

ORIGINAL RESEARCH ARTICLE

Processing of strawberry “Festival” to jam and determination of physical and physicochemical parameters

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ABSTRACT

This work evaluates the physical and physical-chemical parameters of the strawberry variety “Festival”, obtained in the soil and climate conditions of Humpata, Huila Province, Angola, following the transformation into sweet of adequate quality. The analyses made were: the mass determined on an analytical balance and the transversal and longitudinal diameters with a pachymeter. Other analyses were: total titratable acidity by volumetry, pH by potentiometry, total soluble solids by refractometry, moisture and ash by gravimetry. The study showed that the pH of the pulp was 3.41; and in the candy it was 3.31. The titratable acidity in the strawberry pulp had a value of 0.186 g/100 mL and in the jam 0.096 g/100 mL; the ascorbic acid content in the pulp was 18.60 mg/100 g. The average soluble solids content in the pulp was 9.51 °Brix and for the jam 68.83 °Brix. These chemical characteristics of the pulp and jam provide information about their nutritional values.

Keywords: Physicochemical Characterization; Strawberry; Jam; Agro-industry

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1. Introduction

The increase in the consumption of fruits, nowadays, occurs due to their nutritional value and therapeutic effects. Among these it is worth mentioning the strawberry, which is becoming more accessible to consumption “natural” and whose agro-industrial products are widely consumed in the world, due to its pleasant taste and high nutritional value.

The strawberry (*Fragaria Ananassa Duch*) is an attractive fruit due to its peculiar characteristics of bright red color, odor, soft texture and slightly acidified flavor. This coloration is due to the presence of bioactive substances, anthocyanins and flavonoids, antioxidant substances with anti-carcinogenic properties^[1-3].

Rich in vitamins, fiber, folic acid and minerals, it is popular all over the world. It has a high concentration of fruit and sucrose, but is low in carbohydrates, so it is used to lose weight. It promotes iron absorption because it is rich in vitamin C, as well as citric and malic acid. It is also presented as an aid in certain dysfunctions and diseases such as constipation and hypertension. A mild laxative and diuretic, it promotes the emptying of the intestines and the elimination of urine. A large content of natural sugars makes this fruit an excellent liver food, and its aromatic

components act on the nerves of smell and taste, increasing the appetite^[4].

According to Cantillano, some physical characteristics of strawberries in terms of size and mass are: length 37.0 mm + 4.7 mm; diameter 30.2 mm + 3.5 mm and weight 13.0 g + 3.9 g. The physical characteristics of the fruit depend on many factors such as soil and climate conditions, fertilization, etc.^[5] Almeida studied the “Festival” variety of strawberry, produced in Rio grande do sul (Brazil) and determined the results of total soluble solids 8.5 °Brix; pH 3.4; acidity (citric acid) 0.97%; moisture 30.01% and ascorbic acid (AA) of 0.48 mg/100 g. Producers tend to harvest the fruit slightly green, so that it has a longer shelf life. Thus, the contents of total soluble solids and titratable acidity are related to the point of ripeness at which the fruits were harvested^[6].

The high moisture content makes them highly perishable and therefore they should be refrigerated or processed as soon as possible after harvest in order to reduce losses. These can reach very high levels if correct harvesting techniques are not used^[7].

In order to maintain the qualities of the fruit, in addition to adequate growing conditions, it is necessary that the fruit be harvested at the proper time and stage of ripeness, and handled correctly after harvest^[8].

Because it is a fruit of high perishability when sold under natural conditions, it requires the use of appropriate technology for better conservation. An alternative to increase the shelf life of strawberries would be to transform them into different agro-industrial products, through different stages that can guarantee a product that meets the demand of the current consumer market, with a tendency of increasing consumption of healthy and high-quality food^[1]. It is used in the production of juices, jellies, compotes, sweets in syrup, ice creams, yogurts, flavored milks, mousses, liqueurs, in combination with whipped cream as pie fillings, ice cream and cakes. It is also widely used in various culinary dishes as dessert. The characteristic flavor and bright red coloration contribute to the fact that the strawberry and its derived products are very appreciated by a large number of people^[9].

The general objective of the present work is to

evaluate the physical and physical-chemical parameters of the strawberry variety “Festival”, obtained in the Municipality of Humpata, Huila Province, and to transform it through simple operations into a sweet of adequate quality, thus avoiding post-harvest losses.

2. Materials and methods

The region where the fruit is cultivated is located in the southwest of Angola and corresponds to a set of flat areas, of medium altitudes and the highest in the southern part of the territory. With an area of 8,000 km², corresponding to 0.64% of the Angolan territory, its population is mostly peasant.

The Commune of Palanca falls within agricultural zone 30, a plateau surface. In the climatic aspect, there are two seasons: rainy and dry. The values of average annual rainfall are close to 1,200 mm in the north and drop below 750 mm in the extreme southern limit of the zone. As for the average annual temperature, the zone is sensitively involved, by the isotherm of 19 °C, with a gradual decrease towards the interior and as the altitude rises. The annual average relative humidity oscillates between 50% and 60%, the lowest values coinciding with the cold period (25% to 35%) and the highest with the hot period (60% to 80%). The most representative soils in this commune are: weakly yellow ferralitic, weakly red ferralitic, brown, brownish Oxipsamic, Lithosols^[10].

The fruits studied were obtained from Jamba Farm, Palanca Commune, Humpata Municipality, on October 10, 2012. This area was chosen because it is the center of attention in terms of the largest production and sale of strawberries in Angola.

The work was conducted in the period from October 15 to 19, 2012. The processing of the fruits to obtain the jam was done in the Pavilion of Food Technology of the Faculty of Agricultural Sciences. The physical and physicochemical analyses were performed in the Microbiology Laboratory of the Faculty of Agricultural Sciences, José Eduardo dos Santos University (UJES), Angola.

3. Variety studied

The plants of the “Festival” variety are vigorous and productive, adapted to the climatic conditions of

the region. The fruits have a conical shape, medium size, uniform red color, firm texture and excellent flavor (**Figure 1**).



Figure 1. Studied “Festival” variety.

This variety was chosen because it is one that is frequently used in the industry, and for fresh consumption, as it has an ideal sugar content for its transformation, and also has good phenotypic characteristics according to the consumer, which are related to color, shape, size, flavor, and aroma.

4. Experimental procedures

The physicochemical characteristics evaluated for both fruit and jam are: pH, total soluble solids (TSS), titratable acidity, ash, ascorbic acid content, and moisture percentage. For each variable, samples composed of different portions of the fruit (pulp) and of the processing product (jam) were evaluated, in order to obtain more representative results. In the case of the fruit, length, diameter, and weight were also evaluated. Experimental procedures were used according to the analytical methods of the Adolfo Lutz Institute^[11] and the National Commission of Norms and Standards of Brazil^[12]. The definition of the appropriate ripeness for processing the fruit was subsequently determined by the total soluble solids content.

For the possible analytical determinations, the technician was protected with gloves, coat, boots, hat, and masks, trying to protect the product as much as possible from probable contaminations.

4.1 Physical characterization of the fruit

For determination of length and diameter a stainless hardened digital caliper was used and for

weight a Pionner Oahus electronic analytical balance was used, with max cap sensitivity: 210 g and readability 0.0001 g.

4.2 Obtaining strawberry jam

By visual examination, after checking that during transport the fruit was not affected, the calyx was removed. The fruit showed uniform maturation and coloration. To determine yields of the process the raw material used was weighed, with the help of a technical scale. The weight was 11.48 kg. The fruit was washed for 5 min with chlorinated water and then rinsed with plain water. Crushing was performed using Cúter made in France, until it reached the shape of pulp. Afterwards, the weight of the pulp was determined, which was 10.76 kg. In the formulation stage, the proportions of pulp: sugar: lemon juice to be used to obtain the jam were decided. The ratio was 10.76 kg: 7.5 kg: 50 mL. Then the mixture was added to the concentrator to be heated to a temperature of 80 °C for 30 min. The end point of this process was determined by a direct reading from a binocular, which allows a visualization of the product. The packaging was done manually and consisted of a straight filling of the concentrator, through a channel, to the previously sterilized containers (vials). Afterwards the bottles were quickly closed and inverted with the lid downwards, to sterilize it. Cooling is done by sprinkling room temperature water until the lids are covered. Then the jars are allowed to cool down for a while. The completely cooled and dried jam jars are packed in their own boxes.

4.3 Determination of the pH of both fruit and strawberry jam

The pH was measured by glass electrode potentiometry using a Hanna Instruments brand potentiometer, model HI 8014. The instrument was calibrated at pH = 4 and pH = 7. For the determination, the electrode is introduced into a precipitate vessel with sample and the measurement is noted.

4.4 Determination of soluble solids (TSS)

For the determination, one drop of the dissolution is added to the refractometer and the measurement expressed in °Brix is annotated.

4.5 Determination of titratable acidity (TA) of the raw material and final product with titrimetry method

The sample was weighed out to 30 g using a Pionner Oahus analytical balance, and slightly warm distilled water (40 °C to 50 °C) was added up to 200 mL. Then the sample was filtered using a cotton funnel. The filtered product is valued with standard sodium hydroxide solution (Analar Normapur, 32% purity) in the presence of phenolphthalein as indicator. Six valuations were made for each sample. The expression used in the calculation was (1):

$$C_a \cdot V_a = C_b \cdot V_b \quad (1)$$

Where:

C_a : Concentration of the acid

V_a : Acid volume

C_b : Concentration of the base

V_b : Base Volume

4.6 Determination of ascorbic acid in raw material and final product using the calibration curve method and oxidation of vitamin C in the presence of an indicator

A calibration curve was established (Figure 2), which consisted of preparing several solutions of ascorbic acid of exactly known concentration, which are evaluated in the presence of the indicator 2,6-dichlorophenol indophenol, in order to determine the exact volume that was consumed of the sodium bicarbonate solution II (Biochromag) of known concentration as well. Finally, the samples with unknown concentration are titrated according to the described procedure.

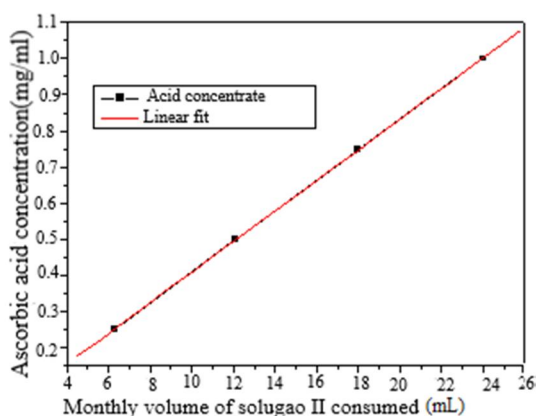


Figure 2. Calibration curve used for the determination of ascorbic acid concentration in the samples studied.

4.7 Determination of ash in food

A sample amount of 5 g is placed in a previously dried and tared crucible. Then the sample was taken to a Gefran 400 muffle furnace for 3.25 h at a temperature of 550 °C for complete incineration of the sample. It was then removed from the muffle furnace and placed in the desiccator to be cooled. It is then weighed on a Pionner Oahus analytical balance. The equation used is (2).

$$\% = \frac{(P - p)}{M} \cdot 100 \quad (2)$$

Where:

P : Mass of the crucible with ashes in grams

p : Mass of the empty crucible in grams

M : Mass of the sample in grams

4.8 Moisture determination in the raw material and finished product

The determination consisted in weighing a dry container to which a sample equivalent to 5 g was added and the container with the sample was weighed again. The sample was then placed in an oven in order to dehydrate it. The sample is taken out and weighed several times until it reaches a constant weight (equation 3).

$$\%Humidity = \frac{(P - P1)}{P2} \cdot 100 \quad (3)$$

P : Weight of container with wet sample in grams

$P1$: Weight of container with dry sample

$P2$: Weight of sample in grams

5. Results and discussion

For the study of fruit qualities, several parameters can be adopted, either physical or chemical. These characteristics are generally influenced by the following factors: soil and climate conditions, variety, time and place of harvest, cultural treatments and handling during harvest and post-harvest, and vary according to the destination of the fruit and the requirements of the consumer market^[13].

The following are the results obtained from the physical-chemical characterization of the “Festival” variety obtained in the soil and climate conditions of the Palanca region, Huila province.

5.1 Physical characteristics of the fruit

Table 1 shows the weight, length, and diameter values of the fruits used in this experiment.

Table 1. Physical characteristics of “Festival” variety strawberry

Fruit	Determinations		
	Weight (g)	Diameter (mm)	Length (mm)
01	12.80	29.81	38.35
02	10.31	28.28	37.91
03	11.29	30.98	33.10
04	7.27	24.94	29.60
05	7.50	23.20	32.92
06	6.85	24.68	31.41
07	4.87	20.62	27.42
08	6.60	22.09	29.30
09	9.68	27.49	32.79
10	8.84	23.23	34.11
Average value	8.60	25.53	32.69
Variance	5.88	11.91	12.44
Standard deviation	2.42	3.45	3.53

The length of the fruits ranged from 27.42 mm to 38.35 mm and the diameter from 20.62 mm to 30.98 mm. These values were close to those found by Filgueira in his studies on the “Festival” variety, which obtained an average length of approximately 35.47 mm and a diameter of 28.33 mm^[3]. In this variety, Cantillano and collaborators found an average length and diameter of 32.68 mm and 24.84 mm, respectively^[5]. The average weight of the fruits analyzed was 8.60 g. This value is similar to the average value of 8.92 g reported by Krolow and Schwengber^[14] and Cantillano^[5] for this variety.

5.2 Determination of pH and titratable acidity in strawberry pulp

When the fruit ripens, the acidity decreases, therefore the pH increases, and the variation of the acidity and the pH can be an indication of the ripeness of the fruit^[15]. **Table 2** shows the results of titratable acidity and pH measurements performed on the pulp and dissolved pulp. The latter was done, to verify the pH variation that can happen when they are used indistinctly.

Oliveira and collaborators reported a pH value of 3.60 for the dissolved pulp of the strawberry

variety “Festival”^[15]. Carneiro found a pH value of 3.52 with a standard deviation of 0.36^[16]. For Antunes and collaborators, who evaluated the production and fruit quality of different strawberry cultivars in trials conducted in Pelotas (Brazil), found pH values of 3.45 for the undissolved pulp^[17]. The experimental values obtained show a great coincidence with these reported values.

During ripening the content of organic acids decreases, due to the oxidation of acids as a result of fruit respiration. The titratable acidity of the analyzed fruits presented an average value of 0.186 g citric acid/100 mL. The variance values and the coefficient of variation are small and indicate little dispersion of the experimental results (see **Table 2**). This value can be explained by the characteristics of the variety studied, the soil and climate conditions in which it was developed, etc. The values experimentally determined are lower than those reported by Carneiro and collaborators, who found a total acidity of 0.58 g citric acid/100 mL^[16]. Zaicovski and collaborators reported a total acidity of 0.66% expressed as citric acid.^[18] The lower acidity of the studied fruits demonstrates their greater maturity.

5.3 Determination of ascorbic acid, % moisture, TSS and ash in strawberry pulp

The absolute contents of vitamin C content are affected by environmental and maturity-related factors of the fruit, among others. In addition, there is a reduction in this content during fruit processing^[19]. The average ascorbic acid content found in this work was 18.60 mg/100 g (see **Table 3**). This value is similar to 26 mg/100 g found by Bender^[20] while Zaicovski^[18] reported a value of 41.72 mg/100 mL.

The average value of the moisture content found in this work was 90.25% (**Table 3**). The same results are very similar to those reported by other researchers. The values of variance and standard deviation are small, which also indicates a small dispersion of the results. Oliveira and collaborators found a value of 89.4%^[15]. They state that the water content decreases as the fruit ripens. Izidoro *et al.*^[21] had a slightly higher value of 92.48%.

Table 2. pH and titratable acidity measurements in the pulp and pH in the dissolved pulp

Study performed	Measurements taken	Average value	Variance S ²	Coefficient of variation
Pulp pH	3.42	3.41	48·10 ⁻⁵	0.022
	3.39			
	3.41			
	3.42			
	3.38			
	3.44			
pH of the dissolved pulp	3.60	3.55	46.5·10 ⁻⁴	0.068
	3.61			
	3.63			
	3.60			
	3.61			
Pulp Titratable Acidity g Citric Acid/100 mL	0.230	0.186 g/100 mL	6.74·10 ⁻⁴	0.026
	0.192			
	0.173			
	0.173			
	0.154			
	0.192			

Table 3. Determination of ascorbic acid, % moisture content and TSS in strawberry pulp

Study conducted	Measurements taken	Average value	Variance S ²	Coefficient of variation
Ascorbic acid (mg/100 g)	21.01	18.60 mg/100 g	2.60·10 ⁻⁴	0.016
	17.42			
	18.39			
	19.73			
	16.47			
% of Humidity	89.9	90.25	0.084	0.29
	90.2			
	90.3			
	90.6			
SST °Brix	9.9	9.51	0.233	0.483
	9.0			
	10.1			
	9.5			
	9.7			
	8.9			

The soluble solids content is a parameter that has been used as an indicator of fruit quality. It is of great importance in fruits, both for consumption in natura and for industrial processing, since high levels of these constituents in the raw material imply less addition of sugars, less time of water evaporation, less energy expenditure and higher yield of the product, resulting in greater economy in processing^[22]. The average value found for the pulp sample is 9.51 °Brix, slightly higher than the value of 8.88 °Brix reported by Zaicovski^[18]. Françaço reports a value of 9 °Brix^[1]. Oliveira determined a value of 6.80° Brix^[15]. The measured experimental

value can give an idea of the ripeness level of the fruit.

The ash content in the pulp was determined and a value of 0.86% was obtained. Taco reports an ash value of 0.58% which is similar^[23].

5.4 Obtaining the jam and some process yields

The jam is obtained using the described procedure. As a result of this obtaining process a pulp yield of 93.72% and a jam yield of 60.99% were obtained. Although we did not find yield values for the jam reported by other authors, it is considered that these are

good and can guarantee the economic profitability of the process of obtaining the jam.

5.5 Results achieved in the physicochemical characterization of strawberry jam

Fruit candy is consumed and enjoyed around the world, not only for its taste, but also because it is a natural source of carbohydrates, vitamins, minerals, and other important components. An appropriate change in diet with regard to the inclusion of components found in fruits and fruit sweets, in general, can be important for the prevention of diseases and for a healthier life. In this regard Angola is initiating research to add to the agro-industry in the country.

Table 4 shows the pH values after making the strawberry jam. To determine the quality of the processed products, pH is the most viable method^[24]. Chim reaches an average pH value of 3.2 when preparing the strawberry jam. This value is very similar to the one obtained in this work^[25].

The most commonly used method to indicate the acidic flavor of a food can be the determination of the titratable acidity^[24]. **Table 4** shows the

titratable acidity results for the candy obtained, whose average value is 0.096 g citric acid/100 mL. This value is a little lower than that reported by Chim, which was 1%^[25]. This low acidity value may not contribute to the necessary average acidity needed to ensure the microbiological quality of the candy.

The soluble solids content provides an indication of the amount of sugar that are present in the food. **Table 4** shows the average value obtained of 68.83 °Brix, which was lower than that reported by Chim, 74 °Brix^[25]. Although this high value of TSS is characteristic of jams and jellies. The content of soluble sugars in fruit jams usually ranges from 65 to 85 °Brix^[25]. This constitutes a major characteristic.

According to Chim the moisture content of strawberry jam was 24.6%^[25]. The average moisture value obtained in this work was 10.53% (**Table 4**). This value is somewhat lower than that reported by Chim. This lower value may be due to the fact that in this work a vacuum concentrator was used to obtain the jam and Chim used an open pan. This lower water content may contribute to a better preservation of the jam.

Table 4. Results of the physical-chemical characterization of strawberry jam

Determinations	Average values obtained	Variance S ²
pH	3.31± 0.052	0.27·10 ⁻²
Titratable acidity (TA) g/100 mL	0.096 ± 0.017	2.89·10 ⁻⁴
TSS °Brix	68.83 ± 3.54	12.56
Humidity (%)	10.53 ± 0.54	0.30
Ash (%)	0.92	

Chim confirms from his analyses for ash a value of 0.44%^[25]. The average value obtained in this work was 0.92% (**Table 4**), which is similar. The ash content in food is related to the composition of inorganic matter in the food.

In general, the research conducted allows, for the first time, to characterize the physical and physico-chemical characteristics of the “Festival” variety of strawberry obtained in the soil and climate conditions of the region of the Commune of Palanca, Municipality of Humpata, Huila Province, which is essential in the intention of knowing the composition of fruit and food in general, in Angola. Finally, the results obtained in the physical-chemical evaluation of the candy are shown. The above constitutes a first

step, on the way to foment the agro-industry in Angola and to diminish the post-harvest losses with the known economic impact that it involves.

6. Conclusions

The physical characterization of the “Festival” variety of strawberry obtained in the soil and climate conditions of the region of the Commune of Palanca, Municipality of Humpata, Huila Province showed that the average values of the fruit are: 8.60 g in weight; 25.53 mm in diameter and 32.69 mm in length. The chemical characterization of the variety under study allowed us to specify that it has: 3.41 of pH; 0.186 g/100 mL of titratable acidity; 9.51 °Brix

of total soluble solids; 18.60 mg/100g of ascorbic acid; 90.25% of moisture and 0.86% of ash. These chemical characteristics provide information about its nutritional value and offer criteria for its processing. The strawberry jam obtained by processing the fruit is characterized by: 3.31 of pH; 0.92% of ash; 10.53% of moisture; 0.096 g of titratable acidity and 68.83 °Brix of total soluble solids. The similarity of these values with those reported by other authors allows us to guarantee the good quality of the strawberry jam obtained.

Authors' contribution

All authors contributed in equal parts to the research presented in this paper, from its conception and design, review of the topic, experimentation, interpretation of results, writing, and final revision of the paper

Conflict of interest

The authors express that there are no conflicts of interest in the submitted manuscript.

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