Agricultural Sciences, 2019, 10, 476-486
http://www.scirp.org/journal/as
ISSN Online: 2156-8561
ISSN Print: 2156-8553

Processing of Snack of Goat Chub Chili (*Capsicum annuum* L.) with Formulations of Tomato and Tomato-Marjoram

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How to cite this paper: López, N.L., Rubio, F.I., Carrasco, C.A. and Herrera, M.A. (2019) Processing of Snack of Goat Chub Chili (*Capsicum annuum* L.) with Formulations of Tomato and Tomato-Marjoram. *Agricultural Sciences*, **10**, 476-486.
https://doi.org/10.4236/as.2019.104037

Received: October 25, 2018
Accepted: April 8, 2019
Published: April 11, 2019

Abstract

The cultivation of goat chili has potentially increased in Chile, due to different varieties of gourmet products made with it; for this reason, new industrial projects are sought to the growing volume to adapt them to the new trends in consumption habits, mainly focused on achieving an attractive meal, a fast preparation and consumption, while nutrients are provided to offer some benefits for human health. The "snacks" products that include the use of fruit satisfactorily respond to these requirements, in addition to providing marketing alternatives to the surplus of fruit exports. For this reason, the present test, consisting of the processing of snacks based on goat chub chili with the addition of tomato and marjoram, was carried out to increase the palatability and the sensorial quality of the final product. The following formulations were used: only chili (T_1); chili and tomato (T_2); chili, tomato and marjoram (T_3). The latter one was characterized by a good flavor and aroma. A large amount of the fruit water content had been removed by drying it with forced hot air. A product without chemical preserves was obtained, with physical and chemical parameters similar to those required by similar foods existing on the market today. In sensorial terms, the formulation to which marjoram was added showed good sensorial and acceptability attributes, highlighting them from the rest of the treatments. The snack color was maintained after the dehydration process, according to panelists.

Keywords

Dehydrated, Snack, *Capsicum annuum* L., Goat Chub

1. Introduction

Chili is a plant native to Tropical America and is part of the Solanaceae family.

In tropical conditions, it is a perennial species, while in temperate climates it is an annual one. This species has a great genetic variability, as it is shown in the different harvests [1].

In Chile, 521.6 ha of chilies were cultivated in 2016, where the largest amount was located in the regions of Coquimbo and Maule [2]. Its consumption is considered a traditional one and it is characterized by its itch and aroma. Lately, the harvest of goat chub chili has potentially increased, due to the different varieties of gourmet products made with it, such as sauces, pastas and jams, among others, besides being used as a dressing in cheeses and snacks [3].

A snack is known as the food eaten among regular meals; it is often used to satisfy hunger for a while [4]. Usually these foods are classified as "junk food" because they have a little or no nutritional value and excessive additives and they are not healthy.

Currently, there is a lack of healthy snacks, being fruits, nuts, cereal bars, cookies, crackers or other similar product made from grains or bran the ones largely consumed. This item is in full growth because there is a tendency to eat healthier foods and to learn about their ingredients and nutritional properties [5].

In this study, snacks will be processed based on goat chub chili with tomato and tomato-marjoram formulations, with nutritional values and sensorial attributes, as an alternative of healthy snacks for the new needs of the population, in addition to the use of a traditional product from Chile.

In this sense, the general objective of this paper is to prepare a snack based on ripe goat chub chili (*Capsicum annuum* L.) with tomato and tomato-marjoram added.

Consider also the specific objectives: a) to evaluate the sensorial and texture attributes aroma, color and taste, as well as to measure the level of acceptability of the processed snacks; b) to evaluate in the processed snacks their nutritional and chemical parameters such as Vitamin C, fibers, pH, acidity and the soluble solids respectively.

2. Materials and Methods

The experimental tests and the chemical and physical analyzes were carried out in the laboratories of the School of Agronomy from the Catholic University of Maule (35˚01'42.0"S, 71˚11'39.8"W). The sensorial analysis was developed in the Rosario Evaluation Center (34˚21'07.6"S, 70˚51'30.5"W).

The goat chub chilies (*Capsicum annuum* L.) were purchased from a producer of INDAP, in the town of Villa Prat, Maule Región (35˚05'47.5"S, 71˚37'04.3'W).

For the treatments with tomato formulation, tomatoes (*Lycopersicon esculentum Mill.*) of HMX industrial variety were used, purchased from a producer in the district of Rengo, region of Libertador General Bernardo O'Higgins (34˚22'06.8"S, 70˚50'35.1"W). In addition, for the treatment with tomato and marjoram formulation, the latter one was obtained from a Villa Prat producer.

The soil where chilies were harvested is of alluvial origin, with good drainage

and a very light texture, having 100 cm effective depth. The tomato soil is of alluvial origin, characterized by a moderately heavy texture, good drainage and 100 cm effective depth [6].

The climate in Rengo has a thermal regime that is characterized by temperatures that vary between 27.9˚C maximum in January to 4.1˚C minimum in July. 1586 days-degrees and 1276 cold hours are annually recorded; its water regime is 495 mm of annual average precipitation, with a dry period of 8 months. While in Villa Prat, the thermal regime is characterized by temperatures between 29˚C in January of maximum and 4.9˚C minimum in July. Annually it has 1762 days degrees and 950 cold hours, the annual average rainfall is 696 mm, with 7 months of dry period [7].

2.1. The Snack Processing

The snack making was developed from the flowchart presented in **Figure 1**.

Fruits were selected by means of the harvest maturity index, which consists of: size, firmness and color of the fruit. The size of the fruit should be 10 to 15 centimeters long and 1.5 to 2.5 centimeters in diameter, while the color should have a minimum of 50% [8]. The result of the process was divided into 3 treatments:

Treatment 1 (T_1): 5 g guar gum was added, previously dissolved in 50 mL of water, for each 60 g dehydrated one, thus chili agglomerates were formed.

Treatment 2 (T_2): Tomatoes were selected for this treatment by means of the harvest maturity index, which focuses on the red color of the fruit. Subsequently, a superficial washing was made with a chlorinated solution and then they were cut into pieces. For dehydration, they were placed in an aluminum tray and they were taken to a stove by forced air (Memmert UFB500) at 60˚C for 12 hours, as estimated in previous tests. After that, they were grounded in a blender (Philips HR2095) until small pieces of approximately 5 mm^2 were obtained. Both dehydrated substances were mixed in a tray, with 5 g guar gum added and previously dissolved for each 50 g mixture to form agglomerates.

Treatment 3 (T_3): The same procedure was followed as in Treatment 2, adding dehydrated marjoram to the mixture.

Packing:

Packing was made in transparent polyethylene bags that were at rest for 15 days to perform the analysis.

2.2. Analysis

2.2.1. Organoleptic Analysis

The organoleptic analysis was carried out by 13 previously trained panelists, who evaluated the sensorial attributes of the snack by means of structured sensorial evaluations primers and by unstructured acceptability ones [9].

2.2.2. Nutritional Analysis

Vitamin C: 2,6-dichloroindophenol for the determination of Vitamin C in fruit juices was obtained through the titrable official analysis method [10].

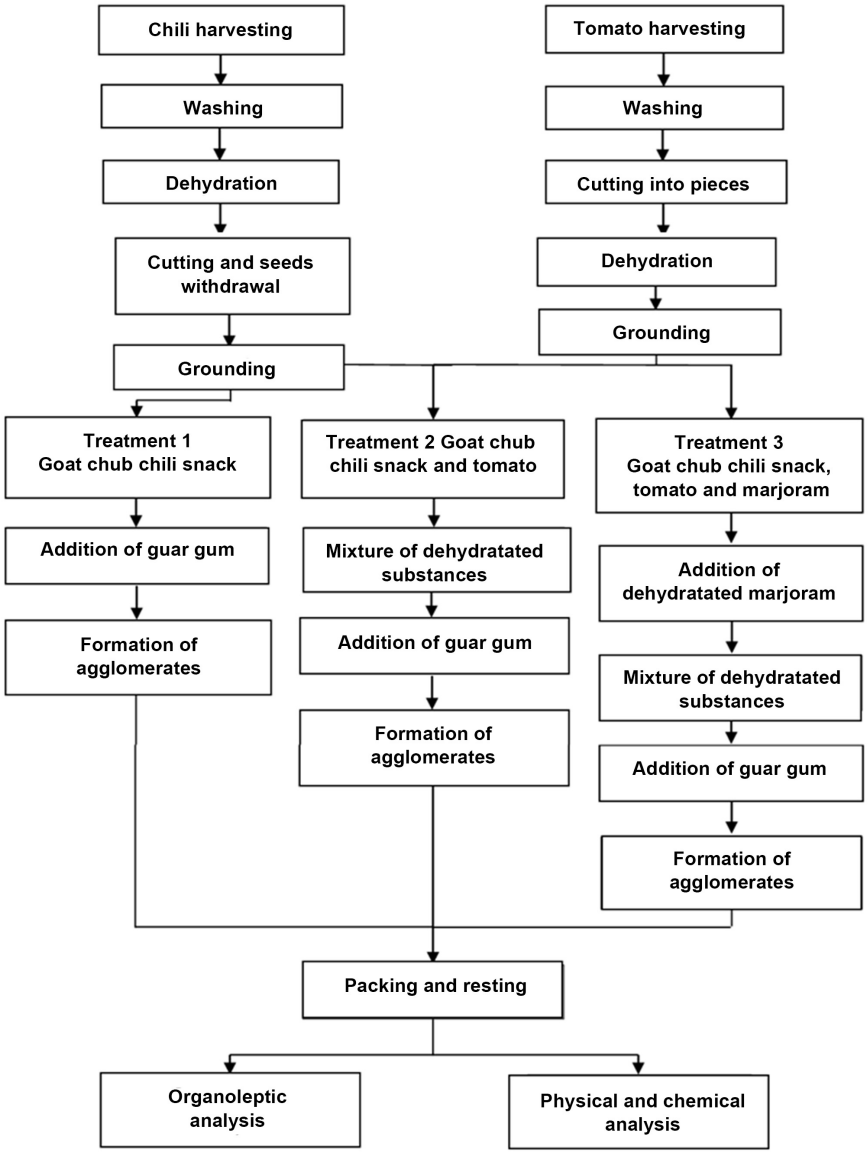

Figure 1. Flowchart of the process of making goat chub chili snacks.

Raw fiber: It was determined by means of the gravimetric method [11] [12].

2.2.3. Chemical Analysis

pH was determined according to the AOAC 981.12 [11], by means of a Hanna HI8424 pH meter.

Soluble solids: The measurement was carried out using a refractometer (Milwaukee MA871), according to the method described by [13] and the results were expressed in ˚Brix.

Total acidity: According to the AOAC 942.15 official method: Acidity (titratable) in fruit products [10].

2.3. Experimental Design

Snacks were prepared from pieces of chili with tomato and marjoram added.

According to the formulations made (Table 1), the effects of the three treatments were evaluated with three repetitions for each of them. The experimental design was randomized; randomizing treatments in a uniform way so as not to influence on the results. The minimum experimental unit in which the treatments were applied was 10 g of chili.

Statistical analysis: They were carried out to determine statistical differences; the results achieved were subjected to an ANOVA variance analysis. When there were differences among the treatments, the data were subjected to the Duncan multiple range test with a level of significance of 95% ($p \leq 0.05$).

3. Results and Discussion

3.1. Physical-Chemical Characterization of the Dehydrated Raw Material

The physical-chemical characterization of the dehydrated raw material was also carried out to describe the dehydrated raw material. Soluble solids, pH, total acidity and Vitamin C were determined (Table 2).

The chili results were compared to researches on *Capsicum annuum* since there are no studies on the goat chub variety. The Vitamin C content of the snack was much lower compared to the study by [14], 37 mg/100 and 70 - 300 mg/100, respectively; this is due to its different varieties, in addition to agronomic factors such as open-air or greenhouse harvests, planting framework, irrigation, fruit maturity, among others [14]. The total acidity was similar to that shown by [15] in their research, 1.83% and 1.6% respectively.

The pH of the research is similar to the one described by [16] in a range between 4.91 and 5.07. According to [17], the range of soluble solids is 7 to 11 ˚Brix, a little lower than the result of the present investigation, which is due to the degradation of fructan polymers in simple sugar molecules or the bigger loss of water in the general composition of the mature fruit [18].

The tomato results in the investigation were similar in pH (4.18 and 4 to 4.8) and they have a difference in soluble solids (15.10 ˚Brix) and in acidity (2.23%), compared to the established ranges by [19], from 1.5 to 4.5 ˚Brix in the first and 0.14% to 0.2% in the second case. This could be due to the origin of the raw material as well as to the harvest techniques. The content of Vitamin C of the present study is similar to that proposed by [20], of 17.8 mg/100 and 16.9 mg/100, respectively.

3.2. Chemical and Nutritional Characterization of the Finished Product

Chili snacks and their formulations were analyzed in terms of their chemical and nutritional components after the dehydration and packing of the finished product. The temperature used is reported in several vegetable studies, where moderately high temperatures are recommended to avoid great degradation of essential components [21] [22].

Table 1. Treatments for tha processing of snack.

Treatments	Characteristics	Dosis used
Treatment 1 (T_1)	Only chili	Without the addition of other products
Treatment 2 (T_2)	Chiliand tomato	For each gr of chili, 1 gr tomato was added (1:1)
Treatment 3 (T_3)	Chili, tomao and marjoram	For each gr of chilli, 1 gr tomato and 0.08 gr marjoram (1:1:0.08) were added.

Table 2. Physical-chemical characteristics of dehydrated raw material.

Characteristics	Chili (*)	Tomato (*)
pH	4.84 ± 0.01	4.18 ± 0.03
Soluble solids (˚Brix)	13.93 ± 0.14	15.10 ± 0.15
Total acidity(%)	1.83 ± 0.03	2.23 ± 0.03
Vitamin C (mg/100)	37.23 ± 1.46	17.80 ± 1.10

*Results obtained in the study corresponding to the mean ± standard error.

The pH results obtained, soluble solids and raw fiber are shown, having a significant difference in the treatments T_1 (chili) and T_2, T_3 (those having tomato and tomato-marjoram formulation respectively (Table 3).

The tomato pH is lower, as observed in Table 2; thus, the pH of the treatments having this fruit in its formulation was significantly different to the treatment with goat chub chili alone. The process of dehydration produces water elimination and other substances are concentrated, such as acids that cause a pH decrease; additionally, as the tomato has more water, pH decreases more than chili does. Barbosa and Vega (2000) reported that this is mainly due to the action of heat. The importance of pH lies in contributing to the stability and preservation of the product.

The soluble solids in Treatments T_2 and T_3 were significantly different to the ones in Treatment T_1. According to [23], this is due to the inherent variation that occurs in the adjustment of water during the dehydration process; as chilies have less amount of water than the tomato, thus a higher concentration of soluble solids in the product is caused.

The raw fiber of the product made in Treatment T_1 coincides with the percentages of fibers shown by [14]; however, the value was higher than the ones obtained in the other treatments, due to the dehydration that occurred in the raw material, which also increased the concentration of fibers, depending on the nature of the fruit. Due to the formulation that the treatments have, raw fiber decreases in the products processed in Treatments T_2 and T_3 (Table 4).

Table 4 shows the results of the analysis of Vitamin C and total acidity, which do not have any significant difference.

Vitamin C did not show any significant difference between the products obtained in the different treatments, but it was observed that the ones obtained In Treatments T_2 and T_3 showed a lower content of Vitamin C in comparison to that from Treatment T_1, probably due to the amount of chili in the formulation

Table 3. Content of pH, soluble solids and raw fiber of the finished product.

Treatment	pH	Soluble solids (˚Brix)	Raw fiber (%)
T_1	4.83 ± 0.04a	9.06 ± 1.33a	23.5 ±1.44a
T_2	4.32 ± 0.02b	7.26 ± 0.11b	11.83 ± 0.44b
T_3	4.36 ± 0.01b	6.80 ± 0.40b	11.16 ± 0.44b

The values correspond to the average ± standard error. Different letters in the column indicate statistical difference ($p < 0.05$).

Table 4. Vitamin C content and total acidity of the finished product.

Treatment	Vitamin C (mg/100)	Total acidity (%)
T_1	17.80 ± 1.10a	1.00 ± 0.05a
T_2	12.76 ± 2.76a	1.43 ± 0.01a
T_3	15.56 ± 1.13a	1.26 ± 0.008a

Results obtained in the study corresponding to the mean ± standard error.

of the different treatments. Another cause of the increase of snacks from Treatment T_3 was due to marjoram, being similar to that reported by [24], who observed an ascorbic acid content of 26 ± 3 mM/g.

With regard to total acidity, no significant difference was observed among the different treatments, according to [25], the percentage of acidity is not toxic if it is less than 3%, coinciding with what is described in the present study. In addition, it can be mentioned that a high percentage of total acidity is beneficial to avoid the proliferation of microorganisms in the snacks, thus being able to generate a stable food over time [26].

3.3. Analysis of Sensorial Attributes and Acceptability of the Final Product

The values registered by the panelists in the aroma attribute were between 3.08 and 6.41 (**Table 5**), being significant differences between Treatment T_3 and the rest; due to the formulation, since marjoram has phenolic compounds, highlighting the thymol that is obtained from the leaves, being the additive compound used the most by the food industry [27].

According to [28], the perception of color has a decisive importance because it is the prior to the other sensorial attributes; therefore, it can be exclusive in the appreciation of a food. In the evaluation of the color attribute, the panelists did not denote significant differences among the different treatments, being the characteristic color of the fruit of origin the one perceived by them (**Table 5**).

The panelists perceived differences among the treatments in relation to the texture attribute, being significant with values of 3.45 and 4.62 (**Table 5**). The differences were due to the formulations of the treatments, the tomato and the marjoram gave different textures to the product, together with guar gum. In addition, the differences were also possible due to the fact that the product is

Table 5. Results of the sensorial evaluation of the finished product.

	Aroma	Color	Texture	Flavor
T_1	3.80 ± 0.38b	6.98 ± 0.20a	4.62 ± 0.40a	3.07 ±0.25c
T_2	4.88 ± 0.42b	6.37 ± 0.30a	3.45 ± 0.33b	5.05 ± 0.42b
T_3	6.41 ± 0.25a	6.68 ± 0.22a	4.26 ± 0.40ab	6.15 ± 0.32a

Results obtained in the study corresponding to the mean ± standard error. Different letters in the column indicate statistical difference ($p < 0.05$).

heterogeneous, as the panelists could perceive the presence of particles of different sizes, evidencing an irregular texture.

Panelists considered that the snacks processed in Treatment T_3 showed a less spicy flavor than the ones processed in other treatments, bringing about significant differences among them (Table 5). This was due to the tomato and marjoram formulation; the latter one is a plant that is used in an aromatic form, as it delivers a particular aroma that charms different tastes; that is why, it is used in different foods. In addition, spices and particularly marjoram stimulate the taste buds [29].

Significant differences were observed among the treatments regarding the acceptability of the processed snacks (Table 6), being the one obtained in Treatment T_1 the one having a rate of 4.41, and belonging to a regular product (4.0 to 4.99), according to the acceptability primer. It happens mainly because this treatment formulation is only composed by chili, which caused panelists to dislike them.

In addition, panelists classified as indifferent the snacks processed in Treatment T_2, with values from 5.0 to 5.99, according to the acceptability primer. The snacks processed in Treatment T_3 were the ones that achieved the highest level of acceptability, being classified as more than regular with ranges between 6.0 and 6.99, according to the acceptability primer, due to its formulation of chili with tomato and marjoram, being the mixture and the marjoram what allowed a higher acceptability of the product by the panelists.

4. Conclusions

It is feasible to process a snack made of goat chub chili (*Capsicum annuum* L.) with formulations of tomato and tomato-marjoram, obtaining a product that provides a higher added value to the chili, besides offering alternatives in the food industry.

The content of Vitamin C did not present significant differences among the treatments, but at the same time, a diminish of ascorbic acid was observed for the treatments that had tomatoes, due to the formulation, where they had less than 50% of chili.

The content of raw fiber was significantly different between the treatment with goat chub chili (T_1) and the treatments with tomato and tomato-marjoram formulations (T_2 and T_3, respectively); this was due to the dehydration of the raw material.

Table 6. Results of acceptability of the finished product.

Treatment	Acceptability
T_1	4.41 ±0.19c
T_2	5.22 ± 0.19b
T_3	6.36 ± 0.18a

The values correspond to the average ± standard error. Different letters in the column indicate statistical difference ($p < 0.05$).

The pH and the soluble solids showed significant differences between Treatments T_1 and T_2 - T_3. This was due to the formulations with tomato during the dehydration process, causing a concentration of acids (pH) and soluble solids; whereas, in the evaluation of total acidity, the treatments did not have significant differences among them.

The treatment with goat chub chili (T_1) did not obtain an adequate sensorial evaluation to be an alternative to the traditional snacks by itself, not being the case of the treatments with formulation of tomato (T_2) and tomato-marjoram (T_3), which obtained a higher acceptability and sensorial evaluation by the panelists.

On the other hand, in the treatment with the tomato-marjoram formulation (T_3), the addition of marjoram showed an attractive option to favor the flavor attribute in the snack. In addition, the acceptability in the treatment with this spice is highlighted; that is why it is feasible to select this treatment as the most attractive in its sensorial evaluation.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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