2015). The concern in Mexico is alarming because more than 50% of the population does not consume vegetables daily, while 20% reported not consuming plain water every day; 80% of the population reported consuming sweetened beverages and about 60% of the population under 20 years of age reported consuming snacks among which corn chips (58%), potato chips (29%), wheat flour snacks and cracklings (4%) highly rich in fat and sodium. With these figures, we can be classified as a country of snackers, since the population consumes at least 90 grams of fried foods per week (Gaona, 2022). Therefore, it was proposed to evaluate the effect of different thermal treatments for frying pork crackling for low-fat snacks. Three formulations were developed to evaluate the heat treatment, dehydration method, penetrability, composition and sensory tests. The results showed that there were no significant differences between the parameters evaluated, showing a preference for the microwave oven chicharrón with a significant decrease in fat according to the analyses performed.



Pork Rinds, low fat, fried

Resumen

Los ácidos grasos saturados (AGS) son de síntesis endógena, necesarios para algunas funciones fisiológicas y estructurales, mientras que los ácidos grasos trans (AGT) provienen casi siempre de la ingesta de alimentos hidrogenados y no tienen beneficios en la salud. La alteración del perfil lipídico es un factor de riesgo para sufrir enfermedades cardiocerebrovasculares. La reducción del consumo de los mismos puede presentar un efecto protector para eventos cardiovasculares (Cabezas et al., 2015). La preocupación en México es alarmante debido a que más del 50% de la población no consume verduras diariamente, mientras que el 20% reportó no consumir agua sola todos los días; el 80% de la población reportó el consumo de bebidas endulzadas y cerca del 60% de la población menor de 20 años reportó consumir botanas entre las que destacan frituras de maíz (58%), papas fritas (29%), botanas de harina de trigo y chicharrón (4%) altamente ricas en grasas y sodio. Con estas cifras bien podemos clasificarnos como un país botanero, ya que la población consume por lo menos 90 gramos de frituras por semana (Gaona, 2022). Por lo anterior, se planteó evaluar el efecto de diferentes tratamientos térmicos de freído del chicharrón de cerdo para snack bajo en grasa. Se desarrollaron 3 formulaciones para evaluar el tratamiento térmico, método de deshidratado, penetrabilidad, composición y pruebas sensoriales. Los resultados mostraron que no presentan diferencias significativas entre los parámetros evaluados, mostrando una preferencia por el chicharrón para horno de microondas con una disminución significativa de grasa de acuerdo a los análisis realizados.



Chicharrón de cerdo, bajo en grasa, freído

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Introduction

The popularity of snacks is due to various advantages such as easy access (they are sold everywhere), relatively low cost, and attractive presentation and packaging. Hence, we find a wide variety of salty products, mainly made from cereal flours (corn and wheat) or tubers (potatoes and taro) obtained by extrusion; sweet snacks made from fried plantains; flour and pork cracklings; popcorn; natural or dehydrated nuts with salt or sugar (blueberries, raisins, figs, walnuts), among the best known.

With regard to consumption statistics, it is difficult to estimate figures, as there are few measurements for each type of snack and, above all, because a large part of sales are made by street vendors. However, in 2020, per capita consumption of fried snacks was 4.7 kilograms, equivalent to $31.4 per capita. The most commonly consumed salty snacks in Mexico are fried corn (58%), potato chips (29%), and wheat flour and pork rind snacks (4%). With these figures, we can certainly classify ourselves as a snacking country, as the population consumes at least 90 grams of fried snacks per week (Estrada et al., 2022).

About pork rinds

Snacks in Mexico are an industry that spans various markets and continues to grow rapidly. Pork rinds, made from pork skin that has been cleaned and fried in animal fat, are foods that provide a large amount of calories (699 kcal per 30 g serving), which come mainly from lipids, due to the lack of control in the frying of the skin. In some countries, chicharron is made by melting pork fat, while in others, the fat is used to fry the skin, with or without meat.

The Pork Rinds can also be made from other animals such as cows, chickens, fish, or lambs, although they are generally considered to be of lower sensory quality. In Mexico, “chicharron” refers to clean pork skin, which is fried almost whole in animal fat (lard) until it becomes fluffy and crispy. The main objective of frying pork rinds is to achieve a specific texture and color on their surface, as well as a characteristic aroma. The crispy texture is associated with changes that occur in proteins, fats, and carbohydrates (Pérez et al., 2016).

Crispiness in fried foods

Frying food is one of the oldest culinary processes on record, probably dating back to the 6th century BC, and was likely one of the first technical culinary processes that allowed food to be preserved for longer.

Technically, frying refers to methods of cooking food by immersing it in edible oil (mainly vegetable oil) or hot fat (mostly vegetable or animal fat) above the boiling point of water (160-180°C) (3,4). The oil acts as a heat transfer medium, producing rapid and uniform heating of the product.

The high temperatures during the frying process cause the water to evaporate, transferring it from the food to the surrounding oil. The oil absorbed by the food partially replaces the water released, constituting up to 40% of the final product and thus influencing all its organoleptic properties, especially flavor, color, crispness, and aroma (Montes *et al*., 2016).

Effect of moisture on pork rinds

The moisture content of the product definitely influences the number of pellets that pop and also their expansion rate. The pellet pops when heated to around 200°C, as the water inside it is superheated and turns into steam. The steam pressure breaks in an explosion, resulting in expansion and a product with a moisture content of less than 4%. Although popping is usually achieved using lard or oil, the use of radiant heat may be more feasible for a quick snack.

That is why during the dehydration process, the aim is to have a moisture content in the product below 4%, as this way it is quicker for the small amount of water to turn into steam when subjected to high temperatures, which generates a quick and uniform bursting of the pellets.

In addition to the above, as it is a product with relatively low moisture content, it has a long shelf life of up to 60 days. Furthermore, as it does not contain a significant amount of water, it is almost certain to be free of microorganisms that accelerate its deterioration, as they cannot find a medium in which to live (Espinel, 2010).

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Dehydration

This is one of the most widely used techniques for food preservation throughout history. Mesh trays are used for dehydration to allow heat to circulate, facilitating the process. The pieces of skin, cut and cooked in butter or oil and seasoned, are spread evenly on the tray and placed in a hot air oven at 50°C for 8 hours or three days in the sun so that they lose as much water as possible (Espinel, 2010).

Materials and methods

Through experimental research, a new product was developed (low-fat pork rind snack) whose main ingredient was pork skin fried using different heat treatments to evaluate the impact of fat reduction. The project was therefore developed in the following stages.

Process for making pork rinds

To begin processing instant pork rinds, the most suitable skin for this type of product was selected, which in this case was American pork skin due to its lower fat content and colour, in order to facilitate the process. After that, all excess fat was removed from the pork rinds to facilitate the next step. Once the skin was clean, it was cut into 5x5 cm pieces, adding 2% iodized salt per kilogram of skin.

Two methods were selected for heat treatment of the skin (frying in oil and lard) in order to evaluate which, heat treatment is most viable for the process. The skin is subjected to a temperature of 200°C for 50 seconds. Once the pork rind has been boiled, it is dehydrated using two methods: drying in an oven for 8 hours at a temperature of 65°C, and drying in the sun for an indefinite period of time until it reaches a moisture content of less than 4%, in order to prevent the development of pathogenic microorganisms.

Three heat treatments were used to pop the dehydrated pork pellets (frying in lard, frying in oil, and popping in a microwave oven) to verify whether there were significant differences between treatments.

Physicochemical analyses

Physicochemical analyses were performed on the final product. These included determining the carbohydrate, fat, protein, moisture, and mineral content in accordance with the methods recommended by the AOAC (Association of Official Analytical Chemists). These analyses were performed at each critical point in the process (boiling, dehydration, and cracking). The results obtained were expressed as averages. The results obtained were compared with those of a commercial Pork Rind (CPR). The aim was to develop a snack with the typical characteristics of commercial pork rinds with a low level of saturated fat and to determine whether there is a difference between the boiling and dehydration heat treatments.

To determine the differences between pork rinds popped in the microwave, oil, and lard (MPR, OPR, LPR) and CPR, the results were analyzed using a randomized block design with a significance level of $\alpha=0.5$, with three replicates; CPR was considered the control, so a Dunnet's test with $\alpha=0.5$ was performed. Minitab version 19 was used for statistical analysis.

Determination of drying curve

For this process, two formulations of instant pork rinds, fried in oil and fried in lard, were analysed. For the dehydrated method of instant pork rinds, two methods were used: oven drying and sun drying. For the oven drying method, a temperature of 65°C was maintained for 8 hours, obtaining a product with a moisture content of 4%. On the other hand, using the sun drying method, the product took a week and a half to reach the desired moisture content of 4%, due to the fact that changes in atmospheric temperature can delay the dehydration process.

Determination of penetrability

A penetrometer was used to determine the penetrability of pork rinds.

A completely randomized design was used for this, with five replicates, in order to verify whether there was a significant difference in the hardness of instant pork rinds and commercial brands.

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Results and discussion

To obtain the final formulation for instant microwave pork rinds, it was necessary to conduct various tests to ensure that the product matched the sensory characteristics of commercial pork rinds. Table 1 shows the formulation, which features a lower sodium content.

Box 1

Table 1

Formulation for pork pellets

Ingredient	Amount (%)
Pork rind	97
Salt	2
Lard	1

Source: own elaboration, 2025

Once the product formulation was obtained, standardization was carried out considering the different formulations of interest to observe possible changes, as described in Figure 1. It is important to mention that during the manufacturing process, it was observed that the main control point that affects product quality is dehydration, which allows the protein to burst in the microwave.

Drying curves

According to Heldman and Lund (2007), drying is defined as the removal of moisture due to the simultaneous transfer of heat and mass. Sharma *et al*. (2003) point out that food drying kinetics is a complex phenomenon and requires reliable models to predict this process. These models are useful tools for estimating the time needed to reduce the water content of the product under different conditions and the ideal temperature, thus improving the efficiency of the process (Iglesias et al., 2018).

Box 2

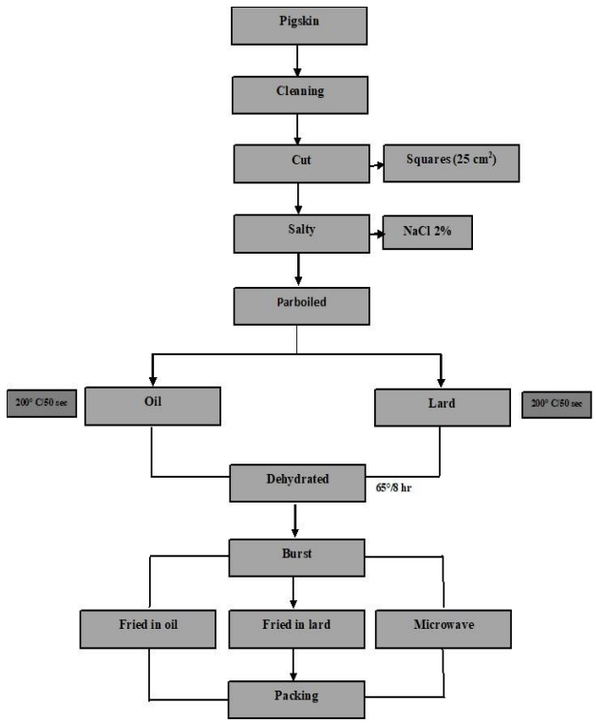

Figure 1

Standardization of the pork rind production process

Source: own elaboration (2025)

Once the product was obtained, the dehydration process was evaluated in order to observe whether there was a difference between the blanching time when dehydrating the pellets in the sun or in an oven (DS and DO). The results are shown in Figures 2 and 3.

Box 3

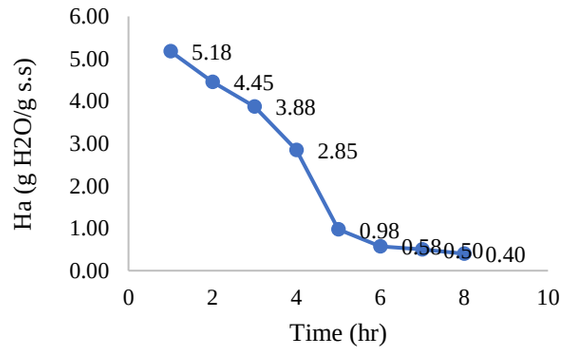

Figure 1

Drying curve in an oven at 65°C

Source: own elaboration, 2025

Looking at both graphs, it was found that temperature control (65°C) reduces drying time to 8 hours by obtaining the required moisture content for cooking the pork pellets, compared to sun drying, which does not achieve the required water content after 13 hours.

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Box 4

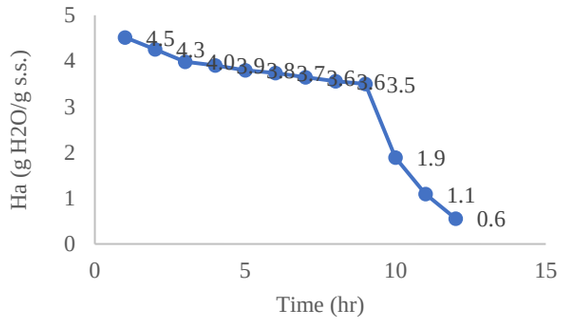

Figure 2
Sun drying curve

Source: Own Elaboration, 2025

Drying is one of the oldest techniques used for food preservation since the dawn of humanity, as it provides the possibility of subsistence in times of scarcity. Although natural drying is the most economical, it has some limitations. Under normal conditions, it takes two to three days; however, in times of low solar radiation and rainfall, the drying time is extended to five days or more, and the product can be negatively affected by biological agents. Due mainly to these disadvantages, it is advisable to consider the use of solar dryers and not just expose the product to the sun (Iglesias *et al*., 2018).

Bromatological tests

Once the product was standardized, its moisture, ash, protein, fat, and carbohydrate content were evaluated in the boiled in oil and lard (BO, BL) process, finding no significant difference between the parameters evaluated, as shown in Table 2.

Box 5

Table 2
Bromatological evaluation of boiled in oil (BO) and boiled in lard (SM)

Parameter	BO	BL
Moisture	30.49 ^{A}	29.40 ^{A}
Minerals	1.42 ^{A}	1.79 ^{A}
Fats	8.84 ^{A}	6.28 ^{A}
Protein	58.68 ^{A}	61.63 ^{A}
Carbohydrates	0.8 ^{A}	0.9 ^{A}

Source: Own Elaboration, 2025

Note: Different letters for each parameter evaluated indicate a significant difference ($p<0.05$).

Bromatological analyses were performed on oven-dried (OD) and sun-dried (SD) sancochos in order to evaluate whether there is a difference between the two methods (Table 3).

Box 6

Table 3
Bromatological evaluation between oven-dried and sun-dried products

Parameter	BO	BL
Moisture	4.57^{A}	5.54 ^{A}
Minerals	2.66 ^{A}	3.29 ^{A}
Fats	26.69 ^{A}	23.44 ^{A}
Protein	62.29 ^{A}	61.72 ^{A}
Carbohydrates	3.78 ^{A}	5.50 ^{A}

Source: Own Elaboration (2025)

Note: Different letters for each parameter evaluated indicate a significant difference ($p<0.05$).

Finally, it was decided to conduct a bromatological evaluation of the different pork rinds: pork rinds fried in oil (PRFO), pork rinds fried in lard (PRFL), and pork rinds fried in a microwave oven (PRFM), comparing them with a commercial brand.

According to the results of the proximate chemical analysis presented in Table 4, it can be observed that microwave pork rinds have a higher protein content and lower fat content, with percentages of 71.79% and 20.88%, respectively. These differences are statistically significant ($\alpha=0.5$) compared to the control (CPR). This is explained by the fact that microwave pork rinds have a 133.43% increase in protein content and a 43.31% decrease in fat content compared to the control sample.

Box 7

Table 4
Bromatological evaluation of different types of popcorn vs. commercial brand

Parameter	PRFO	PRFL	PRFM	CPR
Moisture	4.10^{A}	4.07 ^{A}	4.19^{A}	3.63^{A}
Minerals	2.81^{A}	3.80 ^{A}	2.16 ^{A}	1.86^{A}
Fats	35.35^{A}	34.1 ^{A}	20.88^{B}	46.20^{A}
Protein	56.71^{A}	57.80^{A}	71.79^{B}	53.8 ^{A}
Carbohydrates	1^{C}	0.2^{B}	0.9^{C}	0^{A}

Source: Own Elaboration (2025)

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Note: Different letters for each parameter evaluated indicate a significant difference ($p<0.05$).

Once the standardization process was complete, a completely randomized design was developed, as shown in Table 5, to observe whether there was a significant difference between the penetrability of the formulations developed compared to two commercial brands.

Box 8

Table 5

Evaluation of the penetrability of different formulations compared to commercial brands

Product	Penetrability (mm)
PRFO	13.32^{A}
PRFL	12.72^{AB}
PRFM	13.46^{A}
CPR1	11.96^{B}
CPR2	10.18^{B}

Source: Own Elaboration (2023)

Note: Different letters for each parameter evaluated indicate a significant difference ($p<0.05$).

The results shown in the table above demonstrate that the formulations developed have greater penetrability; this suggests that they are firmer and therefore do not crumble easily, which may be related to the fact that they are crunchier than commercially available brands.

Sensory tests

The study was conducted using a discriminatory (triangular) test in which, once the instant pork rind process had been standardized, a sensory evaluation was carried out. This consisted of forming a group of 30 consumer panelists who were selected through an exam or test in which they demonstrated their ability to detect basic flavors (sweet, salty, sour, and bitter) in order to evaluate and compare whether there were significant differences between the formulations developed and a commercial brand. sour, and bitter) in order to evaluate and compare whether there were significant differences between the formulations developed and a commercial brand. The results obtained from the sensory analysis can be interpreted using Table 3 from Pedrero and Pangborn, 1989.

Depending on the number of judges and the level of significance chosen, the (minimum) thresholds necessary to determine whether there are significant differences are obtained. This analytical differentiation test was performed to determine the participants' ability to discriminate between similar samples. For this test, three samples were used for evaluation by trained panelists. The test consists of a triad, where two samples are the same and one is different.

Based on the problem posed to determine the discriminating ability of the judges, whose test questions have dichotomous YES or NO answers, they distinguish the different sample. It was determined that the most suitable statistical hypothesis test was to use the binomial test resulting from several Bernoulli-type trials according to Infante and Zárate (2000). In the Binomial probability model, the sample space consists of the sequences of successes and failures resulting from *n* independent repetitions of an experiment whose probability model is Bernoulli with a constant probability p of success.

Therefore, the following set of hypotheses was established: H0: $p > 1/3$ vs. Ha: $p \leq 1/3$ Where: Ho: The judge does not distinguish the sample as different from the instant pork rind test triad. Vs. Ha: The judge does distinguish the different sample from the instant pork rind test triad. $p= 1/3$ is the constant probability of success that the judge will distinguish the different sample from the triad. The decision rule is to reject H0 if: $X \leq c$", where c is such that $P(X \leq c \mid p = 1/3) \leq \alpha$ Where X represents the minimum number of judges required to discriminate between samples and c is the number of judges who discriminated between samples in the test with a significance level of $\alpha=0.05$ error.

Based on the above, when conducting the analysis with 30 panelists, only 17 detected the different sample of instant pork rinds in oil and 15 in lard, so it is concluded that there is no significant difference between the instant pork rinds formulation and the commercial brand because a minimum of 20 of them must detect the different sample to say that there is a significant difference, as shown in the following tables of results.

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Box 9

Table 7
Results of the triangular test of the sensory evaluation

Sample	Panelists	
	Noticed a difference	**Did not notice any differences**
In oil	17	13
In Lard	15	15

Source: Own Elaboration, 2023

Box 10

Figure 2
Final product (microwave pork rinds)
Source: Own Elaboration, 2025

Conclusions

In conclusion, the evaluation of heat treatments and parameters for instant pork rinds demonstrates that it is feasible to develop instant pork rinds for microwave ovens. A key advantage of the developed product is its high protein content and low-fat content, which gives it a competitive edge over other commercial brands.

Another advantage of this product is that it is considered safe in terms of microorganism development, since it uses a heat treatment of boiling at a temperature of 200°C and then dehydrates to 4% moisture to prevent the development of microorganisms. Similarly, the product is crunchier than commercial brands, which is an advantage as this is the main appeal of this type of snack on the market.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Carlos Abraham Reynoso Ocampo: Conceived and supervised the overall research project, directed the intellectual framework, and led the process development and product standardisation.

Celerino Arroyo Cruz: Provided specialised technical review and critical validation of the analytical methodologies.

Elia Trejo Trejo: Designed the experimental methodology and performed the statistical analysis and interpretation.

Jesús Cervantes Miranda: Conducted the editorial review and manuscript style correction.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Availability of data and materials

Indicate the availability of the data obtained in this research.

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Abbreviations

AOAC: Association of Official Analytical Chemists.
CPR**:** Commercial Pork Rind
BL: Boiled in Lard
BO: Boiled in Oil
LPR: Lard Pork Rinds
MPR: Microwave Pork Rinds
OD: Oven Dried
OPR: Oil Pork Rinds
PRFL: Pork Rinds Fried in Lard
PRFM: Pork Rinds Fried in Microwave
PRFO: Pork Rinds Fried in Oil
SFA: Satured Fatty Acids
SD: Sun dried
TFA: Trans Fatty Acids

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