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Two Ways Treatment of Watermelon (*Citrullus lanatus*) Nectar and Stability During Storage

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Abstract

Very popular with consumers, watermelon is nutritionally rich, particularly in lycopene. With a low pH, its transformation into nectar requires conservation treatment. This study explores the impact of stabilization treatments on nectars to determine the best conditions for pasteurization and preservation. Nectars were prepared from the Sugar Baby variety (Sb). To study stability, three treatments were carried out: two pasteurization schedules (75°C/10 min and 90°C/10 min) and the addition of a preservative (potassium sorbate). Results showed a reduction in reducing sugar content after pasteurization of over 25% (28.80% for SbT_{75} and 27.40% for SbT_{90}). A drop of 11.40% was also observed for sorbated nectars. Nectars pasteurized at 75°C and stored at 4°C have better stability with a constant pH and reducing sugar, and the lowest lycopene degradation (28.01%) after 24 days. On the other hand, an increase in lycopene content of 19.00% for SbT_{75} and 51.10% for SbT_{90} was observed after pasteurization. Nevertheless, sorbated nectars stored at 4°C show a high degradation of lycopene. On the other hand, all nectars stored at 20°C show a drop in pH and sugars in addition to a high degradation of lycopene. Without any consequences on health, a treatment combined with storage at 4°C allows good availability of nectars over time.

Keywords

Citrullus lanatus; Nectars; Stability; Processing; Micronutrient

1. Introduction

Native to Africa, *Citrullus lanatus* is a horticultural plant in the Cucurbitaceae family, similar to melons and cucumbers [1]. In Senegal, watermelons are grown all year round in a variety of varieties, with production in 2021 estimated at 1,611,188 tons [2]. Watermelon contains a multitude of nutrients, including bioactive compounds such as cucurbitacins and triterpenes [3, 4]. It is rich in sugars, amino acids, minerals, vitamins, and also in phenolic compounds [5, 6]. *Citrullus lanatus* has a high content of carotenoids, including lycopene, the molecule responsible for its red color [7, 8]. This nutritional diversity means that watermelon has a multitude of uses both in food, with the production of juice, jam, or fermented drinks, and medicinally for the prevention and treatment of cardiovascular diseases, as an anthelmintic, anticancer, or antibacterial [9, 10]. Watermelon is a highly perishable fruit due to its low acidity and high water activity [11]. In addition, the heat treatment performed on watermelon juice can lead to different modifications, including coloring or other attributes [12, 13]. Also, there are a few studies comparing chemical and thermal treatment. This work studies the impact of different treatments on watermelon nectar and their stability during storage at different temperatures.

2. Materials and Methods

2.1 Plant material

This study was carried out on a locally grown variety of red-fleshed watermelon. This is the Sugar Baby variety (Figure 1).

Figure 1. Sugar Baby variety whole (a) and cut (b).

2.2 Nectar formulation

The whole fruit is cleaned and cut up to obtain a pulp containing seeds. After being seeded, the red pulp recovered is ground using a LOKI LBL-201C type juice blender and filtered for refining, if necessary. The crude nectar obtained after grinding is used for formulation by adding sucrose. The nectars obtained undergo different treatments before controlling their stability.

2.3 Treatments and preservation of nectars

For the stability study, two treatments (thermal and chemical) are carried out. For heat treatment, two pasteurization schedules are applied at 75°C/10 min [14], optimized for "Madd" (*Saba senegalensis*) nectar, and 90°C/10 min for carrot juice [15]. Concerning chemical treatment, potassium sorbate E202 was added at a concentration of 1 $g.kg^{-1}$ of nectar formulated before homogenization. After stabilization, all nectars (raw, formulated, pasteurized, and sorbated) were stored at 4°C and 20°C. Thereafter, regular monitoring of the physicochemical and biochemical characteristics is carried out weekly for 24 days.

2.4 Nectar coding

A coding system is used to study stability during storage. The various nectars are coded at 2 levels, depending on the treatment applied (thermal or chemical) and the storage temperature used. Codified nectars are written in the form Nxy, where:

- x is the treatment applied, with an index of 1 for nectars pasteurized at 75°C/10 min; 2 for those pasteurized at 90°C/10 min, and 3 for those sorbated (addition of sorbate);
- y is the storage temperature, with an index of 1 for nectars stored at 4°C and 2 for those stored at 20°C.

2.5 Analytical methods

In the course of this study, various physicochemical and biochemical analyses were carried out. pH was determined using an analog pH meter (HANNA HI 223) with an accuracy of 0.05 at 25°C (Norms NF V76-122). Titratable acidity was determined by titration with a sodium hydroxide solution (0.1N) in accordance with the French standard (NF V05-101). Reducing sugar content is determined by the Luff-Schoorl method. Color parameters (L*a*b) are determined using a colorimeter (CM-5, Konica Minolta Sensing America's Inc., US). The various color components are used to define the product in three-dimensional space, with L* indicating lightness or luminance, which varies from black to white; a* corresponding to the green-red antagonist pair; and b* corresponding to the blue-yellow antagonist pair. Lycopene content was determined using the method described by Benakmoum et al. [16]. The extract was centrifuged with a Hexane/Acetone/Ethanol (50/50/1) mixture at 5,000 rpm. The organic phase obtained is then extracted with hexane before measuring absorbance at 472 nm using a UV spectrophotometer.

2.6 Data analysis

The data obtained were processed using Minitab 18.1 statistical analysis software. This made it possible to determine significant differences between several samples by means of an analysis of variance with a probability threshold of 5%.

3. Results and Discussion

3.1 Impact of processing on formulated nectars

The different nectars obtained were characterized in order to evaluate the impact of the different stabilization operations (heat and chemical treatment). All the results obtained are shown in Table 1.

Table 1. Physicochemical and biochemical characteristics of watermelon nectars

Parameters	NF	NP_{75}	NP_{90}	NSo
pH	5,62 ±0,02^{b}	5,51 ±0,02^{ac}	5,53 ±0,02^{c}	5,68 ±0,01^{d}
Titratable acidity (meq.kg^{-1} DM)	42,86 ±0,31^{a}	49,01 ±0,55^{bc}	46,96 ±4,21^{ac}	41,96 ±0,29^{a}
Reducing sugars (g.kg^{-1} DM)	659,05 ±20,57^{a}	469,10 ±4,94^{b}	478,76 ±6,02^{b}	583,91 ±14,62^{c}
Lycopene (mg.kg^{-1})	3,68 ±0,04^{a}	4,38 ±0,16^{b}	5,56 ±0,23^{cd}	3,26 ±0,15^{e}
L*	39,86 ±0,15^{c}	35,89 ±0,09^{bd}	35,36 ±0,56^{ab}	32,84 ±0,26^{e}
a*	11,21 ±0,49^{c}	8,10 ±0,40^{b}	9,03 ±0,24^{a}	7,08 ±0,13^{d}
b*	6,75 ±0,50^{ab}	7,53 ±0,18^{c}	9,51 ±0,25^{e}	5,01 ±0,12^{d}
Brown Index	37,83 ±1,94^{ab}	39,03 ±1,30^{ac}	48,81 ±2,03^{d}	31,38 ±0,96^{ef}

Notes. NF: nectar formulated; NP_{75}: nectar formulated and pasteurized at 75°C; NP_{90}: nectar formulated and pasteurized at 90°C; NSo: nectar formulated and sorbated; DM: dry matter; a, b, c, ... Analysis of variance between nectars, those not sharing the same letter are significantly different.

Statistical analysis of the table shows a decrease in pH of pasteurized formulated nectars from 5.62 to 5.51 for NP_{75} and 5.53 for NP_{90}. Nevertheless, this decrease is not significant to reach the desired values for nectar preservation, which should be ≤ 4.5 [13], [17]. After pasteurization, an increase in titratable acidity is observed regardless of the heat treatment applied (49.01 meq.kg^{-1} DM for NP_{75} and 46.96 meq.kg^{-1} DM for NP_{90}). The increase in acidity is explained by the release, during heat treatment, of acids contained in the cell vacuoles [18-19].

On the other hand, reducing sugar content fell after pasteurization at 75°C (469.10 g.kg^{-1} DM) and 90°C (478.76 g.kg^{-1} DM), i.e., 28.8% and 27.4% respectively. Moreover, the decreases obtained at 90°C are lower than those observed at 75°C. This may be explained by the formation of brown Maillard compounds or the hydrolysis of sugars. In the case of sorbated nectars, there was a drop in the sugar content of sorbated nectars (583.91 g.kg^{-1} DM) compared with formulated nectars (659.05 g.kg^{-1} DM), which may be explained by oxidation of reducing sugars during homogenization.

Lycopene contents in nectars also show a significant decrease after the addition of potassium sorbate (3.26 mg.kg^{-1}). This decrease in lycopene may be explained by oxidation during homogenization of the nectar during formulation. Lycopene is the most efficient free radical scavenger compared to β-carotene and various xanthophylls [20]. Other studies have followed the evolution of lycopene in the preparation of tomato concentrate and juice under industrial conditions. They show that lycopene is affected during the concentration and pasteurization stage for concentrate, and during homogenization for juice [21-22]. As obtained in other studies [23-24], lycopene content increased significantly after pasteurization at 75°C (4.38 mg.kg^{-1}) and 90°C (5.56 mg.kg^{-1}), by 19.00 and 51.10% respectively. Studies have shown that heat treatment of nectars increases the release of lycopene from chloroplasts [25-26]. This has a major impact on the bioavailability of lycopene when the product is consumed.

The clarity of all nectars is above 30.00, due to the relatively low lycopene content of the products. Furthermore, formulated nectars show the highest clarity (39.86). This significant increase in clarity can be explained by the degradation of polyphenols (flavones, lignans, etc.) and carotenoids (lycopene, β-carotene, etc.) present in the nectar. Sorbated nectars show a decrease in clarity (32.84). Formulated nectars show the highest values (11.21) for the a* parameter (red coloration). The release of carotenoids and polyphenols may also explain this decrease. The lowest values obtained for sorbated nectars (7.08) could be explained by the addition of sorbate and the homogenization carried out, which would favor the degradation of certain chromatic compounds (phenolic compounds, carotenoids, etc.).

3.2 Evolution of physico-chemical and biochemical parameters during storage

The results of monitoring the evolution of pH and reducing sugars were used to draw the curves shown in Figure 2.

Analysis of Figure 2a shows a decrease in pH, from the start of storage, for raw nectars (N01 and N02) and sorbate nectars stored at 20°C (N32). After 24 days, the pH ranged between 3.40 and 4.37. This can be explained, for raw nectars, by the lack of stabilization treatment. For pasteurized nectars stored at 20°C, the decrease in pH observed after 16 days can be explained by the heat treatment, which reduced microbial contamination. On the other hand, for nectars stabilized (by pasteurization or addition of potassium sorbate) and stored at 4°C, there was no change in pH. This pH stability shows that nectar stabilization combined with refrigeration (4°C) is effective.

In terms of reducing sugar content (Figure 2b), the same trends are observed as for pH. A decrease in sugar content was observed for both raw nectars and those stored at 20°C. The various losses obtained after 24 days of storage are more significant: 92.30% for N02, 27.74% for N01, 40.99% for N32, 48.57% for N22, and 13.90% for N12. These decreases in sugar content, combined with those in pH, can be explained by nectar fermentation. Stabilized nectars stored in cool conditions (N11, N21, and N31), on the other hand, show no significant change in reducing sugar content.

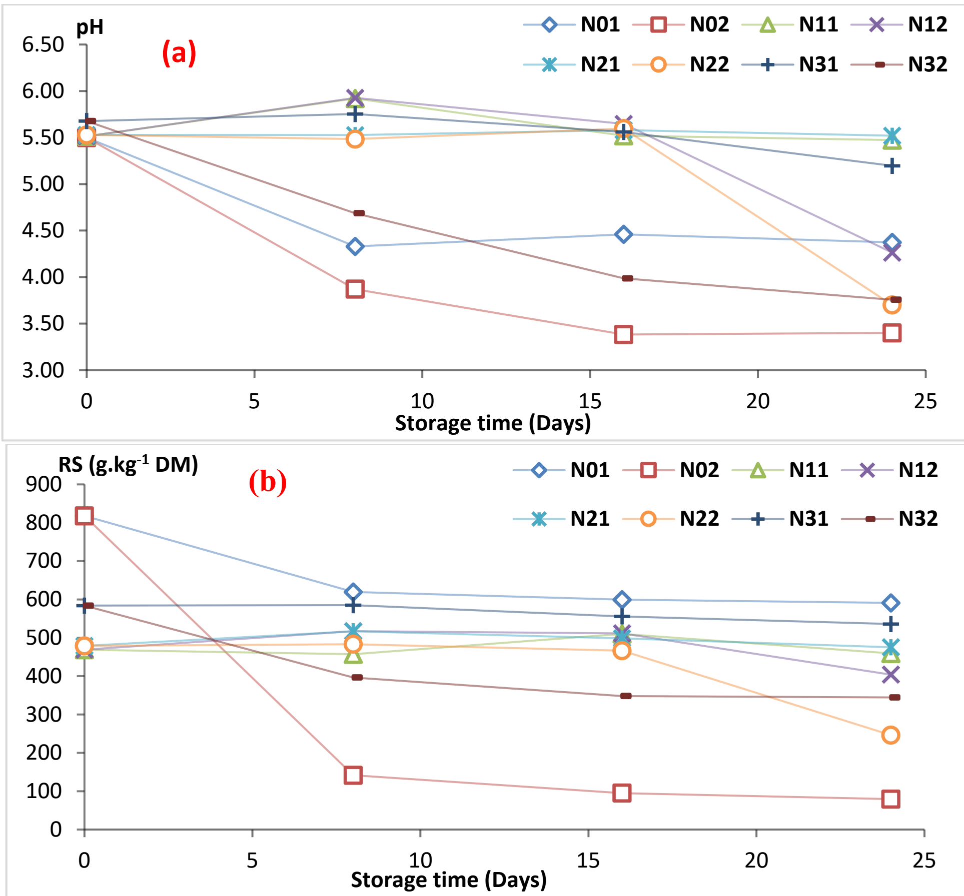

Figure 2. Evolution of pH (a) and reducing sugar content (b).

Notes. N01: raw nectar stored at 4°C; N02: raw nectar stored at 20°C; N11: nectar pasteurized at 75°C and stored at 4°C; N12: nectar pasteurized at 75°C and stored at 20°C; N21: nectar pasteurized at 90°C and stored at 4°C; N22: nectar pasteurized at 90°C and stored at 20°C; N31: nectar sorbated and stored at 4°C; N32: nectar sorbated and stored at 20°C; RS: Reducing Sugar Content; DM: Dry Matter.

Evolution in lycopene content is also monitored during storage, and the various results obtained lead to the curves shown in Figure 3.

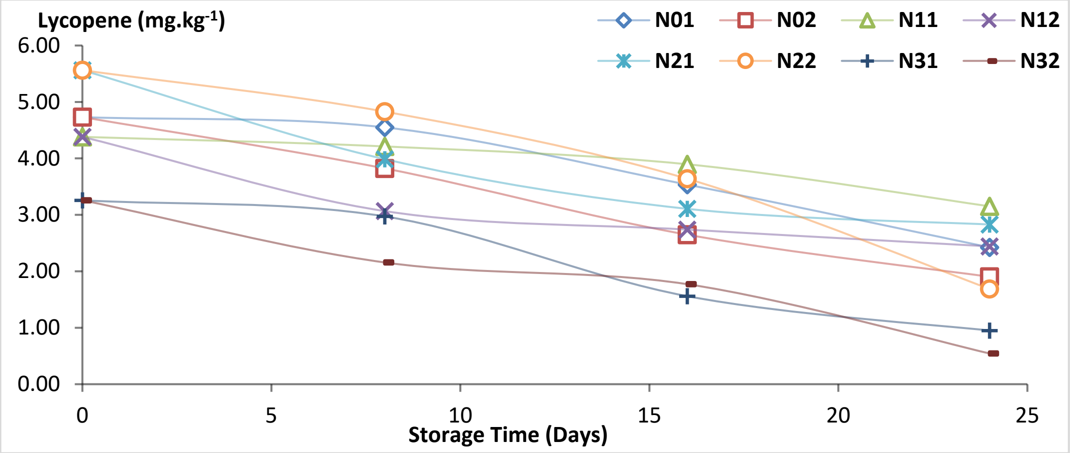

Figure 3. Evolution in lycopene content during storage.

A study of the evolution of lycopene content (Figure 3) shows that, whatever the nectar studied, there is degradation. Lycopene losses are variable and more accentuated according to the level of processing and storage temperature used. Thus, the highest losses are obtained for raw nectars stored at 20°C (N02) with 59.77%, those pasteurized at 90°C and stored at 20°C with 69.66%, and those sorbated (N31 and N32) with 70.84% and 83.30% respectively. These high levels of degradation can be explained by the 20°C storage temperature used. In the case of sorbated nectars, the significant losses can be explained by the sorbic acid and dissolved oxygen present in the nectars, which, along with the storage temperature, are thought to promote lycopene degradation. Indeed, Cole et al. showed that the presence of oxygen in tomato pulp could lead to a 25% degradation of lycopene [27]. Srivastava et al. have shown that lycopene oxidation breaks double bonds, leading to cleavage into smaller molecules that do not absorb sufficient light [28]. Nectars pasteurized at 75°C and stored at 4°C (N11) show the lowest degradation at 28.07%. It should be noted that N11 is relatively stable during the first two weeks of storage, while lycopene degradation increases after 16 days. This stability may be explained by the relatively low pasteurization temperature, which limits the formation of degradation compounds, and the use of refrigeration, which slows down the process. These results show that an increase in storage temperature significantly enhances lycopene degradation. In addition, low heat treatment coupled with low storage temperature would limit lycopene degradation.

4. Conclusion

Overall, this study shows that heat treatment of formulated nectars has a significant impact on acidity and lycopene content, in contrast to the use of potassium sorbate. The storage ageing study showed that pasteurized nectars stored at 4°C were more stable during storage. In addition, nectars stored at 4°C and pasteurized at 75°C showed better lycopene retention (less than 30% after 24 days). The increase in lycopene content after heat treatment would allow good availability, with the slight decreases observed at 4°C. Despite using the maximum recommended concentration (1 $g.kg^{-1}$), potassium sorbate had no significant impact on nectar preservation. The production and preservation of watermelon nectars are of great nutritional and commercial interest. Therefore, to improve nectar stability, it would be interesting to produce cocktails with acidic fruits.

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