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ORIGINAL ARTICLE

Development and characterization of sauces formulation based on tomato and garlic powders

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ABSTRACT

Background: Consumers have increasingly high demands in terms of taste, color and texture; they expect foods to be safe, healthy and nutritious, more appealing in color, texture and taste, and ready-to-use products such as sauces. **Aim**: The aim of this study was to formulate sauces with tomato (TP) and garlic (GP) powders resulted from conventional and microwave dryings. **Material and Methods:** TP was used at 0, 5, 10 and 15% in the formulation of tomato sauce and GP at 0, 5, and 20% in the formulation of garlic sauce. For studying the effects of these powders on quality of sauces, some properties such as pH, Brix, apparent viscosity, mesophilic aerobic total flora (MATF), total coliforms,mold and yeast colony count and sensory evaluation were determined. **Results:** The results showed that the increase in the powders proportions increased pH from 5.32 to 5.72 for garlic sauces but decreased it from 5.42 to 5.04 for tomato sauces. However, the Brix values increased from 12.8 (5% tomato sauce) to 19.6% (15% tomato sauce), and from 15.5 (5% garlic sauce) to 18.8% (20% garlic sauce).On the other hand, it caused decrease in apparent viscosity from 7 to 3.5 cm for tomato sauces and from 5to 2.5 cm for garlic sauces. Similarly, MATF, mold and yeast colony count in sauce samples were diminished. **Conclusion:** The use of TP at 5% (estimated by 60% of the experts) is recommended for the formulation of the tomato sauce whereas for the garlic sauces, the two formulations used were equally appreciated by 100% of the experts.

Keywords: Tomato sauce, garlic sauce, physicochemical analysis, microbiological analysis, sensory analysis.

ARTICLE INFORMATION

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1 Introduction

Sufficient consumption of vegetables is one of the main principles of a healthy diet and can improve overall wellbeing and reduce the risk of major non-communicable diseases. The beneficial health properties of vegetables depend on several points, namely, they are rich dietary sources of various immune-protective substances such as fiber, vitamins, as well as non-nutritive phytochemicals, including carotenoids and phenolic compounds (anthocyanins and flavonoids) [1, 2]. In addition, agri-food products of plant origin occupy an important place in our diet because they are rich in the nutrients necessary to meet nutritional needs [3].

The tomato (*Solanumlycopersicum* L.) is one of the most consumed vegetables in the world in various forms and it is a vegetable of major commercial interest. Tomato is considered a protective food due to its special nutritional value,

antioxidant activities and anti-cancer functions [4]. Moreover, the production and consumption of tomato are constantly increasing. Tomato is often processed into multi-ingredient products that contain vegetable oil, onion, and other vegetables such as carrot, pepper, and celery and are used in products such as sauces, juices, powdered concentrates, and soups or as an ingredient of fully prepared meals [5-7]. The drying of tomato allows to obtain a powder which possesses a long shelf life and gives a specific functionality to the product. Furthermore, it is considered a good source of various macro and micro mineral elements where one hundred grams of tomato powder provides between 6.39 and 87.00 % of the recommended daily allowance for the various macro elements[8].

Garlic (*Allium sativum* L.) is among the foods that possess functional properties and displays some positive effects on health. Moreover, this vegetable is readily available, produced in large quantities and is reasonably priced. The World Health Organization (WHO) recommends eating one or two cloves a day to benefit from the health interests of garlic. Garlic can be consumed and used in several forms: fresh, essential oil, oil extract, aged extract, and powder [9-11].

Nowadays, consumers have increasingly high demands in terms of taste, color, and texture; they are looking for beneficial products for health, attracted by their color, texture and taste as well as ready-to-use products such as sauces [12]. These are a combination of several ingredients including vegetables, fruits, oil, meat products, chicken, fish, spices, and condiments. Sauces are employed to season dishes and intensify their smell, appearing, and consistency and could be used in various foods [13]. They involve ready-to-eat sauces, gravies, and dressings, and mixes to be reconstituted before intake [14].

The large range of the elements that include a sauce leads to the production of a high number of represented sauces for each region. Among the best-known sauces in the world are ketchup, mustard, mayonnaise, soy sauce, fish sauce, and barbecue sauce [14]. Occasionally, the tomato powder is combined with some condiments to enhance the flavor and to offer a more specific taste to the dishes. The garlic powder obtained after drying can be used for the preparation of sauces that can be used to cook several dishes or to enrich certain foods.

Tomato sauce is a red one while garlic powder sauce is a white sauce, they are known to be beneficial to health due to their anti-thrombotic, anti-microbial and anti-cholesterol properties due to their high content of vitamins, minerals and proteins and sulfur compounds. The two sauces are even a rich source of other non-volatile phytonutrients [15, 16].

Usually, it is the concentrated juice or pulp of tomato and garlic which are used to formulate a wide variety of products. This requires expensive technology to produce sauces of good quality. Furthermore, garlic powder is frequently used to season several types of sauces such as barbeque, tomato, chili, and soy sauces. Hence, the novelty of this study consists, after drying the tomato and garlic using conventional drying at different temperatures or from microwave drying at different powers [17], in finding the dehydrated powder that will provide better sauces based mainly on the determination of their acceptability. These sauces can have several applications as Algerians are known by a large consumption of dishes based on tomato and garlic. Thus, tomato and garlic sauces were prepared using different proportions of tomato and garlic powders. These sauces were then analyzed by determining their physicochemical, microbiological, and sensory properties.

2 Material and Methods

2.1 Materials and equipment

The main materials used in this study were: a pH meter (HANNA HI 8424, HANNA Instruments, USA), a refractometer (Carl Zeiss GmbH refractometer, Vienna, Austria), Bostwick consistometer (CSC Scientific Co. Inc., Fairfax, Va., USA), and the thermomix (Thermomix ® TM6, France).

The tomato (*Lycopersicon esculentum* MILL.), variety Guelma 1 and the garlic (*Allium sativum* L.) were purchased fresh in March 2018 at the local market of Bejaia, Algeria. Tomato is originating from the region of Beni Ksila (North-West of the department of Bejaia, Algeria) while garlic is originating from the region of Teleghma (Southeast of the department of Mila, Algeria).

2.2 Tomato and garlic powders preparation

Drying was performed at a temperature of 50, 60, 80, and 100 °C using a conventional oven dryer (Memmert, Germany) or a domestic microwave dryer (Maxipower, model MASMO23S, China) at 300, 500, 800 and, 900 W.

Tomato slices were cut into slices with an average thickness of 0.47± 0.03 cm and garlic of 1.8 ± 0.24 mm. They were spread evenly in a monolayer and placed in the middle of the oven or microwave applicators and the weight loss was monitored for every 30 minutes for the conventional drying and 5 seconds for the microwave drying with an external analytical accuracy of 0.01 g (RADWAG, WPS 600/C/2, Poland). The drying process was continued until a stable sample weight was obtained [17].

The microwave assisted drying was carried out in 5 second increments and each drying experiment was performed in

triplicate with a maximum thickness of 1 cm for both matrices.

The dried tomato and garlic were ground into a powder and sieved, then stored in the dark in glass vials for further analysis.

2.3 Formulation of tomato sauces

The ingredients used for the preparation of tomato sauce were: water, concentrated tomato pulp, sunflower oil, garlic sauce, sugar, tomato paste, herbs of provinces and potassium sorbate. Three types of tomato sauces were prepared using tomato powder produced from conventional drying at 50 °C in varying proportions of 5 %, 10 %, and 15 %.

The process used consists of mixing all the ingredients in the thermomix which ensures the proper homogenization of the sauce and heating to 55 °C for 15 min. Then pasteurization was carried out at 100 °C for 3 minutes, followed by cooling for a few seconds [18]. The sampling of the finished products was carried out aseptically and the formulated sauces were put in sterile bottles until further use.

2.4 Formulation of garlic sauces

Products used for the preparation of garlic sauce were water that underwent microbiological and physicochemical analyses, garlic powder produced from microwave drying at 400 W, non-iodized salt, sunflower oil, and food additives (modified starch, guar gum, carrageenan).

Two formulations of sauces with different percentages of garlic powder were prepared: 5 % and 20 % garlic sauces. The preparation of the garlic sauces consists in mixing together the garlic powder, water, sunflower oil, starch, potassium sorbate which must be dissolved in cold water beforehand, and then the mixture was put in the thermomix. It should be noted that citric acid, carrageenan, guar gum and salt must be added to the thermomix during heating to ensure proper homogenization of the components. The heating was done at 55 °C for 15 minutes and the pasteurization at 100 °C.

The sampling of the final products was carried out aseptically, and the formulated sauces were conserved in sterile bottles until further utilization.

2.5 Physicochemical analysis

The physicochemical parameters assessed were: the pH, determined by pH-meter, the brix, measured at 20 °C using the refractive index expressed by the percentage of mass according to a standardized method [19, 20], and the viscosity the measurement of which was achieved according to a standardized method [21]. The values are expressed in Bostwick cm.

2.6 Microbiological analysis of sauces

The total aerobic mesophilic flora (TAMF) using Plate Count Agar medium (PCA), the total coliforms by Cristal Violet Neutral Red Bile Lactose medium (CVNRBL) and the yeasts and molds using the Sabouraud Dextrose Agar medium (SDA) were researched by adopting a standard protocol [22-24]. The plates were incubated at 30 °C for 72 hours for TAMF, at 37 °C for 24 hours for coliforms and at 25°C for 5 days for the research of yeasts and molds.

2.7 Sensory analysis

The organoleptic quality indicators of the tomato and garlic sauces samples were determined according to the following criteria: color, intensity of smell, aroma intensity, salinity, acidity or pungency, sweetness, mouthfeel, consistency.

The sensory panel was composed of nine expert tasters who are not smokers, had no perfume and had not consumed any food or drink that could influence their perceptions for a period of one hour before the analysis. In order to perform the tasting of the different sauces, the formulated tomato sauces were used to prepare mini pizzas and the garlic sauce to prepare green beans.

2.8 Statistical analysis

The data were analyzed by one way ANOVA assay to assess the statistical difference $p < 0.05$ using Statistica software (STATISTICA 9.0 Stat Soft, USA). All measurements were done in triplicates (n=3). The analysis of the data given by the expert tasters was carried out with XLSTAT add-in for Microsoft Excel software version 2012 (Addinsoft, Paris, France).

3 Results and discussion

3.1 Physicochemical analysis

3.1.1 Hydrogen potential determination

The results of pH measurements obtained for tomato and garlic sauces are summarized in Figure 1. The results showed that the tomato sauces have acidic pH. We noticed that when the percentage of tomato powder increases, the tomato sauce becomes more acidic. Therefore, the sauce prepared at 5 % was less acidic (pH = 5.42) than the sauces prepared at 10 and 15 %. This was caused by the acidity of tomato pulp and powder since their pH was also acidic with values of 4.2 and 4.25, respectively.

It is known that the acidity of tomatoes is provided by organic acids (e.g., citric acid, malic acid, etc.). So, adding the powder brings organic acid, which lowers the pH of the sauce.

In other works, it was also demonstrated that the pH values were affected by various ingredients or conditions. In this

sense, the pH of the unprocessed tomato drink was 4.40 ± 0.05 and no significant difference was observed after thermal (pasteurization) or non-thermal (ultrasonication, ultraviolet, plasma atmospheric cold) treatments for its processing into drink [25].

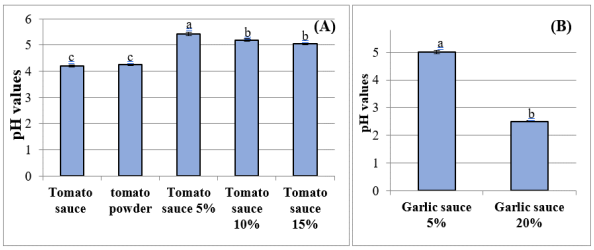

Figure 1. pH values obtained for tomato (A) and garlic (B) sauces. Each value represents the average of three replicates ± standard deviation. Different letters indicate significant difference ($p < 0.05$).

Regarding garlic sauces, we noticed that they become more acidic with the increase of percentage of garlic powder from 5 % to 20 %. According to Mahmood, et al. [26] garlic is known to possess mildly acidic characteristics, with a pH range of 6.0 to 6.4. These characteristics of garlic helped the pH of the sauce to rise substantially. This can also be justified by the composition of garlic in organic acids. Petropoulos, et al. [27] stated that the major organic acid was pyruvic acid which constituted up to 61 % of total organic acids, other acids such as citric, malic and oxalic acids are also present. The acidic pH values could also be explained by the citric acid added to the sauces.

3.1.2 Brix degree determination

The recorded results of brix degrees obtained for tomato and garlic sauces are shown in figure 2. The results obtained by the refractometer showed that the brix degree for the tomato sauce at 5 % was 12.8 °B, followed by that of the sauce at 15 % (17.3 °B). Nevertheless, the tomato sauce at 15 % recorded the highest degree (19.6 °B). According to Sadiq, et al. [28], the sugar content of dried powder samples in net weight was found to be higher than fresh tomato due to moisture loss, which explains that the brix degree of the samples increases with the increase in percentage of tomato powder added to the sauce.

The total soluble solids content of the tomato-based drink was 9.90 ± 0.05 and the thermal and non-thermal treatment did not affect this content and the sugar content [25].

The 20 % garlic sauce recorded the highest degree of brix (18.8 °B) comparatively to that of 5 % (15.5 °B).

For getting higher garlic dry powder, soluble solid content is a deciding criterion. In addition, a major diversity in total soluble solids content between the garlic genotypes was observed by other authors. It ranged from 31.67 % to 42.64 %. Differences were noticed not only between the various

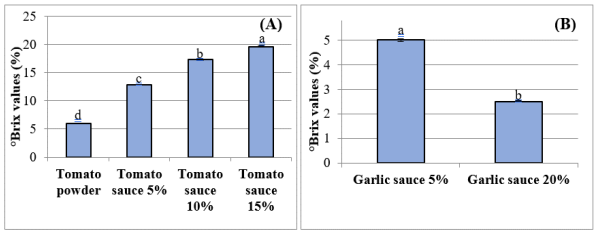

Figure 2. Brix degree values (%) obtained for tomato (A) and garlic (B) sauces. Each value represents the average of three replicates ± standard deviation. Different letters indicate significant difference ($P < 0.05$).

areas but also between genotypes of the same area. This could be attributed to different cultivation practices, soil properties and postharvest handling [27].

3.1.3 Viscosity determination

According to the results obtained (Figure 3), the consistency of the 5 % tomato sauce sample was weak, that of the 10 % tomato sauce was strong and that the 15 % tomato sauce was very thick, so that the consistency of the tomato sauce sample increased as the percentage of tomato increased. This can be explained by the fact that the tomato powder has the absorbing capacity of moisture from the tomato sauce. Furthermore, the same trend was found for the garlic sauces where the consistency of the garlic sauce samples increases with increasing percentage of garlic powder. The consistency of the sample formulated at 5 % was weak comparatively that of the sample prepared at 20 % which has a very strong consistency.

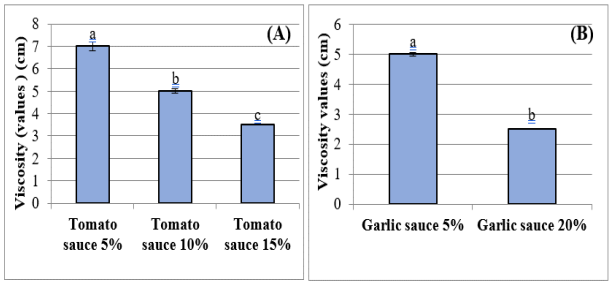

Figure 3. Viscosity values obtained for tomato (A) and garlic sauces (B). Each value is the average of three replicates ± standard deviation. Different letters indicate significant difference ($P < 0.05$).

3.2 Results of microbiological analysis

The results of the microbiological analysis are illustrated in Table 1.

Table 1. Microbiological results of tomato and garlic sauces

Tomato sauces	FTAM	Total Coliforms	Yeasts and molds
Tomato sauce 5%	Abs	Abs	Abs
Tomato sauce 10%	Abs	Abs	Abs
Tomato sauce15%	Abs	Abs	Abs
Garlic sauce 5%	Abs	Abs	Abs
Garlic sauce 20%	Abs	Abs	Abs
JORA standard	Abs	Abs	10^5 CFU

Abs: absence

Sauces are subject to microbial growth hence the need to perform microbiological analysis. It has been shown that wet pepper sauce (especially those prepared with additional ingredients such as garlic, ginger, tomatoes, onion, green spices) can provide a favorable environment for the growth of microorganisms. The bacterial isolates all belonged to the family Enterobacteriaceae.

The presence of enteric bacteria in food can be an indicator of fecal contamination likely due to poor hygiene practices by food handlers, particularly storing food at inappropriate temperatures for long periods of time.

The type of storage container also plays an important role in the contamination of chili sauce. Bacterial counts were higher in pepper stored in jars and dishes compared to pepper stored in bottles [29, 30].

The results obtained after incubation of tomato and garlic sauces are presented in Table 1. The microbiological results showed a total absence of coliforms, yeasts, and molds and TAMF which is in accordance with the standards. The total absence of coliforms in the samples analyzed testified to the satisfactory nature of the sample and showed that there was no cross-contamination. The nonexistence of yeasts and molds in the sauces would be explained by the fact that they were treated under appropriate hygienic conditions. The unavailability of the total flora would be due to the various treatments applied during the preparation of the raw materials.

It is well established that tomato and garlic powders possess an antimicrobial effect and participate in food preservation. According to Qiu and Chin [31] tomato powders from different oven-drying temperatures (60, 80 and, 100 °C) added to pork patties improved the antimicrobial ability with the increase of drying temperature. The addition of 0.5 % and 1.0 % tomato powder extract to raw patties has induced the decrease of total bacteria and enterobacteria.

Furthermore, the addition of tomato powder can decrease the pH, resulting in a decrease in the number of microbes. Thus, the addition of tomato powder could lead to an increase of flavonoids or flavonoid derivatives, thus improving the antimicrobial activities of pork patties [31].

Garlic is also known for its antimicrobial power, Yin and Cheng [32] noticed that the incorporation of lipophilic sulfur compounds such as diallyl sulfide and diallyl disulfide into meat products can reduce the proliferation of pathogenic microorganisms. Additionally, the antimicrobial effects of garlic powder were assessed towards microbial growth in raw chicken sausage during storage at 3°C. The incorporation of garlic at 9 g/kg significantly decreased the microbial growth and, subsequently, the shelf-life of the product was extended to 21 days [33].

Nevertheless, the antimicrobial capacities of garlic powder were affected by various factors such as drying methods. Accordingly, its activity was higher when freeze-drying is adopted compared to the hot air drying [34].

3.3 Results of sensory analysis

The sensory evaluation is the most popular approach for assessing the freshness of foods. It is rapid, simple, and provides immediate quality information. The sensory characteristics of tomato and garlic sauces are essential for consumer satisfaction [35]. Therefore, sensory evaluation was conducted to provide an objective view of the organoleptic characteristics of the sauce samples, based on the results of the expert panel. It also used to identify the formulation most appreciated by the panelists, in order to select a formula for subsequent studies on the product's stability, with a view to its eventual marketing.

3.3.1 Tomato sauces

The sensory profiles of the four tomato sauce samples presented in Figure 4, showed that: samples with 15 and 10% tomato powder had similar organoleptic properties but the one with 15 % tomato powder was more intense. These two sauces were characterized by a strong consistency and a strong aromatic intensity; their texture was grainy, their sweetness

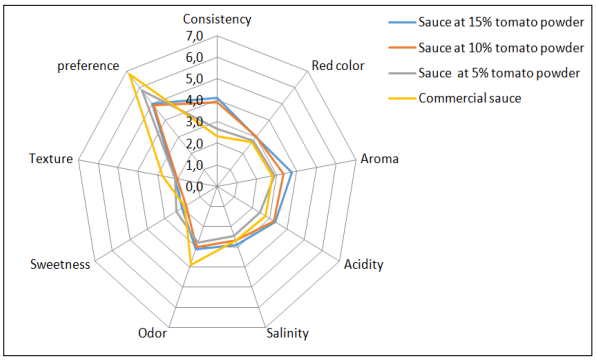

Figure 4. Spider graphs of tomato sauces sensory profiles

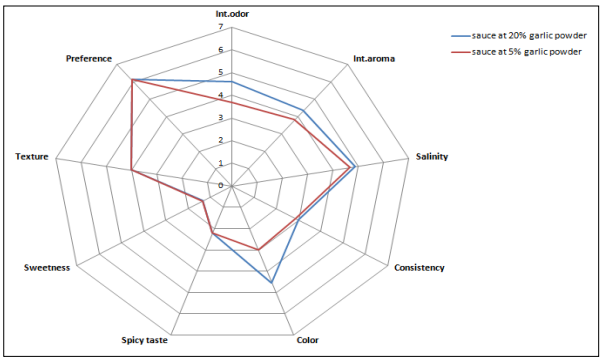

Figure 6. Spider graphs of garlic sauces sensory profiles

Sample A: sauce prepared at 5% of garlic powder, sample B: sauce prepared at 20% of garlic powder.

was low, and they were less appreciated compared to the other samples.

The sensory profiles of the four tomato sauce samples presented in Figure 4, showed that: samples with 15 and 10% tomato powder had identical organoleptic properties but the one with 15% tomato powder was more intense. These two sauces were characterized by a strong consistency and a strong aromatic intensity; their texture was grainy, their sweetness was low, and they were less appreciated compared to other samples.

The sensory parameters that have an effect on the acceptance of the formulated tomato sauces have been presented using the External Preference Mapping (PREFMAP). According to this mapping (Figure 5), the commercial sauce used as control which was characterized by its high odor intensity, smoother mouth texture and lower consistency and was more appreciated by the experts (100%). It was followed by the sauce at 5% which was distinguished from the others by its higher sweetness (60% of experts). The sauce at 10% was appreciated only by 20% of the experts; this may be due to its salinity and high acidity, while the sauce at 15% was not appreciated by the panelists because its consistency and high intensity of aroma compared to the other samples.

Jayathunge, et al. [36] formulated tomato sauces and evaluated them for color, taste, consistency/texture, and overall acceptability. They found that all the scores were similar, and the prepared sauce was accepted by the panel.

3.3.2 Garlic sauces

The sensory profiles of the garlic sauces (Figure 6) show that the properties of color, smell, aroma of the 20% garlic sauce were more intense compared to the garlic sauce at 5%. However, the texture, sweetness, consistency, salinity, and preference were very close.

According to the PREFMAP of garlic sauces (Figure 7), both formulated sauces were similarly appreciated by the experts (100 % of the experts) because they had identical organoleptic

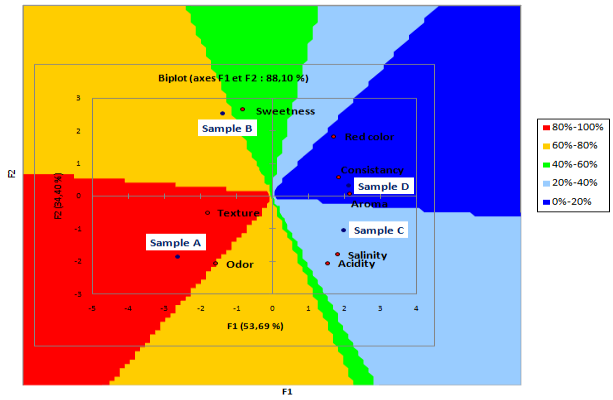

Figure 5. External Preference Mapping (PREFMAP) of tomato sauce samples

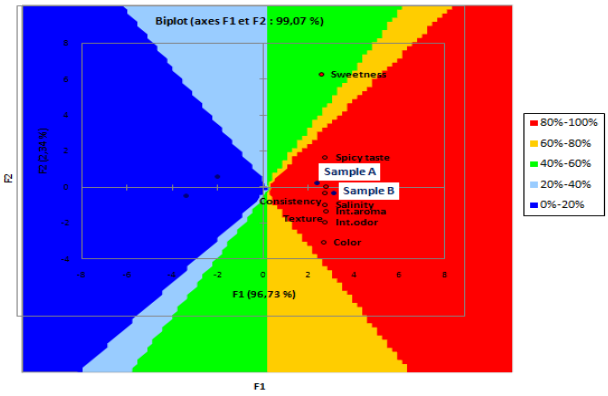

Figure 7. External Preference Mapping (PREFMAP) of garlic sauces

characteristics. This can also be explained by the nature of the powder used which was produced from microwave drying.

4 Conclusion

This work focused on the formulation of tomato sauces with tomato powder dried in a ventilated oven and garlic sauces with garlic powder dried in the microwave. Then, the physicochemical, microbiological, and sensory analyses of the formulated sauces were evaluated. A proportion of tomato powder at 5 % was sufficient to obtain a sauce with good physico-chemical and an organoleptic property since better sensory acceptance was obtained.

On the other hand, for garlic sauce, despite that the sensory analysis did not reveal any differences between the sauces prepared at 5 % and 20 %, the overall physic-chemical analyzes are in favor of the sauce prepared at 5 %. Besides, all sauce samples exhibited good microbial quality. It would be interesting to carry on our development study by undertaking nutritional analyses, by improving the formulation of the sauces in order to make them better. We also propose to perform extensive physico-chemical with phytochemical analyzes in order to evaluate other parameters of the sauces and to carry out a market study to concretize the idea.

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Authors contribution: F.B and S.G conceived and designed the study and undertook the literature research. All authors participated in the experiment and data acquisition. S.G and K.-A.M. performed the data analysis. L.S. carried out the statistical analysis, F.B, L.B-M, and K. M prepared, reviewed and drafted the manuscript. All authors approved the final version before submission. All authors have read and agreed to the published version of the manuscript."

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