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Research Article

Formulation, Characterization, and Determination of the Rheological Profile of Loquat Compote *Mespilus Germánica* L. through Sustenance Artificial Intelligence

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The theme of the presented study is to create a compote that is functional, inexpensive in cost, free of preservatives, and will have long shelf life, as well as to assess its rheological, sensory, and physicochemical properties. The objective was to construct a loquat compote (*Mespilus germánica* L.) using agar from cochayuyo (*Chondracanthus chamissoi*) for infants, determining its rheological profile with the addition of agar extracted from cochayuyo in three concentrations (0.10, 0.15, and 0.20) % w/w, respectively, with help of artificial intelligence (AI) pathway. Agar was withdrawn from the cochayuyo by alkaline treatment with 0.04 M NaOH, obtaining a yield of 1%. Consequently, each compote was subjected to a sensory attributes using a 5-point hedonic scale with 60 panelists (30 undergraduate students and 30 infants between 3 and 5 years of age using a graphic hedonic scale). The sensory analysis using AI as a base is applied to both adult and infant panelists determined that the compote that had as input agar from cochayuyo at a concentration of 15% had greater acceptability due to the fact that significance was reported ($p < 0.05$) according to Friedman's test. The compote with the highest acceptability was subjected to proximal chemical characterization, reporting the following: moisture (64%), protein (1.68%), fat (1.01%), fiber (2.35%), ash (1.34%), and carbohydrates (29.62%). Its physicochemical characterization was also determined, reporting the following: pH (4.32), soluble solids (16° Brix), and total acidity (0.23 g malic acid/100 g compote). Finally, A Brookfield RV-DVIII ULTRA viscometer with Spindles N° 5 and 6 was used to integrate AI data gathering and use it for rheological profile assessment. The loquat compote was found to have a non-Newtonian, pseudoplastic behavior that was adjusted to the Ostwald–De Waele model with an $R^2 = 0.987$.

1. Introduction

The medlar (*Mespilus germánica* L.) is a subtropical evergreen fruit species (family Rosaceae, subfamily Mathat Ioideae) native to southern China. 90% of the cultivation is now centered in the Sicily area, particularly in the province of Palermo. Farina et al. [1] based on multiple hybrids and native sustainability in the market, with an extended harvesting time. Medlar fruits are brown-reddish in color, 1.5–3 cm in diameter, and 10–80 g in weight for the little ones. The firm fruits are collected in the fall and stored in cold, dark places. Since antiquity, plants have been esteemed for their therapeutic powers [2, 3]. According to Gentile et al. [4], nonindigenous cultivars and local ecotypes with high nutraceutical potential are used extensively in Sicilian loquat agriculture. The same is also found in Gentile et al. [5] noticeable physicochemical features. Currently, there is an increasing interest in commercial loquat production, which is oriented towards superior quality loquat cultivars [6]. Loquats are abundant in potassium, magnesium, carotenoids, and phenolic compounds, all of which may aid to prevent and treat heart disease. The potassium in loquat fruit helps dilate blood vessels in the cardiovascular system. This reduces the strain and stress put on the blood vessels and arteries.

In Peru, the production of medlars reaches a total of 2 thousand tons. Faostat [7], a capa lipophilic called cuticle, shelters the fruits' surface, and it contains two primary constituents. According to Buschhaus and Jetter, cuticular wax refers to the lipophilic chemicals released by solvent extraction as a whole, whereas cutin refers to the lipophilic element that cannot be removed due to its polymeric nature [8].

Several studies have identified several bioactive chemicals that are likely linked to the health benefits of loquat. Loquat trees are indigenous to China, which can be seen growing in the wild. Loquats are being used in traditional Chinese medicine for thousands of years. It contains a high concentration of antioxidants, which are chemicals that protect cells from injury and illness. In one study, loquat leaves were shown to have a higher antioxidant impact than 54 other medicinal plants. According to early research, loquat fruit and leaves may help prevent cancer. The antioxidants in loquat fruit help to inhibit the genesis of malignant tumors. Coughs, diabetes, and cancer were among the ailments treated with loquat fruits and leaves by the Chinese [9, 10].

For the first time, a Portuguese explorer brought the fruits back to Europe in the 16th century. Loquats have a high concentration of antioxidants, which have been chemicals that protect cells from injury and disease. In one study, loquat leaves were found to have a higher antioxidant effectiveness than 54 other medicinal plants [11, 12]. According to Ahumada et al. [13], numerous epidemiological research has suggested that consistent dietary depletion of phenolic compounds may help to avoid chronic illnesses associated with oxidation. According to Li et al. [13, 14], in loquat leaves and flowers, triterpenoid substances such as ursolic and oleanolic acids have been found in varying amounts based on the stage of growth and cultivar type. According to preliminary study, loquat fruit and leaves may help prevent cancer. Loquat fruit contains antioxidants that aid in the suppression of malignant tumor development. Loquat extract or fruit can help eliminate cancer cells within the body, preventing tumor formation and spread. Loquats have been proven to have anticancer properties in animals and at the cellular level, although this has not been explored in people [15, 16]. Artificial intelligence (AI) is, at its most basic level, any process in which a machine makes a decision rather than a human. An AI model is a type of AI in which data are used to train a model with real-world examples until it is capable of performing a certain task. Using AI, making a loquat compote is straightforward.

The soluble solid percentage of a good grade loquat fruit is above 12 percent, with an acidity of 0.3 to 0.6 percent. According to Dhiman et al. [17], this pulp contains high levels of vitamin A, ascorbic acid, calcium, and active ingredients including kaempferol, ursolic acid, oleanolic acid, and quercetin, as well as pharmacological qualities such as anti-inflammatory, antioxidant, and antidiabetic capabilities. According to Testa et al. [6], loquat has a limited shelf life and is prone to a variety of physiological problems as well as postharvest decompensation. Therefore, appropriate physical, chemical, and biological storage and postharvest treatment techniques are required. According to Xiao et al. [18], to expand customer accessibility and add value to loquat, it is turned into a variety of products such as jam, juice, jellies, compotes, and wine. The potassium in the loquat fruit helps the cardiovascular system dilate blood vessels. In this method, you can reduce the strain and stress on the blood vessels and arteries. Potassium also helps to keep your heart healthy by lowering blood pressure. After all, high blood pressure carries a slew of health hazards, including stroke, heart problem, eyesight loss, and heart failure, to name a few [19, 20]. According to Testa et al. [6], however, their production implies guaranteeing a product that complies with different quality standards as recommended in CODEX STAN 79, FAO [21]. The compote is made in the form of puree, usually by adding sugar and spices, and mixing them to obtain a consistency/texture (usually using xanthan gum) suitable to avoid the risk of choking in babies, FAO [21]. Operators can analyze and ensure optimum circumstances, such as soluble solid content and concentration of different nutritions, such as vitamin, with the help of an artificially intelligent system, in order to achieve superior results with a high-quality index.

Food rheological feature is vital for process design and optimization, and it also has a link to product stability and quality prediction, as well as product formulation. According to Zhou et al. [22], rheological properties of fruit juice used in various food products such as nectars, jams, and compotes. Similar work is also reported by Al-Amoudi et al. [23] and Salinas et al. [24]. They looked examined how adding apple fiber and changing the temperature affected the rheological qualities of apple juice and found that apple juice presented a thixotropic behavior above a 10% fiber content for the whole range of applied temperatures. Likewise, according to Huang et al. [25], the chemical and rheological parameters of litchi pulp polysaccharides were investigated using the power law model to analyze litchi flow behavior. However, Barbieri et al. [26] determined the rheological characteristics and properties of gabiroba pulp and jams, in which they determined that gabiroba pulp presented a gel performance with thermal stability. On the other hand, Quintana et al. [27] determined the shear stable and dynamic rheological properties of pumpkin (cucurbita moschata) pulp. They found that the flow behavior of the product is well described by the Carreau–Yasuda model with an $R^2 = 0.9712$ demonstrating the closeness of the data. Due to its importance, the objective of the present research work was to elaborate a compote based on the juice of the nispero de palo (*Mespilus germánica* L.) for infants, functional, low cost, without preservatives, and with a considerable shelf life, as well as to measure its rheological, sensory, and physicochemical characteristics.

The rheological properties of loquat compote have been identified and defined. This will help to promote heart health because to the high concentration of vitamins, minerals, and antioxidants. Their potassium and magnesium levels, in particular, are essential for blood pressure control and proper arterial function. Carotenoids and phenolic compounds contained in the peel and meat of loquats have anticancer properties. However, one constraint is that Peruvians only drink compotes of known fruits and are hesitant to buy them when the same product is given with a different raw material. Now that recipes are represented by attributes rather than ingredients, we might be able to use this as AI training data. However, researchers like to create a recipe that is defined by ingredients rather than features. Figure 1 shows the block representation for the preparation of loquat compote using artificial intelligence. Various steps are taken to ensure the output quality. This will help to develop low cost and without preservative added material.

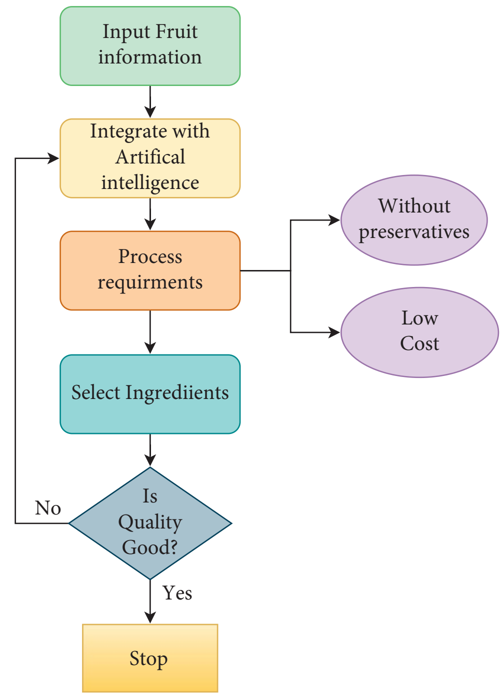

Figure 1: Use of AI for loquat compote preparation.

2. Materials and Methods

2.1. Níspero (Mespilus Germánica L.). Samples of loquat (*Mespilus germánica* L.) were collected at the ripening stage during August 2021 in the province of Huanta (latitude: −12.94, longitude: −74.2478; latitude: 12° 56′ 24″ south, longitude: 74° 14′ 52″ west). Department of Ayacucho is located at 2761 m.a.s.l. and is one of the largest producers of loquat. Experimental and analytical tests were carried out in the laboratories of the Professional School of Agroindustrial Engineering of the Faculty of Applied Sciences of the National University of Central Peru, Tarma Branch.

2.2. Preparation of the Loquat Pulp (Mespilus Germánica L.). Healthy loquat (*Mespilus germánica* L.), which is free of any deterioration, was selected, washed, and disinfected by immersion in water with 50 mg/L of sodium hypochlorite for 5 minutes and dried at room temperature. According to Mishra et al. [28], for peeling and pulping, it was previously scalded in boiling water (85°C for 3 min); in this way, the peel was softened and the peeling could be done manually, and consequently, the pulping could be carried out. The pulp was cut into pieces of approximately 1 × 1 cm and taken to a pulper (Vulcano, DFV 19–40 I/C, Peru), with water in a ratio of 1 : 0.25% w/v to obtain a pasty pulp. It was then sieved to remove any solid material present. Finally, the pulp obtained was pasteurized at 95°C for 10 min, packed in airtight containers, and stored refrigerated (4°C) for subsequent use in compote formulations. AI can be used for healthy loquat pulp extractions. It can guide the operators about the exact process with perfect timing for the preparation.

2.3. Chondracanthus Chamissoi. The Chondracanthus Chamissoi was attained in the native market in the province of Acobamba (latitude: −12.8428, longitude: −74.5694; latitude: 12° 50′ 34″ south, longitude: 74° 34′ 10″ west), during the month of August 2021, being transported in a cooler to the Laboratory of Agroindustrial Processes 01 of the Professional School of Agroindustrial Engineering of the UNH, Acobamba. According to Mishra et al. [28], where they were washed and disinfected by immersion in water with 50 mg/L of sodium hypochlorite for 5 minutes and dried at room temperature, drying was carried out in an oven (Memmert UN 30) at 60°C for 12 hours. Afterwards, the sample was crushed with the help of a grinder (Grindomix GM200) to obtain uniformity in granulometry. Finally, the sample was collected in airtight containers and stored at (4°C) until its respective use.

2.4. Agar Extraction from Chondracanthus Chamissoi. For the extraction of agar, the methodology proposed by Meena et al. [29] was followed, 25 g of dry algae was weighed in 1 L of distilled water and left to stand for 12 h, and then, the extraction was carried out in triplicate at 90°C for 2 hours using 0.04 M sodium hydroxide; with the help of a piece of cloth, it was possible to filter and obtain an extract that was left to stand at 15°C until it gelled.

Then, it was frozen at 5°C and thawed to filter it in cold with the help of a cloth. The obtained supernatant was taken to heating adding 250 mL of water until its boiling for 15 min. Then, it was filtered to the vacuum, dried, and weighed and the yield was calculated.

2.5. Preparation of the Compote. The formulations used are described in Table 1. It shows the standard formulation of medlar compote. Various materials are added, which are clearly mentioned along with their respective percentage level. The mixture of each formulation was homogenized in

Table 1: Standard formulation of medlar compote (*Mespilus germánica* L.).

Component	F1 (%)	F2 (%)	F3 (%)
Loquat pulp	88	88	88
Corn flour	1.8	1.8	1.8
White sugar	8.2	8.2	8.2
Powdered milk diluted at 24% in water and 0.4% citric acid	1.9	1.9	1.9
Agar	0.10	0.15	0.20

*The water was previously boiled with cinnamon for 5 min. F1, F2, and F3: formulations 1, 2, and 3.

order to standardize and find a compote with adequate characteristics. This product was cooked at 85°C for 15 minutes. The compotes were packed in glass containers of 4 ounces each, being subjected to heat treatment (115°C for 25 min) using an autoclave (AMERICAN 50-X) to eliminate the presence of pathogenic microorganisms and obtain a harmless product. The containers were stored in a cool, dry place.

2.6. Sensory Profile. The sensory properties of loquat compote samples (*Mespilus germánica* L.) using agar from cochayuyo (*Chondracanthus chamissoi*) were classified through the following attributes: color, odor, flavor, texture, and general appearance as recommended by Anzaldua, [30]. According to Forghani et al., there were 60 untrained panelists of which 30 of them were recruited from the Professional School of Agroindustrial Engineering of the National University of Huancavelica, 15 were male and 15 were female, with ages ranging from 19–30 years, a 5-point hedonic scale was used: bad (1 point) to excellent (5 points) [31]. Here, 3 formulations (agar at 0.10, 0.15, and 0.20%) were tested. In order not to alter the appreciations due to hunger or satiety, the time of tasting was carried out in the morning from 10:00 to 11:00 hours. Previously, according to Hartmann et al., the loquat compote (*Mespilus germánica* L.) was shaken to improve the sensory characteristics and its presentation. Also, 10 mL of this compote was filled into disposable cups for subsequent tasting. Finally, the samples to be tasted were coded according to the amount of agar added (see Table 1) and were given in order to the panelists, seeking their evaluation to subsequently determine the degree of acceptability of this compote.

The compote with the highest score in degree of satisfaction was subjected to a second evaluation, these being 30 children between 3 and 5 years of age (initial level), belonging to the I.E. Inicial N° 125 of the district of Paucará, Province of Acobamba, Region Huancavelica, Peru. With parental consent, each child was given a 4-ounce jar of compote (approximately 113 g) and a spoon for consumption. The total consumption of each jar was then verified in order to establish the percentage of acceptance and the percentage of rejection of the product [32].

2.7. Characterization of Loquat Compote. Once the loquat compote with the addition of agar was obtained from *Chondracanthus chamissoi*, the following determinations were carried out.

2.7.1. Physical and Physicochemical Analysis of the Most Acceptable Loquat Compote. Soluble solids were measured using a digital refractometer (SCHMIDT-HAENSCH, DHR-60, Germany), scale from 0 to 60% Brix at 20°C using the refractometric method 932.12, AOAC [33]. Following the titration method of total acidity, 942.15, AOAC [33], the outcome was stated as percentage of malic acid. The pH was evaluated by potentiometric technique, using a pH meter (Hanna HI22091-01), according to AOAC method 981.12.

2.7.2. Proximal Chemical Analysis of the Most Acceptable Loquat Compote. It was evaluated by the procedures suggested by the Association of Official Agricultural Chemists-AOAC international, AOAC [34], in protein (Kjeldahl method), ash (total ash method), fiber (Weende method), fat (Soxhlet method), moisture (oven drying method), and carbohydrates (by difference of 100% minus the result of the previous analyses).

2.7.3. Microbiological Analysis of the Most Acceptable Compote. Several microbiological analyses were determined, including fungi and yeast counts: COVENIN 1337 [35], coliform count. COVENIN 1086 [36], and mesophilic aerobic count. COVENIN 902 [37], according to NTP 203.106 and CODEX STAN 79–1981, in order to ensure that the product is safe and reliable for the consumer.

2.7.4. Rheological Evaluation of the Most Acceptable Loquat Compote. The compote samples were conditioned at temperatures of 17°C, 25°C, 35°C, and 45°C and rotational speeds of 0.5, 1, 2, 4, 10, 20, 50, and 100 rpm using a rotational viscometer (Brookfield, DV III Plus, the United States). With the data obtained, the rheological profile was determined using the Mitschka methodology and the Ostwald–De Waele model, Sánchez et al. [38].

Mitschka's methodology allows us to obtain data from different rheograms and those rheograms obey that behavior. Ortega et al. [39] in their study of the effect of temperature and concentration on the rheological properties of Tommy Atkins variety mango pulp grown at 15°C, 30°C, 45°C, and 60°C and Aguilar [40] in the influence of temperatures at 25°C, 45°C, and 65°C on the rheological behavior of prickly pear pulp. And in the present study, four different temperatures, 17°C, 25°C, 35°C, and 45°C, are chosen.

2.8. Statistical Analysis. The data obtained in the sensory evaluation were processed using the FRIEDMAN non-parametric test with a significance level of 5%. Finally, Student's *t*-test was applied to establish the best formulation of loquat compote (*Mespilus germánica* L.) using agar from cochayuyo (*Chondracanthus chamissoi*), with greater acceptability in terms of color, odor, flavor, texture, and general appearance. All the statistical studies were carried out using the software "SPSS ver. 25" and *R* Project (free software), ver. 3.3.6. *R* Team Core [41].

3. Results and Discussions

3.1. Sensory Profile. The analysis of the sensory profile of loquat compote (*Mespilus germánica* L.) with different percentages of agar from cochayuyo (*Chondracanthus chamissoi*) was evaluated using Friedman's method (see Table 2). A significant difference $p < 0.001$ was found for the attributes of color, odor, flavor, texture, and general appearance. For the color attribute, the highest score was found when 0.20% agar was added in the preparation of the compote from nispero followed by the addition of 0.10% agar with a mean score of 4.63 and 4.43 (good) and when 0.15% agar was added it had the lowest score with 4.37 (very fair). Regarding the attribute odor, consistency flavor, and general appearance (see Figure 2), the highest score is found when 0.20% agar is added in the loquat compote, with scores of 4.23, 4.43, and 4.37, showing a rating of good.

In the second stage of sensory evaluation with infants (preschool age), the loquat formulated with (0.20%) of agar extracted from (*Chondracanthus chamissoi*) showed better sensory attributes in panelists from 19 to 30 years of age. Finding in infants from 3 to 5 years of age is an acceptability of 96.7%. According to Pedrero and Pangborn [42], a minimum score of 85% in acceptability of compotes is required to be considered highly acceptable in the market. Thus, the results found allow us to think of carrying out an investment project with economic indicators for its subsequent application on an industrial scale in the province of Huancavelica, Peru.

Likewise, Quintero et al. [43] obtained an acceptability of 70% of infants for loquat compote with *Gracilaria debilis*. On the other hand, Camayo-Lapa et al. [44] reported an acceptability of 96.67% in preschool children with a pumpkin compote. The findings lead us to consider putting out an investment project with economic statistics for eventual industrial uses in Peru's Huancavelica area.

3.2. Physical and Physicochemical Composition. The physicochemical parameters of the most acceptable compote formulated with 0.20% agar from *Chondracanthus chamissoi* are presented in Table 3.

The pH at 18°C showed a value of 3.93 ± 0.09, indicating that the compote is an acid food. This acidity is related to the addition of citric acid in the formulation. This outcome is alike to that found by Tapia et al. [45], in Jicama compote with a pH of 3.97, and Ferweez and Ismail [46], who reported a pH between 3.63 in date compote prepared with different levels of Dibs and milk. On the contrary, Marrugo et al. [47] and Quintero et al. [43] found pH of 4.28 and 4.32 in mango compote and loquat compote, respectively, when Zaragoza bean starch gelling agent was used.

The percentage of acidity in the compote showed a value of $0.55 \pm 0.042\%$. Camayo-Lapa et al. [44] reported lower values of (%) acidity (0.23 ± 0.04) in the squash compote. By contrast, Perez and Mera [48] found a higher acidity content of 1.20% in quinoa and mango compote. The difference in acidity content may be related to the raw material used for compote formulation.

The soluble solid showed a value of $12.00 \pm 0.07\%$. This value is within the established by the standards NTP 203.106 (2012) and INEN 1995–10 (2009), with minimums of 16.5% and 15.0%, respectively. A similar finding (11%) was reported by Tapia et al. [45], in their Jicama (*Smallanthus sonchifolius*) compote. On the contrary [10], we obtained 16.6% soluble solids in quinoa and mango compote, which may be related to the fact that the investigations are from different countries whose regulations also have different parameters.

3.3. Proximal Chemical Composition. Table 4 shows the proximate composition of loquat (*Mespilus germánica* L.) and of the compote made from loquat pulp with the addition of (0.20%) agar from *Chondracanthus chamissoi*. A higher content of all parameters was observed in the loquat compote with the exception of moisture due to the cooking process.

The moisture content of the loquat compote showed a value of $78.90 \pm 0.21\%$. A similar finding was reported by Pilamala et al. [49], on sweet potato and goose compote (79.64%), but lower than quinoa and mango compote (25.85 ± 1.8 to 52.15 ± 1.4 %). The similar work is reported by Perez and Mera [46], for loquat compote (62.2 ± 2.6 to 66.1 ± 2.2) %. By Quintero et al. [59] and Camayo-Lapa et al. [60] for pumpkin.

It is to be noted that rheology in viscous liquid meals is important because it helps engineers solve engineering equations, design new products, perform quality controls, determine shelf life, and emulsion stability, among other things. The loquat leaf, seed, and fruit have been shown to reduce inflammation, which is the body's overreaction to an irritant such as germs or allergies. Loquat leaves have long been used in Chinese medicine to treat diseases caused by inflammation, such as bronchitis [50, 51]. The ash content was $1.05 \pm 0.28\%$, a value higher than that reported by Perez and Mera [48] (0.45 to 1.26%) in quinoa and mango compote. Likewise, a lower value is reported than that reported by Quintero et al. [43] (0.81 ± 0.11 to $0.85 \pm 0.08\%$) in loquat compote. On the other hand, Ferweez and Ismail [46] reported a higher value (2.24 ± 0.01 to $2.65 \pm 0.02\%$) in date compote made with various amounts of Dibs and milk.

The reported protein value is $2.20 \pm 0.32\%$, which is within the value reported, i.e., 1.86 to 3.33% by Ferweez and Ismail [46] for date compote made with various amounts of Dibs and milk. As well as Perez and Mera [48] has reported

Table 2: Results of the Friedman test between treatments for each sensory attribute.

Attribute	Treatments	Sum (ranks)	Mean (ranks)	T^2	p value
Color	0.10% de agar	119.00	1.98^b	3.14	0.0468
	0.15% de agar	111.00	1.85^a		
	0.20% de agar	130.00	2.17^b		
Odor	0.10% de agar	105.00	1.75^a	4.47	0.0135
	0.15% de agar	126.00	2.10^b		
	0.20% de agar	129.00	2.15^b		
Flavor	0.10% de agar	109.00	1.82^a	8.11	0.0005
	0.15% de agar	111.00	1.85^b		
	0.20% de agar	140.00	2.33^c		
Texture	0.10% de agar	100.00	1.67^a	41.55	<0.0001
	0.15% de agar	103.00	1.72^b		
	0.20% de agar	157.00	2.62^c		
General appearance	0.10% de agar	106.00	1.77^a	17.42	<0.0001
	0.15% de agar	107.00	1.78^b		
	0.20% de agar	147.00	2.45^c		

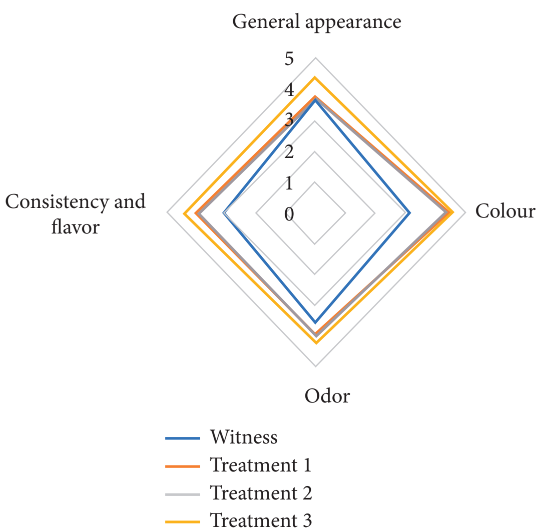

Figure 2: Evaluation of the sensory attributes of loquat compote (*Mespilus germánica* L.).

2.06 to 7.29% in quinoa and mango compote. On the other hand, this value is higher than that reported by Pilamala et al. [49], with 0.32% protein in sweet potato and goose compote. Similar findings are being reported by Quintero et al. [43], 0.39 ± 0.02 to 0.42 ± 0.01% in loquat compote and by Camayo-Lapa et al. [44], 1.68 ± 0.02% in pumpkin compote.

Fat was 0.05 ± 0.02%, lower value than that presented by Ferweez and Ismail [46]. 1.53 to 2.38% in date compote made with various amounts of Dibs and milk. It is also reported by Quintero et al. [43], 0.45 ± 0.04 to 0.50 ± 0.01% in loquat compote; by Camayo-Lapa et al. [44] 1.01 ± 0.01% in pumpkin compote; and Perez and Mera [48], 0.83 to 3.42 % in quinoa and mango compote.

In fiber, it was 2.10 ± 0.21%; a value similar to that reported by Ferweez and Ismail [46], i.e., 2.24 to 2.65 % in date compote prepared with different levels of Dibs and milk. Similar studies have been reported for apple, sweet potato, and goose compote (2.29%) [49], and pumpkin compote (2.35 ± 0.04%) Camayo-Lapa et al. [44].

Table 3: Physico-chemical composition of the compote of nispero de palo (*Mespilus germanica* L.) formulated with agar from *Chondracanthus chamissoi* (0.20%).

Analysis	Results
pH	3,93 ± 0,09
% Acidity (expressed as ascorbic acid)	0.55 ± 0.04
% Soluble solids	12,00 ± 0,07

Finally, in carbohydrates (17.80 ± 0.13%), the result is within that reported by Perez and Mera [48], (14.78 to 36.73) % in quinoa and mango compote. However, Pilamala et al. [49] reported a higher value of 14.60% in sweet potato and goose compote and Camayo-Lapa et al. [44] reported a higher value of (11.17 ± 0.04%) in pumpkin compote. The variability of the results could be due to the difference in the raw materials used in them.

3.4. Microbiological Analysis. Mold and yeast counts showed values <100 cfu/ml, while total coliforms were <10 cfu/ml. These results indicate that the loquat compote (*Mespilus germánica* L.) with the addition of agar from *Chondracanthus Chamissoi* is suitable for human consumption since there is no microbiological risk. In addition, this compote complies with NTP 203.106 (2012) (product free of microorganisms under normal storage conditions), NTS 071-MINSA/DIGESA for products with pH of 4.6 (semi-preserved), which indicates low probability of development of microorganisms, and CODEX STAN 79–1981, with which it can be affirmed that the product is safe and meets a guarantee for consumption.

3.5. Rheological Profile. The rheological characterization was carried out in stationary flow tests, at different temperatures (17, 25, 35, and 45°C) and with the most acceptable loquat compote prepared with 0.20% agar extracted from *Chondracanthus chamissoi*, using the Ostwald–De Waele model, with three repetitions (R1, R2, and R3), observing the shear stress behavior. The viscous

Table 4: Proximal composition of loquat (*Mespilus germánica* L.) and compote from loquat pulp with addition of 0.20% agar from *Chondracanthus chamissoi*.

Parameter	Medlar tree	Compote of medlar tree
Moisture	85.90 ± 0.02	78.90 ± 0.21
Ash	0.51 ± 0.32	1.05 ± 0.28
Protein	0.40 ± 0.29	2.20 ± 0.32
Fat	0.01 ± 0.05	0.05 ± 0.02
Fiber	1.80 ± 0.11	2.10 ± 0.21
Carbohydrates	13.18 ± 0.18	17.80 ± 0.13

Note. Data are expressed as mean ± standard deviation (S.D.), $n = 3$.

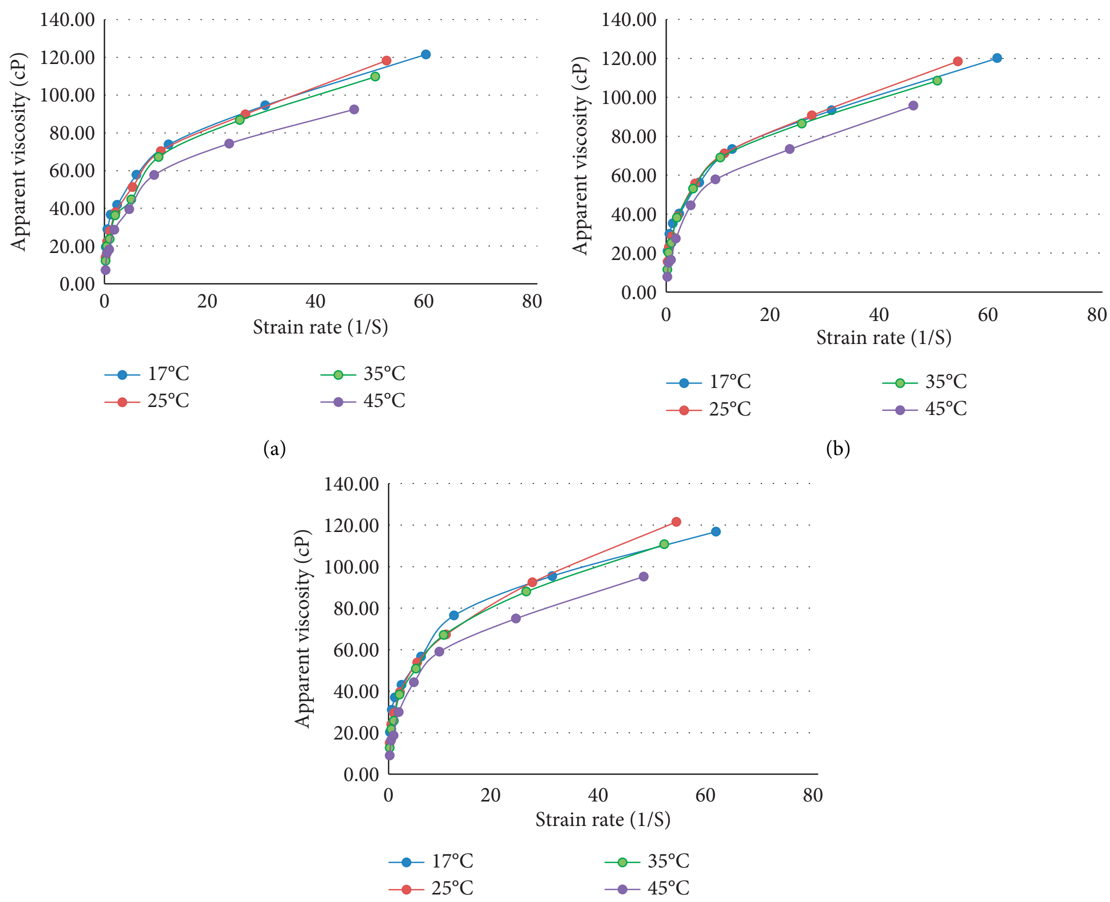

Figure 3: Rheological curves of loquat compote (*Mespilus germanica* L.) with 0.20% agar from *Chondracanthus chamissoi* with three replicates: (a) repeat 1, (b) repeat 2, and (c) repeat 3 at four different temperatures (17°C, 25°C, 35°C, and 45°C).

flow curves of the loquat pulp (Figure 3) show characteristics of a non-Newtonian fluid of the pseudoplastic type, because it presents a nonlinear trend with a concave curve. It is to be noted that, with the increase in the strain rate, the apparent viscosity of the fluid increases. This dignifies the output significance of the compote, considering that the particle size and processing temperature significantly affect all rheological parameters of the solutions according to Dogan et al. [52].

In similar investigations on rheological behavior of fruit juices, several power laws have been used; however, the most frequent is the Ostwald–De Waele power law [53], where they worked with Malbec grape juice and found that this juice conforms with great precision to the Ostwald–De Waele model. Likewise, Silva et al. [54] reported similar results in mixed nectars containing pineapple skin juice and fruit pulp; these nectars showed a non-Newtonian behavior that conformed to the power law. Similarly, Maieves et al. [55] investigated the rheological behavior of Hovenia dulcis pulp considered as an exotic fruit, reporting that the data fit much better to the Ostwald–De Waele and Herschel–Bulkley model. Also, Lukhmana et al. [56] reported in sour cherry puree a rheological behavior adjusted to the Herschel–Bulkley law. Finally, Mendoza-Palencia et al. [57]

Table 5: Ostwald–De Waele model n and K parameters for loquat compote (*Mespilus germánica* L.) with 0.20% agar from *Chondracanthus chamissoi* with three replicates: (A) repeat 1, (B) repeat 2, and (C) repeat 3 at four (17°C, 25°C, 35°C, and 45°C) temperatures.

Repetitions	T (°C)	Flow consistency index K (Pa.S^n)	Flow behavior index (n)	R^2	r
R1	17	32.1440	0.3274	0.9917	0.9958
	25	26.8534	0.3852	0.9913	0.9956
	35	24.3108	0.4025	0.9869	0.9934
	45	18.9234	0.4504	0.9654	0.9825
R2	17	32.2255	0.3174	0.9937	0.9968
	25	27.9062	0.3745	0.9933	0.9966
	35	25.0207	0.4066	0.9751	0.9874
	45	18.8538	0.4600	0.9739	0.9867
R3	17	32.9382	0.3151	0.9881	0.9940
	25	27.9576	0.3739	0.9917	0.9958
	35	25.6389	0.3916	0.9835	0.9917
	45	20.1280	0.4340	0.9782	0.9890

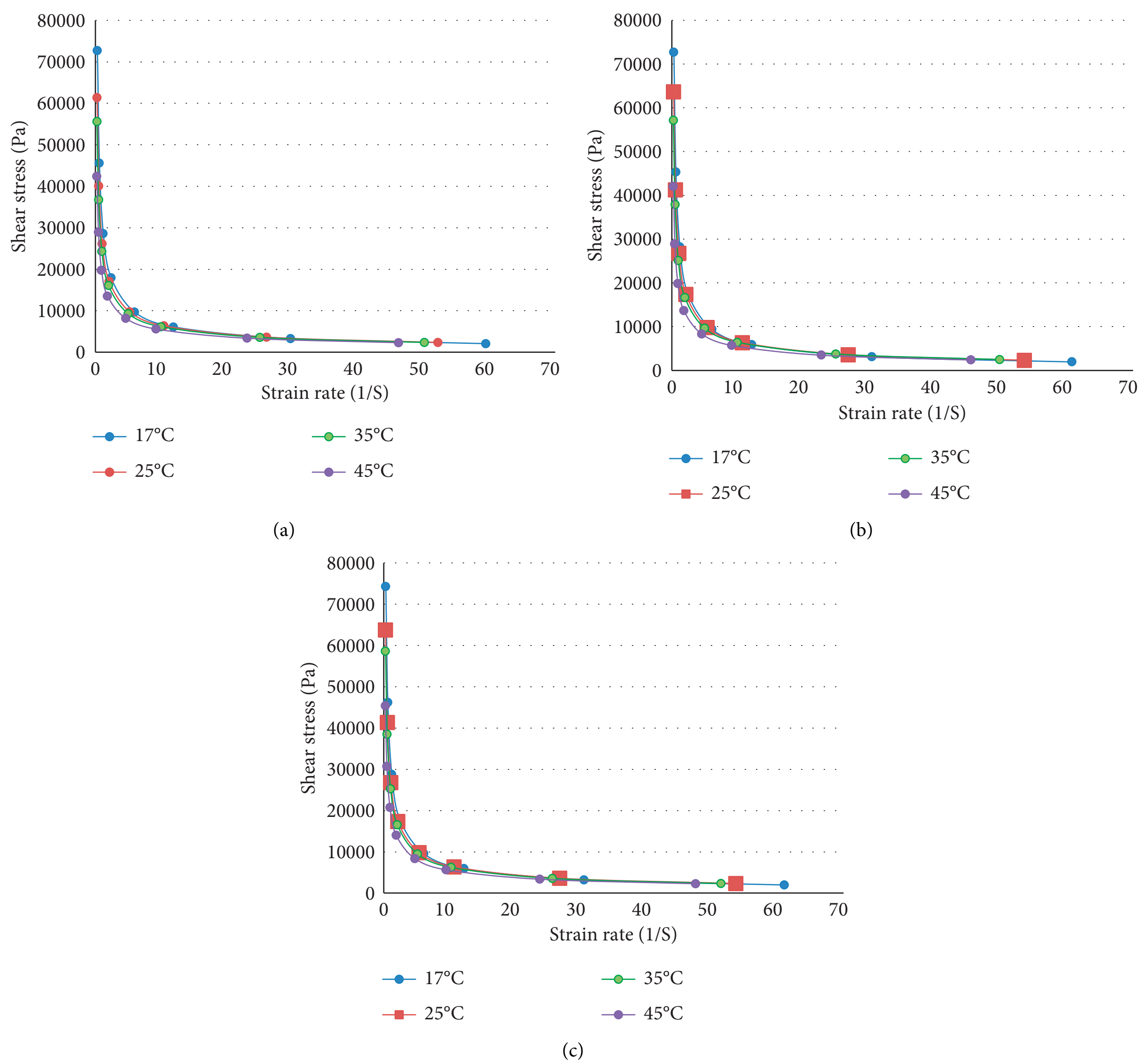

Figure 4: Apparent viscosity corrected with the Ostwald–De Waele model in the compote of *Mespilus germanica* L. with three replicates: repeat 1 (a), repeat 2 (b), and repeat 3 (c).

evaluated the rheological behavior of sapote pulp, also reporting a fit to the Ostwald–De Waele model.

Due to the behavior of the loquat compote, the data obtained (shear stress vs. strain rate) were adjusted to the Ostwald–De Waele model, which is expressed by the following equation (1), and its data are found in Table 5.

$$\tau = k(\gamma)^n, \quad (1)$$

where (k) is the consistency index, and (n) is the flow behavior index.

The aguaymanto compote acts as a non-Newtonian, pseudoplastic fluid in Figure 4, with the corrected apparent viscosity decreasing as shear stress increases. When subjected to hydrodynamic forces, the structure of the molecules cracks, and with increased alignment of the reactant molecules, the pseudoplastic fluid behaves. According to Obradovic et al. [58], the hysteresis loop between the curves may be related to the change of loquat compote viscosity over time. Normally, fruits have thixotropic behavior, so the viscosity of the compote at a constant shear rate decreases with time. According to Kubo et al. [59], from Figure 4, it is observed that loquat compote has thixotropic behavior, where the viscosity decreased with time for all three replicates and temperatures. Similar trends were reported in acai berry pulp and strawberry compote by, Costa et al. [60] and Obradovic et al. [58], respectively. Moreover, the apparent viscosity decreases with increasing temperature and strain rate (Figure 4). Similar behavior was reported in pineapple and tropical fruit nectars. Similar behavior was reported in pineapple and tropical fruit nectars by Silva et al. [54] and for strawberry pulp byChen et al. [61] and mango pulp by Tonin et al. [62].

Physiochemical properties of the liquid profile have been shown by the graphs in the in Figure 4. The graphs are plotted between shear stress and strain rate. The temperature is also varied for the evaluation. The curves show non-Newtonian behavior with pseudoplastic fluid characteristics through AI base line. Table 5 shows the dependence of the parameters of Ostwald–De Waele model (n = flow behavior index and K = flow consistency index in Pa.s) for loquat compote at four (17, 25, 35, and 4)°C different temperatures in three replicates. As can be observed, the Ostwald–De Waele model fits well to the measured values, which is demonstrated by the values of the coefficient of determination R^2 (0.9654–0.9937). In all three replicates when the temperature is increased, the flow consistence index (K) decreases, and the flow behavior index (n) had a slight increase. The same trends were found by, Pilamala et al. [49], in apple, sweet potato and goose compote, Camayo-lapa et al. [44], in pumpkin compote, de Hombre et al. [63], in mango pulp. Figueroa-Flórez et al. [64], in sweetened mango pulp, and Mechato and Siche, [65]. The flow behavior index (n) showed values lower than unity, thus confirming the pseudoplasticity in the formulation of loquat compote. This point to the existence of high-molecular-weight compounds including polysaccharides, solids dispersed in liquid, protein content, and soluble salts. So, the detected pseudoplastic performance could be a significance of both the existence of starch, proteins (low concentration), and mainly of the gelling agent. Similar findings were observed by Pilamala et al. [49], with values of (n) ranging from 0.451 to 0.502 (apple compote), De Hombre et al. [63] reported a value of 0.31 for (n) (mango pulp), and Figueroa-Flórez et al. [64], reported a value of (n) of 0.32. All the replicates prepared with agar from Chondracanthus chamissoi showed pseudoplasticity properties. Because it has a nonlinear tendency with a concave curve, the viscous flow curves of the loquat pulp reveal features of a pseudoplastic non-Newtonian fluid. Because fruits exhibit thixotropic properties, the viscosity of the compote reduces with time at a constant shear rate. The presence of starch, proteins, and, most importantly, the gelling agent might explain the observed pseudoplastic behavior.

4. Conclusion

Artificial intelligence and machine learning are ways for controlling processing equipment to deal with gradations, nuances, and causes that are too complex or numerous for the human mind to grasp. Artificial intelligence (AI) is currently being employed in several food processing applications and has the potential to be used in a wide range of others, including pulp extraction, composition preparation, and so on. The loquat compote (*Mespilus germánica*) prepared with agar from *Chondracanthus chamissoi* had a non-Newtonian behavior with pseudoplastic fluid characteristics through AI baseline. This compote is practically digestible, containing nutrients such as protein, fiber, and carbohydrates that contribute to digestion. In addition, microbiological analyses guarantee the safety and guarantee of this product in relation to national and international technical standards. The fact of preparing compotes based on loquat juice with *Chondracanthus chamissoi* agar and determining its rheological behavior offers an excellent alternative to know the type of fluid in this product and its application on a large scale in the food industry. One of the strengths of this research work is that loquat is harvested all year round in several provinces of Peru. However, one limitation is that Peruvians only consume compotes of known fruits and hesitate to buy them when the same product is presented with different raw materials. The preparation of this compote is a promising potential source of nutrients not only for infants but also for people of all ages, since it has been demonstrated that it is a very nutritious food in terms of its proximal chemical and physical-chemical composition being within the stipulations of the Peruvian technical standards and the Codex Alimentarius, being economically accessible to the consumer. Through the observations, it was found that it has a nonlinear tendency with a concave curve, and the viscous flow curves of the loquat pulp reveal features of a pseudoplastic non-Newtonian fluid. Because fruits exhibit thixotropic properties, the viscosity of the compote reduces with time at a constant shear rate. In future, various physiochemical properties can be improved by using efficient steps while production through AI and ML.

Data Availability

Data are available from the corresponding author upon request.

Conflicts of Interest

The authors declared that there are no conflicts of interest.

References

[1] V. Farina, G. Gianguzzi, and A. Mazzaglia, “Fruit quality evaluation of affirmed and local loquat (eriobotrya japonica lindl) cultivars using instrumental and sensory analyses,” *Fruits*, vol. 71, no. 2, pp. 105–113, 2016.

[2] R. Khan, N. Tyagi, and N. Chauhan, “Safety of food and food warehouse using VIBHISHAN,” *Journal of Food Quality*, vol. 2021, pp. 2021–12, Article ID 1328332, 2021.

[3] M. Yang, P. Kumar, J. Bhola, and M. Shabaz, “Development of image recognition software based on artificial intelligence algorithm for the efficient sorting of apple fruit,” *International Journal of System Assurance Engineering and Management*, vol. 13, no. 5, 2021.

[4] C. Gentile, C. Reig, O. Corona et al., “Pomological traits, sensory profile and nutraceutical properties of nine cultivars of loquat (eriobotrya japonica lindl.) fruits grown in mediterranean area,” *Plant Foods for Human Nutrition*, vol. 71, no. 3, pp. 330–338, 2016.

[5] C. Gentile, E. Di Gregorio, V. Di Stefano et al., “Food quality and nutraceutical value of nine cultivars of mango (mangifera indica L.) fruits grown in mediterranean subtropical environment,” *Food Chemistry*, vol. 277, pp. 471–479, 2019.

[6] R. Testa, G. Migliore, G. Schifani, I. Tinebra, and V. Farina, “Chemical–physical, sensory analyses and consumers’ quality perception of local vs. imported loquat fruits: a sustain-able development perspective,” *Agronomy*, vol. 10, no. 6, p. 870, 2020.

[7] FAOSTAT, “Food and agriculture organization of the United Nations,” 2022, https://www.fao.org/.

[8] C. Buschhaus and R. Jetter, “Composition differences between epicuticular and intracuticular wax substructures: how do plants seal their epidermal surfaces?” *Journal of Experimental Botany*, vol. 62, no. 3, pp. 841–853, 2011.

[9] A. Malik, G. Vaidya, V. Jagota et al., “Design and evaluation of a hybrid technique for detecting sunflower leaf disease using deep learning approach,” *Journal of Food Quality*, vol. 2022, pp. 1–12, Article ID 9211700, 2022.

[10] S. Mohanasundaram, E. Ramirez-Asis, A. Quispe-Talla, M. W. Bhatt, and M. Shabaz, “Experimental replacement of hops by mango in beer: production and comparison of total phenolics, flavonoids, minerals, carbohydrates, proteins and toxic substances,” in *International Journal of System Assurance Engineering and Management*Springer Science and Business Media LLC, Berlin, Germany, 2021.

[11] L. Wang, P. Kumar, M. E. Makhatha, and V. Jagota, “Numerical simulation of air distribution for monitoring the central air conditioning in large atrium,” *International Journal of System Assurance Engineering and Management*, vol. 10, 2021.

[12] A. Mehbodniya, I. Alam, S. Pande et al., “Financial fraud detection in healthcare using machine learning and deep learning techniques,” *Security and Communication Networks*, vol. 2021, Article ID 9293877, 8 pages, 2021.

[13] J. Ahumada, C. Fuentealba, J. A. Olaeta et al., “Bioactive compounds of loquat (eriobotrya japonica lindl.) cv. golden nugget and analysis of the in vitro functionality for hyperglycemia management,” *Ciencia e Investigacian Agraria*, vol. 44, no. 3, pp. 271–283, 2017.

[14] W. Li, H. Yang, Q. Zhao, X. Wang, J. Zhang, and X. Zhao, “Polyphenol-rich loquat fruit extract prevents fructose-induced nonalcoholic fatty liver disease by modulating glycometabolism, lipometabolism, oxidative stress, inflammation, intestinal barrier, and gut microbiota in mice,” *Journal of Agricultural and Food Chemistry*, vol. 2019, no. 27, pp. 7726–7737, 2019.

[15] V. Jagota, M. Luthra, J. Bhola, A. Sharma, and M. Shabaz, “A secure energy-aware game theory (SEGaT) mechanism for coordination in WSANs,” *International Journal of Swarm Intelligence Research*, vol. 13, no. 2, pp. 1–16, 2022.

[16] S. Katiyar, R. Khan, and S. Kumar, “Artificial bee colony algorithm for fresh food distribution without quality loss by delivery route optimization,” *Journal of Food Quality*, vol. 2021, Article ID 4881289, 9 pages, 2021.

[17] A. Dhiman, R. Suhag, D. Thakur, V. Gupta, and P. K. Prabhakar, “Current status of loquat (eriobotrya japonica lindl.): bioactive functions, preservation approaches, and processed products,” *Food Reviews International*, vol. 1-31, pp. 1–31, 2021.

[18] G. Xiao, Y. Xu, and Y. Yu, *Asian Berries. Bioscience, Food Science Y Technology*, CRC Press, Boca Raton, FL, USA, 2020.

[19] T. Gera, J. Singh, A. Mehbodniya, J. L. Webber, M. Shabaz, and D. Thakur, “Dominant feature selection and machine learning-based hybrid approach to analyze android ransomware,” *Security and Communication Networks*, vol. 2021, Article ID 7035233, 22 pages, 2021.

[20] S. N. H. Bukhari, A. Jain, E. Haq et al., “Machine learning-based ensemble model for zika virus T-cell epitope prediction,” in *Journal of Healthcare Engineering*, C. Chakraborty, Ed., vol. 2021, Article ID 9591670, 10 pages, 2021.

[21] FAO, *Codex Alimentarius, Quick Frozen Processed Fruits and Vegetables*, Joint FAO/WHO Food Standards Program, Rome, Italy, 2nd edition, 1995.

[22] L. Zhou, Y. Guan, J. Bi et al., “Change of the rheological properties of mango juice by high pressure homogenization,” *LWT—Food Science and Technology*, vol. 82, no. 1, pp. 121–130, 2017.

[23] R. H. Al-Amoudi, O. Taylan, G. Kutlu et al., “Characterization of chemical, molecular, thermal and rheological properties of medlar pectin extracted at optimum conditions as determined by box-behnken and ANFIS models,” *Food Chemistry*, vol. 271, no. 15, pp. 650–662, 2019.

[24] D. Salinas, A. Garvin, R. Ibarz, and A. Ibarz, “Effect of apple fibre addition and temperature on the rheological properties of apple juice and compensation study,” *Lebensmittel-Wissenschaft & Technologie*, vol. 116, no. 2019, Article ID 108456, 2019.

[25] F. Huang, Y. Liu, R. Zhang et al., “Chemical and rheological properties of polysaccharides from litchi pulp,” *International Journal of Biological Macromolecules*, vol. 112, no. 2018, pp. 968–975, 2018.

[26] S. F. Barbieri, C. L. de Oliveira Petkowicz, R. C. B. de Godoy, H. C. M. de Azeredo, C. R. C. Franco, and J. L. M. Silveira, “Pulp and jam of gabiroba (campomanesia xanthocarpa berg): characterization and rheological properties,” *Food Chemistry*, vol. 263, no. 15, pp. 292–299, 2018.

[27] S. E. Quintana, D. Machacon, R. M. Marsiglia, E. Torregroza, and L. A. Garcia-Zapateiro, “Steady and shear dynamic

rheological properties of squash (cucurbita moschata) pulp," *Contemporary Engineering Sciences*, vol. 11, no. 21, pp. 1013–1024, 2018.
[28] V. Mishra, G. Abrol, and N. Dubey, "Chapter 14-sodium and calcium hypochlorite as postharvest disinfectants for fruits and vegetables," *Postharvest Disinfection of Fruit and Vegetables*, vol. 2018, pp. 253–272, 2018.
[29] R. Meena, K. Prasad, M. Ganesan, and A. K. Siddhanta, "Superior quality agar from gracilaria species (gracilariales, rhodophyta) collected from the gulf of mannar, India," *Journal of Applied Phycology*, vol. 20, no. 4, pp. 397–402, 2008.
[30] A. Anzaldua, *Sensory Evaluation of Foodstuffs in Theory and Practice*, Acribia Publisher S.A, Zaragoza, Spain, 1st edition, 1994.
[31] Z. Forghani, M. H. Eskandari, M. Aminlari, and S. S. Shekarforoush, "Effects of microbial transglutaminase on physicochemical properties, electrophoretic patterns and sensory attributes of veggie burger," *Journal of Food Science & Technology*, vol. 54, no. 8, pp. 2203–2213, 2017.
[32] G. L. Hartmann, A. M. Marconato, M. M. Romeiro Santos, L. A. Do Amaral, E. F. Dos Santos, and D. Novello, "Addition of pumpkin peel flour affect physicochemical and sensory characteristics of bovine burger," *International Journal of Regulation and Governance*, vol. 8, no. 2, pp. 254–263, 2020.
[33] Association of Official Agricultural Chemists–AOAC, *Official Methods of Analysis*, AOAC, Rockville, MD, USA, 1996.
[34] Association of Official Agricultural Chemists–AOAC, *Official Methods of Analysis of AOAC International*, AOAC International, Rockville, MD, USA, 18th edition, 2006.
[35] COVENIN 1337, "Venezuelan standard. Method for counting molds and yeasts," 1990, https://www.sencamer.gob.ve/sencamer/normas/1337-1990.pdf.
[36] COVENIN 1086, "Venezuelan standard. Method for counting coliform bacteria in pietri dishes," 1984, https://www.sencamer.gob.ve/sencamer/normas/1086-84.pdf.
[37] COVENIN 902, "venezuelan standard. Method for counting colonies of aerobic bacteria in petri dishes," 1987, https://www.sencamer.gob.ve/sencamer/normas/902-87.pdf.
[38] SÁNCHEZ Et al., (2002).
[39] Q. Ortega, F. Alberto, S. Galván et al., "Effect of temperature and concentration on the rheological properties of Tommy Atkins variety mango pulp," *ION Magazine*, vol. 28, no. 2, pp. 79–92, 2015.
[40] A. Matos-Chamorro and D. Aguilar-Alata, "Influence of temperature and concentration on the rheological behavior of prickly pear pulp (Opuntia ficus Indica)," *Journal of Research in Food Science and Technology*, vol. 1, no. 1, 2010, https://revistas.upeu.edu.pe/index.php/ri_alimentos/article/view/820.
[41] R. Team Core, *A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria, 2019.
[42] D. Pedrero and R. Pangborn, *Sensory Evaluation of Foods: Analytical Methods*, Mexican Alhambra, San Luis Potosi, Mexico, 1st edition, 1997.
[43] M. Quintero, A. Mujica, M. Linarez, M. Toyo, and Y. Acosta, "Gelling effect of gracilaria debilis agar in the preparation of loquat (manilkara zapota) compote," vol. 48, pp. 195–202, 2021.
[44] B. Camayo-Lapa, M. Quispe-Solano, E. De La Cruz-Porta, G. Manyari-Cervantes, C. Espinoza-Silva, and A. Huamán-De La Cruz, "Pumpkin (dutch maximum dutch.) compote for infants, functional, low cost, preservative-free and of considerable shelf life: rheological, sensory, physicochemical, nutritional, and microbiological characteristics," *Scientia Agropecuaria*, vol. 11, no. 2, pp. 203–212, 2020.
[45] V. Tapia, M. Parada, and M. Herrera, "Obtaining compote from jicama (smallanthus sonchifolius)," *Profil*, vol. 2, no. 18, p. 2017, 2017.
[46] H. Ferweez and H. Ismail, "Evaluation of date compote prepared with different levels of dibs and milk," *Egyptian Journal of Nutrition*, vol. 33, no. 2, p. 2018, 2018.
[47] Y. Marrugo, I. Rios-Dominguez, E. Martínez, C. Severiche-Sierra, J. Jaimes, and C. Del, "Preparation of a compote-type food using the starch of the zaragoza bean (phaseolus lunatus) as a thickener," *Research Please and Ambient*, vol. 8, pp. 119–125, 2017.
[48] A. Pérez and T. Mera, "Formulation of compote based on quinoa (chenopodium quinoa) and mango kent (mangifera indica)," *Functional Food Science and Technology Journal*, vol. 2, no. 1, pp. 43–55, 2020.
[49] A. Pilamala, J. Reyes, L. Cerda, and C. Moreno, "Harvesting of andean crops camote (ipomoea batata) and oca (oxalis tuberosa) in the improvement of the texture of an apple-based compote variety emilia (malus communis-yellow reed of blenheim)," *Agroindustrial Science*, vol. 8, no. 1, pp. 7–13, 2018.
[50] D. D. C. Flores, M. S. Escobar, and A. S. Nuñez, "Perfil reológico de compota de níspero (mespilus germánica l.) utilizando agar a partir de cochayuyo (chondracanthus chamissoi)," *Data*, vol. 2, no. 3, pp. 13–26, 2022.
[51] R. A. Mirondo, *Contribution of Enzymes and Other Components in Food in the Formation and Destruction of Volatile Compounds*, Doctoral dissertation, The Ohio State University, Columbus, OH, USA, 2016.
[52] M. Dogan, D. Aslan, and V. Gurmeric, "The rheological behaviors and morphological characteristics of different food hydrocolloids ground to sub-micro particles: in terms of temperature and particle size," *Journal of Food Measurement and Characterization*, vol. 12, no. 2, pp. 770–780, 2017.
[53] R. R. Evangelista, M. A. R. Sanches, M. B. M. de Castilhos, D. Cantú-Lozano, and J. Telis-Romero, "Determination of the rheological behavior and thermophysical properties of malbec grape juice concentrates (vitis vinifera)," *Food Research International*, vol. 137, no. 2020, Article ID 109431, 2020.
[54] D. Silva, A. Braga, L. Lourenco, A. Rodrigues, and J. Peixoto, "Rheological behavior of mixed nectars of pineapple skin juice and tropical fruit pulp," *International Food Research Journal*, vol. 24, no. 4, pp. 1713–1720, 2020.
[55] H. A. Maieves, L. C. Bosmuler Züge, A. D. P. Scheer, R. H. Ribani, P. Morales, and M. C. Sánchez-Mata, "Physical properties and rheological behavior of pseudofruits of hovenia dulcis thunb. In different maturity stages," *Journal of Texture Studies*, vol. 48, no. 1, pp. 31–38, 2016.
[56] N. Lukhmana, F. Kong, W. Kerr, and R. Singh, "Rheological and structural properties of tart cherry puree as affected by particle size reduction," *Lebensmittel-Wissenschaft & Technologie*, vol. 90, no. 2018, pp. 650–657, 2016.
[57] O. J. Mendoza-Palencia, O. A. Perez-Sierra, R. Torres-Gallo, F. A. Ortega-Quintana, E. J. Montes-Montes, and R. D. Andrade, "Effect of maltodextrin and gum Arabic concentration on the rheological behavior of sapote (calocarpum sapota merr) pulp," *Advance Journal of Food Science and Technology*, vol. 16, no. SPL, pp. 138–141, 2018.
[58] V. Obradovic, M. Ergovic, H. Marcetic, and S. Skrabal, "Properties of strawberries puree stored in the freezer," *Advance Journal of Italian Journal of Food Science*, vol. 32, no. 2020, p. 945, 2020.

[59] M. Kubo, M. Rojas, A. Miano, and P. Augusto, "Chapter 1: rheological properties of tomato products, in tomato chemistry, industrial processing and product development, 2019," *Food Chemistru*, vol. 10, no. 2019, pp. 1–25, 2020.

[60] H. C. B. Costa, F. O. Arouca, D. O. Silva, and L. G. M. Vieira, "Study of rheological properties of açai berry pulp: an analysis of its time-dependent behavior and the effect of temperature," *Journal of Biological Physics*, vol. 44, no. 4, pp. 557–577, 2020.

[61] L. Chen, L. Chen, K. Zhu, X. Bi, Y. Xing, and Z. Che, "The effect of high-power ultrasound on the rheological properties of strawberry pulp," *Ultrasonics Sonochemistry*, vol. 67, no. 2020, Article ID 105144, 2020.

[62] I. P. Tonin, C. C. Ferrari, M. G. da Silva et al., "Performance of different process additives on the properties of mango powder obtained by drum drying," *Drying Technology*, vol. 36, no. 3, pp. 355–365, 2018.

[63] R. de Hombre, G. Panadés, and L. Sardiñas, "Rheological properties of aseptically processed mango pulp at the valle del caujerí factory," *Journal of Food Science and Technology*, vol. 27, pp. 40–43, 2017.

[64] J. Figueroa-Flórez, K. Barragán-Viloria, and J. Salcedo-Mendoza, "Rheological behavior in sweetened mango pulp (mangifera indica L. cv. Magdalena river)," *Ciencia y Tecnología Agropecuaria*, vol. 18, pp. 615–627, 2017.

[65] A. Mechato and R. Siche, "Rheological properties of passion fruit (passiflora edulis) juice with the addition of dietary fiber," *Agroindustrial Science*, vol. 10, no. 3, pp. 229–234, 2020.