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Research Article

Impact of the Production Process and Added Sugar Content on the Sensory and Physico-Chemical Characteristics of Natural Watermelon Juice

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Abstract

Natural juice production is an increasingly popular activity in Burkina Faso, but it is carried out under conditions that can sometimes affect its organoleptic and physicochemical qualities. This study aimed, therefore, to assess the impact of production technology and added sugar content on certain organoleptic and physicochemical parameters of artisanally produced watermelon juice to meet consumer preferences. Monitoring the production process consisted of analyzing the entire process in accordance with the Codex Alimentarius recommendations and its impact on the quality of watermelon juice. Sensory and physicochemical analyses were performed using standard methods. Five watermelon juice formulations named P0, P8, P10, P13, and P15, containing 0%, 8%, 10%, 13%, and 15% sugar, respectively, were produced according to a standard watermelon juice production scheme. Sensory analyses showed that, overall, the treatment had no major impact on the color, flavor, and texture of watermelon juice. No significant differences were found in the tasters' assessments. However, the addition of sugar significantly altered the sweetness, consistency, and clarity of the juice. Physicochemical analyses confirmed these results, as pH, acidity, Brix degree, refractive index, and impurity content were significantly influenced by the addition of sugar to watermelon juice (pH from 3.97 to 4.14; acidity from 0.20 to 0.13 g/L; Brix degree from 18.60 to 27.23 °B; refractive index from 1.36 to 1.37 and impurity content from 0.42 to 2.26 g/L. All analyses showed that adding 8% sugar to the juice was considered the most appealing formulation by the majority of judges.

Keywords

Production Technology, Juice Formulations, Watermelon Fruit, Sensory Parameters, Physicochemical Parameters, Sugar Content

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1. Introduction

Watermelon is a creeping plant of the Cucurbitaceae family, native to South Africa, domesticated for its large, sweet, and juicy fruits [1]. It is generally cultivated in warm regions due to favorable climates and has gradually spread to the rest of the world [2]. According to the Food and Agriculture Organization of the United Nations, global watermelon production was estimated at over 90 million tons in 2023 [3]. Among the major producing countries, China holds the first place with an estimated production of 60 million tons, followed by Turkey with 4 million tons, and Algeria (first place in Africa) with 2.2 million tons [4, 5]. Watermelon cultivation in Burkina Faso remains modest, with a still high import rate of the fruit, but it is increasingly intensifying among market gardening products [6]. However, in the face of post-harvest losses, part of the production is oriented towards processing into value-added products, such as juices and cocktails [7]. The consumption of watermelon fruit has increasingly become part of the food consumption habits of Burkinabe people. According to literature data, the demand for watermelon fruits has increased by nearly 0.02% in recent years [6, 8]. In Burkina Faso, watermelon fruit is mainly marketed or consumed as fresh fruit [6]. Watermelon fruit is one of the largest cultivated fruits in the world; it is composed largely of water (92%), vitamins (A, C), polyphenols and antioxidants [9]. Watermelon is a rich source of bioactive phytochemicals, such as lycopene and citrulline, with multiple demonstrated antioxidant and anti-inflammatory properties that thus contribute to the fight against chronic diseases, including cardiovascular diseases, hypertension, diabetes and certain cancers [10]. Watermelon fruit is subject to rapid deterioration because when left at room temperature without adequate preservation, there is a loss of physiological weight due to water loss through transpiration and respiration, a loss of firmness due to the degradation of cell walls, a change in color due to alteration of red pigmentation, an increase in the content of total soluble sugars, an increase in titratable acidity and microbial development [11]. Thus, valorization techniques such as canning in boxes, processing into jams, syrups and juices are implemented to avoid its deterioration and make the product and its derivatives available at all times of the year [10]. Watermelon fruit, like orange, mango and Pineapple, is one of the fruits that retains most of its nutritional value, particularly its most important bioactive compounds during processing [10, 12]. In Burkina Faso, the processing of watermelon fruits is generally carried out artisanally or using semi-industrial techniques, sometimes with insufficient hygienic conditions [13]. Several studies have been conducted on watermelon cultivation, watermelon consumption and certain derivative products from watermelon fruit processing (syrup, jam, preserves, cocktails) [2, 14]. Although there are many studies on watermelon juice [15, 16], very few recent studies have focused on the evolution of the organoleptic characteristics of watermelon juice during artisanal processing. The objective of this study was therefore to contribute to the evaluation of the impact of production technology and added sugar content on certain organoleptic and physicochemical parameters of artisanal watermelon juice in order to meet consumer preferences.

2. Materials and Methods

2.1. Study Setting and Period

This study took place from October 2023 to January 2024 in the city of Bobo Dioulasso, Burkina Faso. The juices were produced by an artisanal company, VOA Elite, located in Bobo Dioulasso, specializing in the production of several types of natural fruit juices (mango, orange, pineapple, vines, and other non-timber forest products). The technological, physicochemical, and sensory analyses were carried out in the Applied Biochemistry and Immunology Laboratory (LaBIA) and Laboratory of Biochemistry, Biotechnology, Food Technology, and Nutrition (LABIOTAN) at Joseph Ki-Zerbo University.

2.2. Watermelon Juice Production Technology

2.2.1. Raw Material Sourcing

The raw materials for the production of watermelon juice consisted of ripe, whole watermelon fruit and refined sugar. The watermelon fruit was obtained from producers in the market gardening plains of Bobo Dioulasso and neighboring regions, while the sugar was obtained from local businesses.

2.2.2. Watermelon Juice Production Method

Watermelon juice production is carried out according to a standard protocol covering the essential production steps established in accordance with the recommendations of the Codex Alimentarius [17]. The equipment required for production was of the quality recommended for agri-food production. The raw materials were of acceptable quality and selected from local producers according to the production company's specific criteria. All stages of production are carried out in compliance with good hygiene and production practices [18]. The equipment was previously washed, cleaned and arranged according to the forward flow principle to avoid cross-contamination. The watermelon juice production process includes the following essential steps: checking the quality of the raw material, sorting, washing, weighing, cutting, crushing, juice extraction, juice filtration, pasteurization, sweetening and packaging of the juice produced. Upon receipt of the raw material, quality controls and rigorous sorting are carried out to ensure the quality of the watermelon fruits is retained before any use. Only ripe, firm fruits without any signs of deterioration are retained for further processing. The retained fruits are then washed with plenty of potable water to remove impurities (dead leaves, grains of sand, insects and other waste). Three washes are necessary to completely remove the impurities. Then the washed fruits are weighed to determine the quantity to be processed. In this processing unit, approximately one to two tons of watermelon fruit are processed per day. The next step involves peeling the fruit and cutting it into pieces. The watermelon fruits are peeled to remove the outer pericarp, and then the pulp obtained is cut into several pieces of approximately 50 g to facilitate grinding. The pieces are then ground to obtain the watermelon pulp paste, and then the watermelon fruit juice is extracted. A first filtration is carried out several times after this step to remove the seeds and fibers. The first juice obtained is pasteurized at 75 °C for 15 minutes to eliminate microbial contaminants. From this step, two production routes have been adopted: one route for the production of juice enriched with sugar and another for the production of juice not enriched with sugar. The steps of the two routes are fundamentally identical except for the sweetening step, which is not carried out in the context of juice without added sugar. Thus, after the first pasteurization, part of the juice was enriched with sugar at specific levels (8%, 10%, 13% and 15%) while the other part was not enriched with sugar. The different juices have been coded as follows: P0 for sugar-free juice, P8 for juice with 8% sugar, P10 for juice with 10% sugar, P13 for juice with 13% sugar and P15 for juice with 15% sugar. Both parts will then undergo a second filtration and then be packaged in bottles. After packaging, a second pasteurization is carried out at 90 °C for 15 minutes before storage. All handling is carried out in compliance with good hygiene and manufacturing practices.

2.3. Sensory Parameter Evaluation

The sensory parameter evaluation was carried out according to the protocol described by Lefebvre & Bassereau (2003) with some modifications. The method is based on the assessment and description of the organoleptic characteristics of the samples through the five senses [19]. This study was conducted using a panel of twenty-four trained tasters tasked with describing and classifying the different formulations (P0, P8, P10, P13, and P15) according to their own sensitivities. The panelists were selected using the reasoned selection method, taking into account their knowledge of fruit juices. The criteria of product consumption, absence of allergy to any of the components, ability to read scales, availability, ability to detect sensory differences, and informed consent to participate in the tasting panel were taken into account when selecting the panel of tasters. Gender, age, religion, and intellectual level were not considered. The various juice samples were coded and then served in transparent disposable glasses to the tasters. Before the tasting began, the panelists received instructions and explanations on how to use the results sheets. Each taster received all the coded samples in random order, along with the various results sheets. Characteristics such as juice color, juice aroma, sweetness, smoothness, consistency, and clarity were assessed by the panelists. The various assessment scales were recorded on the sheets, allowing the panelists to choose the level corresponding to their assessment [20]. At the end of the tasting panel, the various results sheets were collected and compiled in Excel 2016.

2.4. Evaluation of the Physicochemical Parameters of Watermelon Juice

2.4.1. Watermelon Juice Sampling

A total of 25 samples were taken from the different juice formulations for physicochemical analyses, with 5 samples per formulation. The samples were collected aseptically, labeled, stored in coolers at 4 °C, and then transferred to the laboratory for analysis within 24 hours of production.

2.4.2. Determination of Titratable Acidity

Titratable acidity was determined according to the international standard NF EN 12147V 76-130 (1997). Thus, 10 ml of watermelon juice was collected in a beaker and titrated with a 0.1 N sodium hydroxide (NaOH) solution in the presence of phenolphthalein (1%) as a color indicator. The volume of the NaOH solution dropped at the color change (pink) of the sample solution was used to calculate the titratable acidity (expressed as the percentage of citric acid contained in the juice) according to the following formula:

$$\text{AT (g/L citric acid equivalent)} = \frac{V1*N*0.64*1000}{V2}$$

N: NaOH concentration; V1: NaOH volume in ml; V2: juice sample volume in ml; 0.64: citric acid conversion factor.

2.4.3. Determination of Brix and Refractive Index

Brix (°B) and refractive index (RI) were determined according to international standard NF V05-109 (1970) using a dual-function handheld refractometer. After calibrating the refractometer (1.3330) with distilled water, a drop of the watermelon juice solution was placed on the refractometer prism to read the Brix and refractive index. Distilled water served as a calibration buffer for reading the Brix and refractive indices of the different formulations.

2.4.4. pH Determination

The pH was determined according to the AOAC method (1990) using a HANNA Instruments pH meter. It was pre-calibrated with two buffer solutions of pH = 4 ± 0.1 and 7 ± 0.1. After calibration, the pH meter electrode was inserted into a beaker containing 50 ml of juice for 20 to 30 seconds.

2.4.5. Determination of Impurity Levels

The impurity content of watermelon juices was determined according to the international standard ISO 663 (2017). The different watermelon juice formulations were filtered using paper filters to retain impurities. The filters were first weighed empty (M1) and then placed in jars to filter 100 mL (0.1 L) of each juice sample for 2 to 3 hours. After the sample was completely drained, the filters were oven-dried for 24 hours at 105 ℃ and then weighed (M2). The impurity content was calculated using the following formula:

$$\mathrm{Imp}(g/L) = \frac{(M_2 - M_1)}{0{,}1}$$

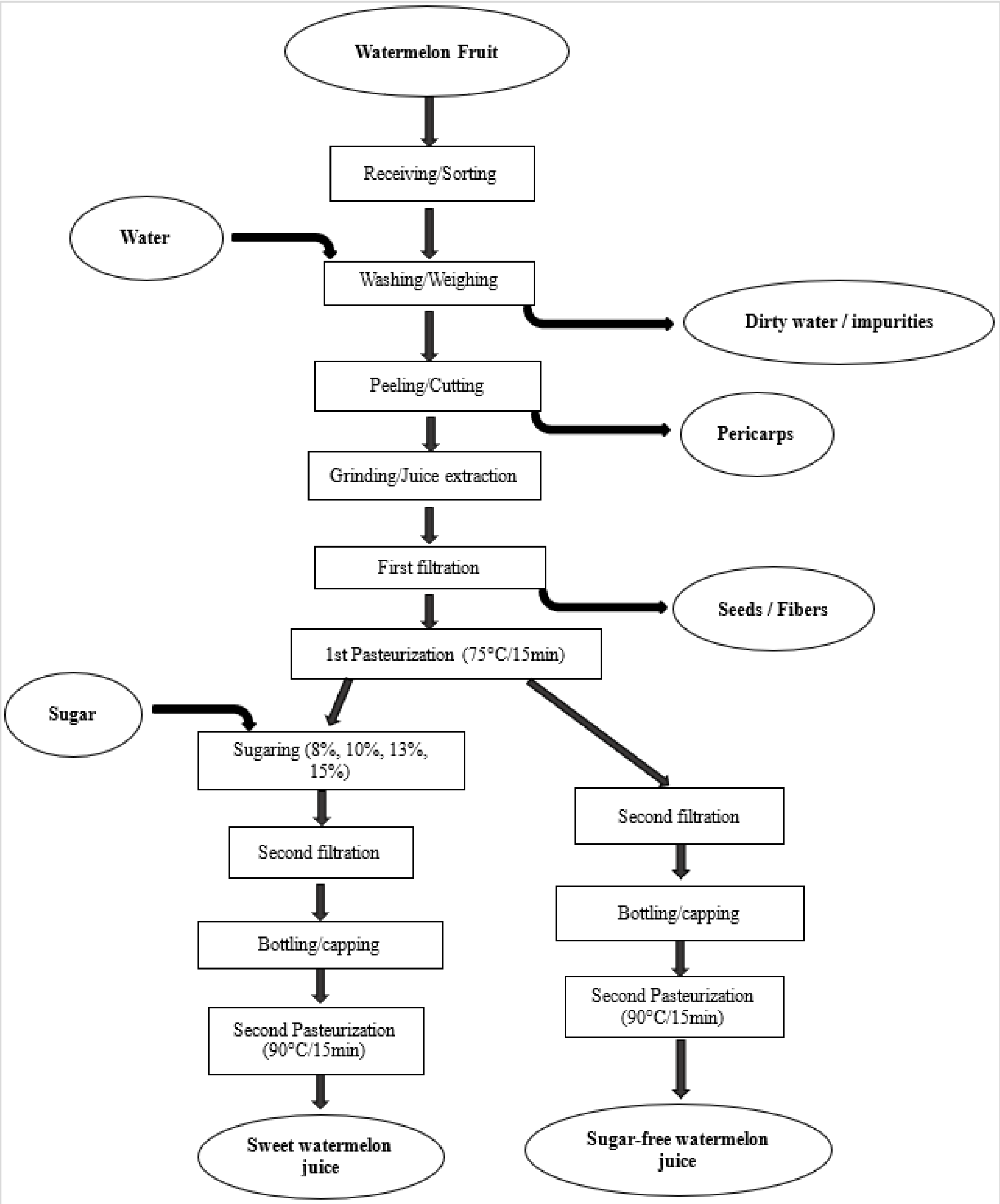
Imp (%): Impurity content; M1: mass of the empty filter; M2: mass of the filter after drying.

2.5. Data Processing

The results were conducted using Excel 2016 software. The various assessments were confirmed using principal component analysis to determine the best matches. The means were compared using analysis of variance (ANOVA) using the Tukey test at the significance level of p = 0.05.

3. Results

3.1. Watermelon Juice Production Process



NB: Rectangles = operations; circles = raw materials or products

Figure 1. Watermelon juice production flow chart.

Figure 1 presents the technological flowchart for watermelon juice production. The flowchart outlines the essential steps in juice production, which begin with obtaining the raw material from local producers, followed by pretreatment of the raw material (sorting, washing, and weighing). These steps ensure that the raw material is free of any waste that could contaminate the finished product. The next step involves the processing and extraction of the watermelon juice. The fruits are stripped of their outer pericarps before being ground into a pulp, thereby reducing the chlorophyll and other fiber content in the final juice. The diagram also includes two filtrations to remove seeds and internal fibers, and two pasteurizations of the juice, respectively, at 75 ℃ and 95 ℃ for 15 minutes to eliminate microbial germs after extraction. Observation of the diagram shows that all the formulations are produced according to the same process except the sweetening step, which does not exist in the production of unsweetened juice.

3.2. Sensory Analysis of Watermelon Juices

3.2.1. Watermelon Juice Color Assessment

The results of the juice color assessment test presented in Figure 2 show that all the juices presented were mostly judged to be light red by the tasters. On average, between 40 and 50% of tasters indicated that the color of the juices submitted to them was light red. However, the color of juice P0 was judged to be the brightest compared to the other juices by 33.33% of tasters, followed by juices P8 and P10 with 29.17% of tasters, respectively, while juice P15 was judged to be the clearest by 20.83% of tasters. Juices P8 and P13 appear to have the most balanced red color scales.

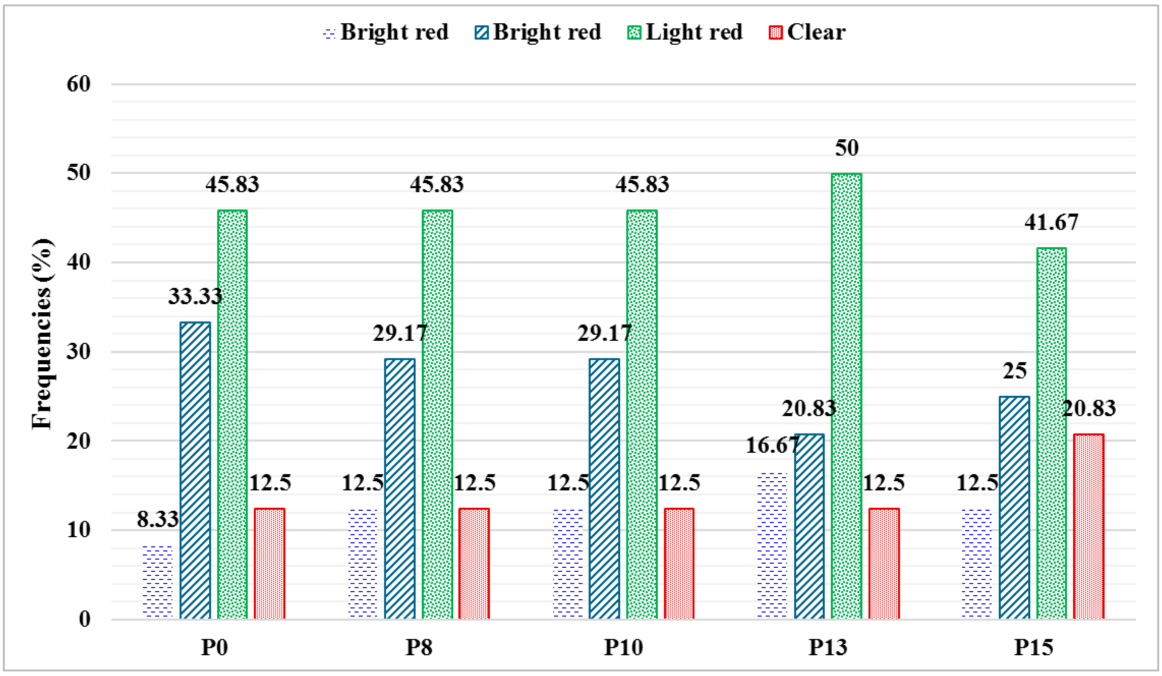


Figure 2. Watermelon Juice Color Assessment Chart.

3.2.2. Watermelon Juice Flavor Assessment

The juice flavor assessment test showed that the flavor of all juices presented was mostly deemed pleasant, with an average rating of between 37.5% and 54.17% of tasters (Figure 3). Juices P8 and P13 were rated the most pleasant by 29.17% and 41.67% of tasters, respectively, while juices P0 and P15 were rated the most unpleasant by 33.33% of tasters. Based on the data obtained, juice P13 appeared to have the flavor most appreciated by all tasters.

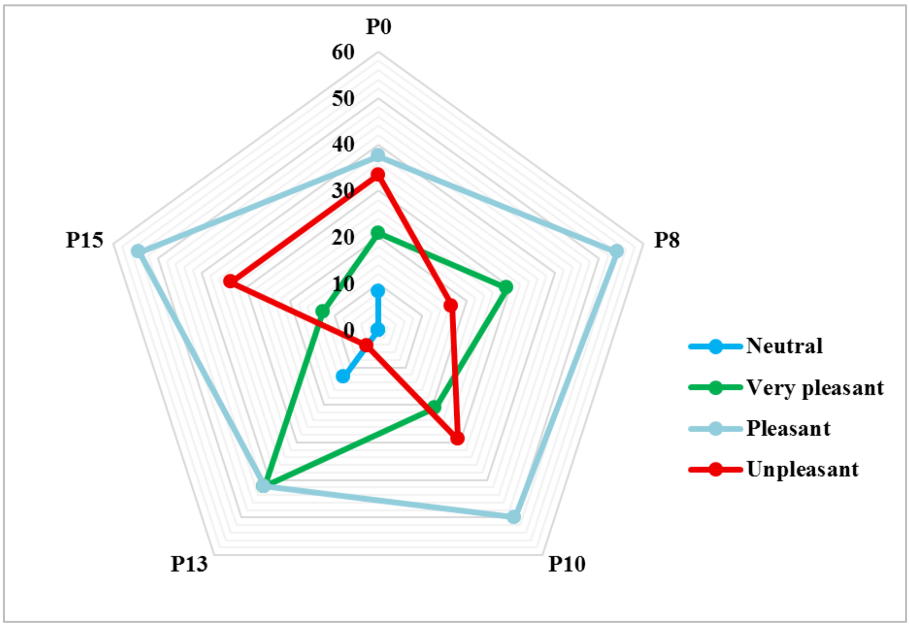


Figure 3. *Flavor Assessment of Watermelon Juices.*

3.2.3. Sweetness Assessment of Watermelon Juices

The sweetness assessment test for the juices showed that all the juices presented were mostly judged to be sweet (Figure 4). Juices P13 and P15 were judged to be too sweet by 54.17% and 58.33% of tasters, respectively, while juices P0 and P8 were mostly judged to be moderately sweet by 58.33% and 66.67%, respectively. However, juice P0 was most widely judged to be bland by 12.5%. Thus, based on the data obtained, juice P8 appears to have the most balanced sweetness scales.

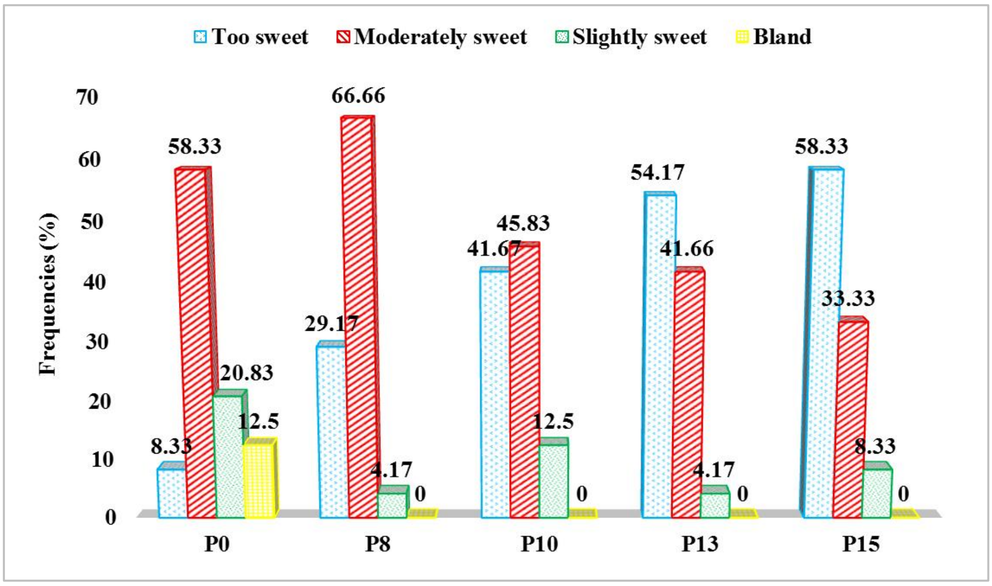


Figure 4. *Sweetness assessment diagram for watermelon juices.*

3.2.4. Smoothness Assessment of Watermelon Juices

Figure 5 presents the results of the smoothness assessment test for watermelon juices. All juices presented were mostly judged to be smooth, with an average rating of between 50% and 54.17% of tasters. Juice P10 was judged the least smooth by 50% of tasters, while juice P0 was judged the least viscous by 16.67% of tasters. Regarding graininess, all juices were judged to be grainy. Conversely, juices P8 and P15 were judged the least grainy by 4.17% of tasters, respectively. Juices P0 and P15 were judged to be drier by 16.67% of tasters, respectively, while juice P8 was judged to be sweeter by 8.33% of tasters. Based on the data obtained, P8 juice appears to have the most balanced smoothness scales.

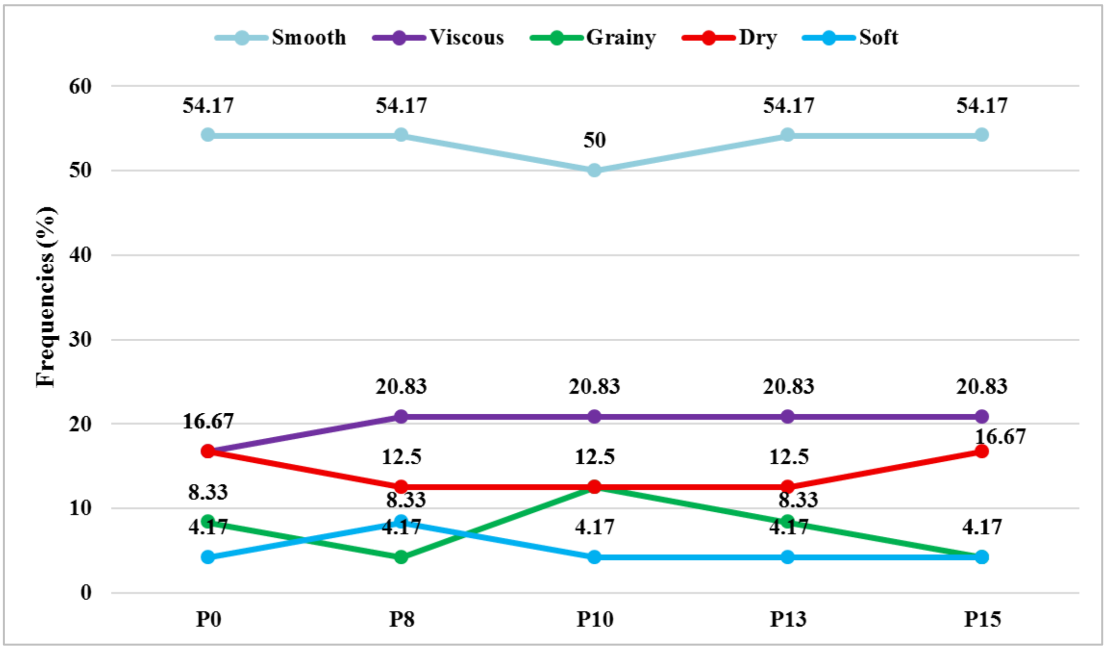


Figure 5. Watermelon Juice Smoothness Assessment Chart.

3.2.5. Watermelon Juice Consistency Assessment

The juice consistency assessment test showed that all juices presented were mostly judged to be thick by 58.33%, 62.5%, and 66.67% of tasters, respectively (Figure 6). Juices P13 and P15 were judged the thickest by 33.33% of tasters, respectively, while juice P0 was mostly judged to be too thin by 8.33% of tasters. Based on the data obtained, juice P8 appears to be the most balanced regarding the consistency scales.

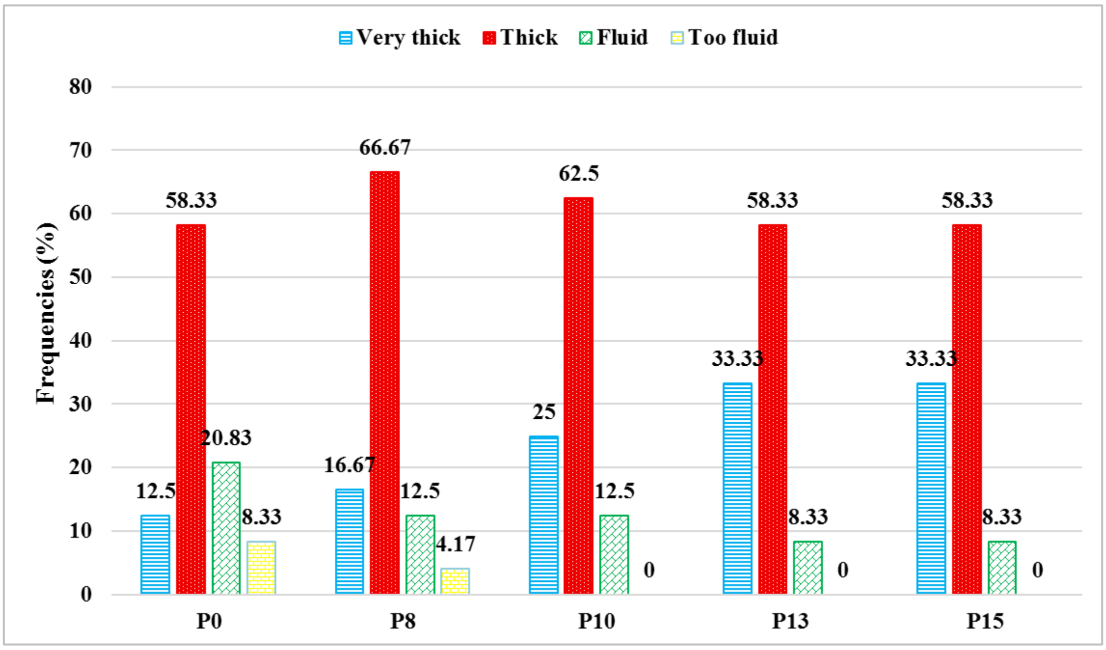


Figure 6. Watermelon Juice Consistency Assessment Chart.

3.2.6. Watermelon Juice Clarity Assessment

The juice clarity assessment test showed that all juices presented were mostly considered clear by 62.5% and 66.67% of tasters (Figure 7). Juices P10 and P13 were considered the clearest. Regarding homogeneity, juices P0, P10, and P13 were considered the most homogeneous by 25% and 29% of tasters, respectively. The presence of sediment was reported in juices P0, P8, and P15 by 4.17% of tasters, respectively. Juices P8 and P15 were mostly considered the cloudiest by 12.17% of tasters. Based on the data obtained, juices P10 and P13 appear to have the most balanced clarity scales.

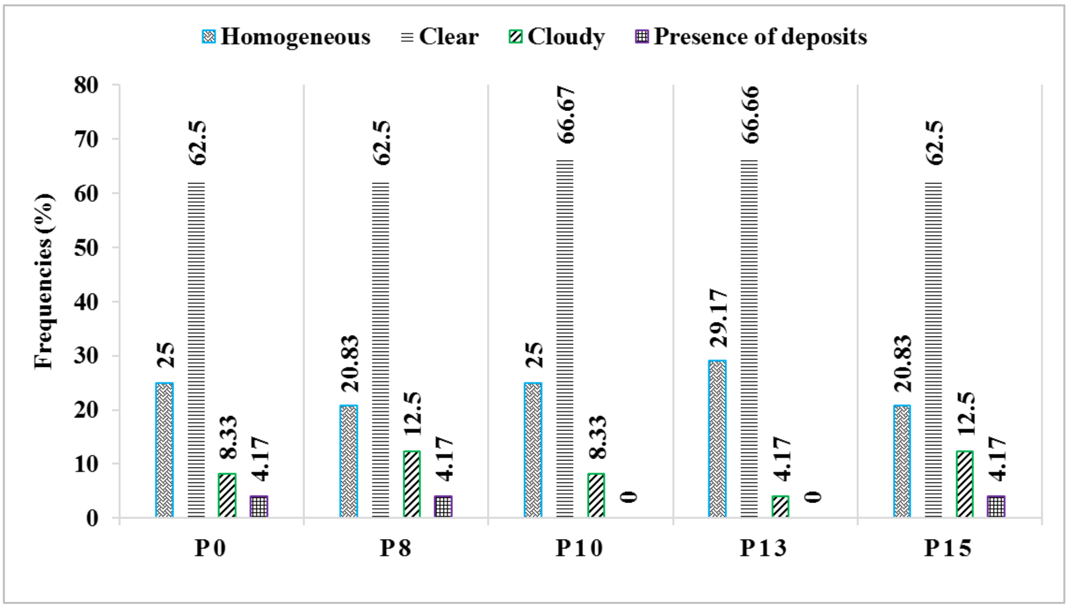


Figure 7. *Watermelon juice clarity assessment diagram.*

3.3. Physicochemical Parameters of Watermelon Juice

Table 1 presents the results of the physicochemical analyses of the watermelon juices. The pH ranged from 3.97 to 4.72. The highest pH was obtained in juice P8, while the lowest pH was obtained in juice P0, with significant variation. The acidity of the juices ranged from 0.11 g/100 g to 0.20 g/100 g. Juice P8 had the lowest acidity, while the highest acidity was obtained in juice P0, with significant variation. The Brix level ranged from 18.60 °B to 27.23 °B. The lowest Brix values were obtained in juices P0 and P8. Regarding the refractive index, it ranged from 1.36 to 1.37, with the highest index being obtained in juices P8, P10, P13, and P15. The impurity level ranged from 0.42 g/L to 2.26 g/L. Juice P0 significantly had the lowest impurities.

Table 1. *Physicochemical parameters of watermelon juices.*

Sample	pH	Acidity (g/L)	Brix (°B)	IR	Imp (g/L)
P0	3.97 ± 0.05^{a}	0.20 ± 0.00^{d}	18.60 ± 0.34^{a}	1.36 ± 0.00^{a}	0.42 ± 0.12^{a}
P8	4.72 ± 0.03^{c}	0.11 ± 0.00^{a}	22.66 ± 0.72^{b}	1.37 ± 0.01^{ab}	1.54 ± 0.02^{b}
P10	4.08 ± 0.01^{b}	0.18 ± 0.00^{d}	23.43 ± 1.32^{b}	1.37 ± 0.00^{ab}	1.46 ± 0.07^{b}
P13	4.12 ± 0.01^{b}	0.16 ± 0.00^{c}	26.66 ± 0.11^{c}	1.37 ± 0.00^{ab}	2.23 ± 0.06^{c}
P15	4.14 ± 0.00^{b}	0.13 ± 0.00^{b}	27.23 ± 0.40^{c}	1.37 ± 0.00^{b}	2.26 ± 0.08^{c}

pH: hydrogen potential; IR: refractive index; Brix: Brix degree; Imp: impurity level

4. Discussion

The process flow chart described for watermelon juice production presents a standard but hygienically rigorous process, particularly due to the washing and pasteurization steps. Double pasteurization at 90 ℃ eliminates common foodborne vegetative pathogens, including Escherichia coli, Listeria monocytogenes, and Salmonella spp., as well as inactivates enzymes. Heat treatment also induces the denaturation of proteins and enzymes essential for microbial metabolism, leading to cell death. However, pasteurization remains ineffective against bacterial spores such as Bacillus spp. and Clostridium spp., whose main sources of contamination during production and post-production undoubtedly remain predominantly manual operations [21]. Their presence could pose risks for the preservation of the juice but also for consumers [22]. According to a recent study carried out in China on low-acid fruit juices, more drastic treatments such as UHT sterilization are necessary to eradicate these spore-forming forms [23]. The usefulness of two heat treatments, especially at different temperatures, is debatable. Although one might think that the first treatment (75 ℃) aimed to inactivate the enzymes after extraction (thus avoiding clarification during the process) and the second (95 ℃) to ensure microbiological stability before packaging, this still seems redundant. A single, better-optimized pasteurization process at 85-90 ℃ for 30-60 seconds continuously, followed by aseptic packaging, would likely be more effective in preserving sensory and nutritional quality while ensuring microbiological safety [24, 25].

From a technological and qualitative perspective, this process, while advantageous from a microbiological perspective, nevertheless presents risks of degradation of watermelon's valuable nutritional compounds (lycopene, citrulline, vitamin C) and its authentic sensory characteristics. Indeed, a recent study showed that severe heat treatments (>85 ℃) on watermelon juice resulted in significant losses of ascorbic acid and total antioxidants [12]. Similarly, heat induces Maillard reactions (caramelization of sugars) and degrades aromatic volatile compounds, which can generate “cooked” or “caramel” flavors and an alteration of the bright pink/red color [11]. Pretreatment steps are essential to reduce the initial microbial load and physical contaminants (soil, pesticide residues). Watermelon, being a fruit grown on the ground, presents a high risk of contamination by pathogens. Thus, effective washing with potable water possibly supplemented with food disinfectants is crucial for microbiological safety [26]. Peeling is a key step to reduce the content of chlorophyll, fiber, and phenolic compounds that can impact color and cause bitterness. However, it is important to note that peeling also removes a significant portion of bioactive compounds, such as citrulline and lycopene, which are concentrated in the pericarp [27]. The double filtration contained in the diagram allows for the complete removal of seeds and fibers, thus ensuring a clear and stable smoothness. However, the complete removal of insoluble fibers and pulp also means a loss of dietary fibers and may affect mouthfeel. This double filtration could also directly influence the viscosity and stability of the suspension, which could undergo sedimentation during storage in the absence of stabilizers. The addition of sugar increases the osmotic pressure of the medium, slightly inhibiting microbial growth and improving sensory perception (acidity/sweetness balance). However, this significantly increases the calorie and free sugar content, which is contrary to WHO recommendations for combating obesity and diabetes. The unsweetened juice market, which highlights the fruit's natural profile, represents a more advantageous health positioning.

Sensory analysis is an essential scientific tool for assessing the perceived quality of food products, linking physicochemical properties to human perception [28]. Color perception, mostly considered "light red," is a key indicator of the quality and freshness of watermelon juice. The color of watermelon-based juices is mainly attributed to lycopene, a carotenoid with antioxidant properties [29, 30]. The color difference perceived by tasters could be due to the denaturation of lycopene in some juices under the effect of heat. Indeed, the double pasteurization applied could have induced oxidation or isomerization of lycopene, altering its colorimetric intensity [31]. As for the difference in clarity and homogeneity observed in some juices by tasters, it could be linked to the difference in size of suspended particles and colloidal stability, which constitutes a major technological challenge for the African food industry [32]. The presence of red pigments can also lead to cloudiness in the juice [33]. In a previous study, the authors also reported that the presence of deposits in some juices was linked to physical instability due to pulp sedimentation or insufficient clarification [34]. Smoothness, judged mostly as “smooth,” is a key attribute for juice acceptability. Perceived granularity is often associated with the presence of large pulp particles or aggregates. The fact that juices P8 and P15 were judged to be the least granular suggests that their manufacturing process better disintegrated cellular structures [35]. Consistency, related to viscosity, is influenced by the content of pectin and other polysaccharides. Perceived granularity in juices can be attributed to the presence of pulp, small fruit particles, and precipitation of phenolic and pectic compounds [36]. Unlike Western standards that often favor a perfectly smooth smoothness, many African consumers appreciate the presence of pulp and particles, perceived as a guarantee of authenticity and fiber richness [37]. Juices P13 and P15, perceived as the thickest, could have a higher solids or soluble fiber content, which is consistent with their higher °Brix. The perception of the predominantly “pleasant” flavor is a positive result. The marked preference for juice P13 (41.67% “more pleasant”) suggests an optimal volatile profile. This difference in flavor and taste could also be explained by the applied thermal treatments that were not sufficiently standardized. Aromatic compounds in watermelon, such as aldehydes and alcohols, are sensitive to technological processes [38]. Appreciation of sweetness is directly correlated with the soluble solids content (°Brix). The perception of juices P13 and P15 as “too sweet” (54.17% and 58.33%) corresponds perfectly to their high °Brix (26.66 and 27.23 °B). Conversely, P0 and P8, perceived as less sweet, have the lowest °Brix (18.60 and 22.66 °B). However, sweetness perception is not solely a function of sugar content; it is modulated by acidity. Juice P0, mostly judged “bland,” combines the lowest °Brix (18.60 °B) and the highest acidity (0.20 g/100 g), thus creating a sensory imbalance where acidity is not compensated by sugar [39]. However, the perception of sweetness appears to be multimodal; it may be influenced by the fruity red aromas of the juice, which can enhance the perception of sweetness, smoothness, and culture [40, 41]. The "dry" astringency perceived in watermelon juices is a common characteristic of many tannin-rich fruits [42]. Thus, the fact that P0 and P15 were judged to be "drier" suggests a higher concentration of astringent polyphenols.

The results obtained regarding pH revealed a slight acidity in the different watermelon juices. The pH values obtained in this study were close to those found by Abreu et al. (2005), which were 4.4 in cashew apple juice [43]. The measured pH values were generally consistent with the limit established for acidic fruit juices or acidified juices (pH $\leq$ 4.5) by the Codex Alimentarius (2019) [18]. Juices with added sugar had higher pH values than juices without added sugar. This could be explained by a dilution effect of hydrogen ions. This claim is correlated with the acidity of the juices analyzed. The addition of sugar, a neutral molecule, increases the volume of the liquid matrix, contributing to a dilution of the concentration of natural organic acids (citric acid) responsible for acidity [44]. The titratable acidity of watermelon juices was lower than that of Djouder and Mansour (2019) in watermelon juice [45]. These differences could be explained by varietal variations, agronomic conditions (soil type, climate) and the stage of fruit ripening. Riper fruits generally have lower titratable acidity due to respiration and the metabolism of organic acids [46]. The generally low acidity in the watermelon juices in this study could also be explained by the very nature of watermelon, which is a fruit characterized by a high-water content and a low proportion of organic acids compared to citrus or other tropical fruit juices (mango, passion fruit, etc.). The Brix degrees of the watermelon juices obtained in this study were lower than those of Fundo et al. (2018), who obtained Brix degrees ranging from 7.50 °B to 9.47 °B in watermelon juices [47]. These differences could also be explained by varietal variations, agronomic conditions and the stage of fruit ripening. In addition, greater water availability during fruit growth can lead to larger fruits but with a lower sugar concentration [48]. The results also showed that the higher the added sugar content, the higher the Brix. Brix, which measures the sugar concentration in the juice, changes with the added sugar content. This claim is in perfect correlation with the results of the sensory analysis, which showed that formulations P13 and P15 were the sweetest. The refractive index, which characterizes the quantity of dissolved solids in the juice, is an indicator of juice purity and allows monitoring of the quantity of sugar dissolved in the juice [49]. It confirms the low impurity content obtained in this study and, at the same time, shows the quality of certain aspects of the production technology. Indeed, the low impurity content demonstrates that the pretreatment, processing, and filtration steps were properly performed, ensuring juices containing fewer undesirable dissolved substances. Furthermore, the juices with added sugar had higher refractive indices and impurity levels than the juice without added sugar. This could be explained by the fact that the refractive index is directly correlated with the total dissolved solids concentration. The addition of sugar, which is a dissolved solid, mechanically increases this concentration, increasing the refractive index [44].

5. Conclusion

The results, although preliminary, highlight diverse sensory profiles among the different juices. The sensory evaluation revealed the different perceptions of the judges. The results of the physicochemical analysis showed that most of the sensory conclusions are correlated. However, further studies in the form of ethno-sensory tests with consumers and evaluation of antioxidant composition.

Abbreviations

LaBIA	Applied Biochemistry and Immunology Laboratory
LABIOTAN	Laboratory of Biochemistry, Biotechnology, Food Technology, and Nutrition
NaOH	Sodium Hydroxide
RI	Refractive Index
AOAC	Association of Official Analytical Chemists
ANOVA	analysis of variance
UHT	Ultra-High Temperature
WHO	World Health Organization
pH	Hydrogen Potential

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Author Contributions

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Conflicts of Interest

The authors declare that they have no competing interests.

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