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EFFECT OF PLANT EXTRACTS ON SOME QUALITY PARAMETERS OF CANNED MIXED SWEET CORN-RED BEAN

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ABSTRACT

The leading export product of Hungary is canned sweetcorn, which is available in single-component or blended varieties with a focus on colour retention, for which the food industry mainly uses ascorbic acid and EDTA in the brine of canned vegetable. Thoughtful customer behavior is pushing the food industry to switch to natural plant extracts instead of synthetic additives.
In order to investigate if acerola plant extract is suitable as a replacement for ascorbic acid, we investigated the potential uses of two varieties of acerola extract in three different concentrations in the case of canned mixed sweet corn and red bean. After production, and after 1 week of thermostating at 55°C and storage at room temperature for 4 and 8 weeks, the changes in pH value, salt concentration, water-soluble dry matter content, colour, total polyphenol content, and antioxidant capacity of the brine were all evaluated in this experiment.
The results showed that both acerola extracts were promising in fixing the colour, with the higher application of the first extract and the lowest and highest dosage of the second extract showing the best results.
During storage, the polyphenol content and antioxidant capacity of some samples decreased slightly compared to their initial values.

Keywords: sweet corn, red bean, heat-treatment, acerola extract, colour parameters

1. INTRODUCTION

Hungary is the leading corn grower in Europe, with the largest area under corn cultivation on the continent [1, 2]. Corn is a leading product in the country as it is the most widely grown raw material among cereals. It occupies a prominent place in the processing industry, especially in the canning industry. Canned sweetcorn products, such as those containing only crumbled sweetcorn or in vegetable mixes, are in great demand and are exported in large quantities [3].
In the case of mixed products from the canning industry, colour preservation is an important quality factor, and the processing industry places great emphasis on this in order to keep consumers. Additives are used to preserve the original colour of the vegetables. These additives are usually EDTA and ascorbic acid or other colour stabilizers, which are produced synthetically. However, there is a new consumer awareness movement towards naturalness, which is promoting the use of natural ingredients rather than artificial additives. Naturally, the use of natural substances, such as various plant extracts, is also being promoted by industry in order to keep or even increase consumer and market share.
The change of well-established recipes that have been in use for many years, or even decades, is a major challenge for the processing industry, due to the lack of available literature and experience in this field. It requires considerable research and development by companies, including not only the canning industry but also those producing the extracts. Industrial development should also follow this line if this direction is to be followed. Sources of natural antioxidants include various spices, herbs, teas, seeds, oils, vegetables, fruits, cocoa shells, cereals, enzymes and proteins [4]. Phytoncides are also widely used antioxidants and antimicrobials, e.g. the antioxidant effect of rosemary extract has been known for a long time. Oregano, sage, thyme, cloves, ginseng, ginger and white oak are rich and powerful antioxidants [5].

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Several studies have shown that acerola has an exceptionally high ascorbic acid content, high levels of phenolic compounds and antioxidant activity [6]. There are already examples of the browning of plants [7-8], and its many beneficial properties make it very potentially promising as a natural antioxidant [9-10].
The aim of the study was to replace the colour-preserving ascorbic acid in the brine of canned sweetcorn and red beans with natural plant extracts. We were looking for an answer to the question whether acerola as a plant extract could become a suitable alternative to ascorbic acid, thus providing a possible way for the industry to replace colour preserving additives with natural ingredients.

2. MATERIALS AND METHODS

2.1. Materials

Fresh corn and frozen red beans were used to prepare the samples. Canned products with a net weight of 340 g contained 285 g of vegetable mixture (85% crumbled sweet corn and 15% red beans), with 55 g of brine. The composition of the brine per 1 l is shown in Table 1. Two different types and different concentrations of acerola extract were tested (acerola extract 1 and 2). Samples 3 and 4 were prepared following the recommendations of the manufacturers for the use of the plant extracts, so that samples A and C were prepared at the two extreme recommended concentrations, while samples B were prepared at the midpoint of the recommended dose range.

Table 1. Amount of ingredients and water per 1 litre of brine (T=secret)

	1.	2.	3.A	3.B	3.C	4.A	4.B	4.C
water (g)	1000	T	953.15	950.2	947.25	960.5	960	959.5
salt (g)	-	T	38	38	38	38	38	38
ascorbic acid (g)	-	T	-	-	-	-	-	-
EDTA (g)	-	T	-	-	-	-	-	-
acerola extract 1. (g)	-	-	8.85	11.8	14.75	-	-	-
acerola extract 2. (g)	-	-	-	-	-	1.5	2	2.5

The first step in preparing the samples was to prepare fresh, crumbled sweetcorn and frozen red beans. Since the red beans were pre-cooked and frozen, the vegetables only needed 2-3 minutes of heating in warm water, then they were strained and the right quantities were filled into the cans.
After the cans were filled, we prepared the brine in the composition as specified in Table 1 and heated it to 70°C. We then poured the right amount of the brine into the cans filled with vegetables. The cans were sealed with a laboratory sealing machine in a vacuum chamber using double seaming.
The sealed cans are marked. The sealed samples were heat treated, and the compliance of the heat treatment was monitored with an F_0 probe at the cold point of the product. After production, the samples were thermostated at 55 °C for 1 week and stored at room temperature for 4 and 8 weeks to check the product parameters.

2.2. Methods

The pH was measured from the brine of the product using a Testo digital pH meter. The water soluble solids content was measured with an ATAGO DBX-55 digital refractometer. Konica Minolta CR 400 digital

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colorimeter was used to determine the value of color coordinate based on CIELab system: *L** (lightness factor), the *a** (the transition from red to green) and the *b** (from blue to yellow) were measured. The color difference parameter (ΔE^*_{ab}) was calculated according to Equation(1):

$$\Delta E^* = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \quad (1)$$

Evaluation of ΔE * using in Tab. 2.

Table 2. Summary of color difference [11]

ΔE*	Sensable difference
0-0.5	Not noticed
0.5-1.5	Hardly noticeable
1.5-3.0	Noticeable
3.0-6.0	Clearly visionable

Total phenolic content (TPC) was analyzed by means of the Folin-Ciocalteu‘s method according to Singleton and Rossi [12] where Gallic acid was used for the calibration curve and the results were expressed as microgram Gallic acid equivalent per milliliter (μg GAE mL^{-1}). Absorbance was monitored by Hitachi U-2900 spectrophotometer at 765 nm

The antioxidant activity was quantified by the means of Ferric reducing ability of plasma (FRAP) according to Benzie and Strain [13] where Ascorbic acid was used for the preparation of the calibration curve and the results were expressed as microgram Ascorbic acid equivalent per milliliter (μg AAE mL^{-1}). FRAP assay was conducted by Hitachi U-2900 spectrophotometer at 593 nm.

3. RESULTS AND DISCUSSION

3.1. Results of pH values

The pH values after 1 week of incubation is shown in Fig. 1. Sample 1 had the highest pH value of 6.43 after the samples were prepared, according to the measurements of the pH values. Sample 4.C displayed the lowest value, which was 6.05. All samples' pH levels decreased after one week of incubation, with a nearly uniform reduction across all of them. 3.C, which had a pH of 5.74 after incubation, had the lowest pH value. Sample 1 also had the highest pH value following incubation, measuring 6.18.

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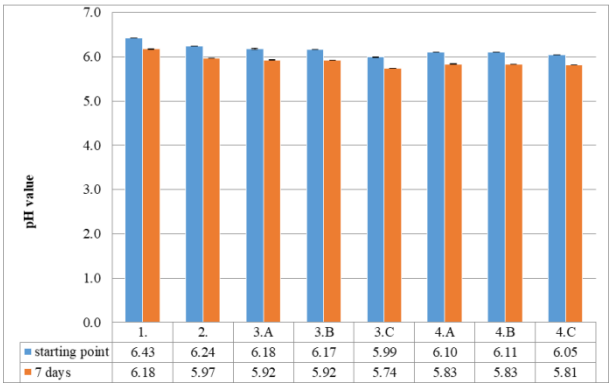
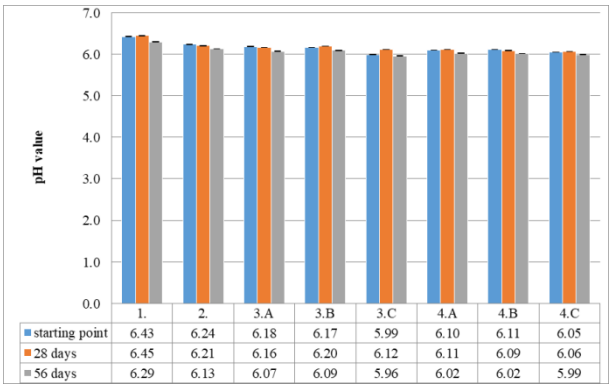


	1.	2.	3.A	3.B	3.C	4.A	4.B	4.C
starting point	6.43	6.24	6.18	6.17	5.99	6.10	6.11	6.05
7 days	6.18	5.97	5.92	5.92	5.74	5.83	5.83	5.81

Figure 1: pH values after 7 days of thermostatting compared to the starting point



	1.	2.	3.A	3.B	3.C	4.A	4.B	4.C
starting point	6.43	6.24	6.18	6.17	5.99	6.10	6.11	6.05
28 days	6.45	6.21	6.16	6.20	6.12	6.11	6.09	6.06
56 days	6.29	6.13	6.07	6.09	5.96	6.02	6.02	5.99

Figure 2: pH values change during storage at room temperature

There was a slight increase in the pH of sample 4.A after 28 days of storage, increasing by 0.1 from the initial value, which decreased to 6.02 after 56 days of storage. Based on the pH values measured at each time point, samples 3.B and 4.C showed a similar trend. The variation of pH values is also influenced by the ascorbic acid added during production and by the plant extracts added.

3.2. Results of water soluble solids content

Examining the refraction values measured after the preparation of the samples, the highest values were found in the samples labelled 3, including sample 3.C (11.83%). The lowest water soluble solids content was found in sample 1 (10.53%). After 1 week of thermostatting, the refraction values of the samples showed different variations. Samples 1 and 3.C showed a decrease. Sample 4.B did not show any change in the tested parameter, while the other samples showed an increase. After thermostatting, sample 3.A had the highest water soluble solids content of 12.03%. The largest increase was observed for sample 2, with a 0.43% increase in the water soluble solids content.

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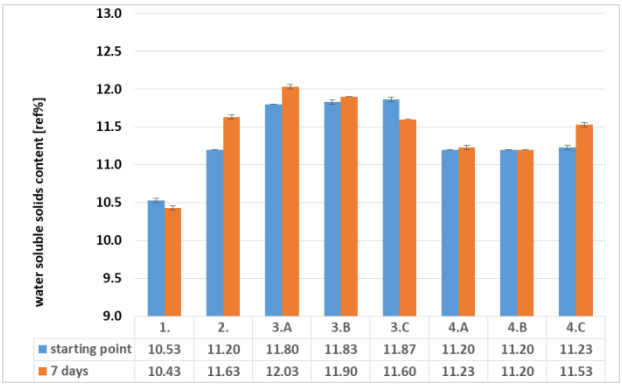

Figure 3: water soluble solids content after 7 days of thermostatting compared to the starting point

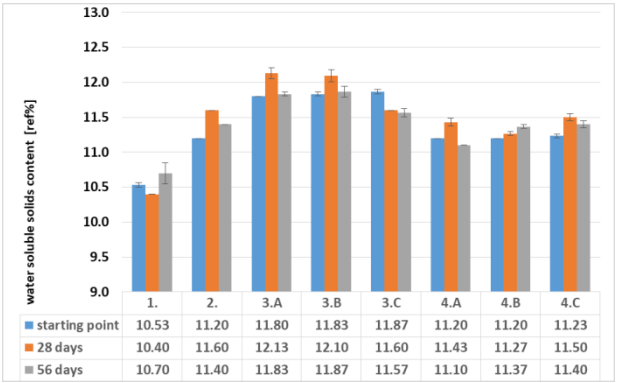

Figure 4: water soluble solids content values change during storage at room temperature

Comparable to the thermostatting test, a decrease was observed in the room temperature storage for samples 1 and 3.C at day 28, which continued to day 56 for sample 3.C. Sample 4.B showed a very slight increase, but only on day 56. The other samples showed an increase after 4 weeks of storage and a decrease by week 8. Sample 3.B had the highest water soluble solids content value of 11.83%, which decreased to 11.87% after 56 days, close to the initial value. A similar trend was observed for sample 3.A, where the initial percentage increased after 28 days of storage and then decrease to close to the initial value.

3.3. Results of colour difference

The ΔE* colour difference calculated from L*, a* and b* data after 1 week of thermostatting is shown in Fig. 1. The value of ΔE* is found to be greater than 0.5 for all samples, so the color change is noticeable, but to different rates.
Sample 1 (without color stabilizer) and 3.B fall into the „clearly visible" category ($3{,}0<\Delta E*\leq 6{,}0$), both with ΔE* values above 3. In sample 4.C the difference is "hardly noticeable", while samples 2, 3.A, 3.C, 4.A and 4.B have values in the ($1.5<\Delta E*\leq 3.0$) category.

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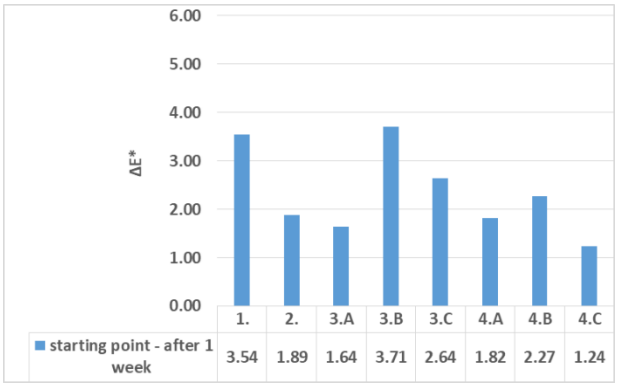

Figure 5: ΔE* values after 1 week of thermostatting compared to the starting point

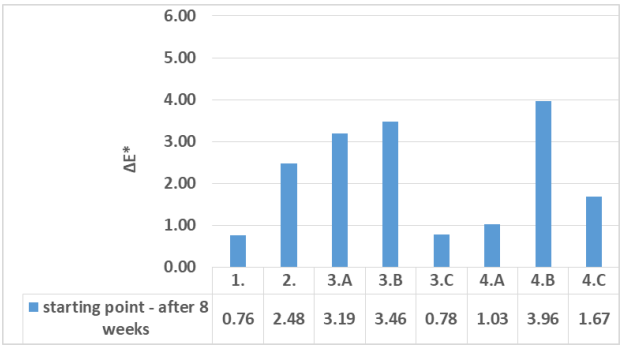

Figure 6: ΔE* values after 8 weeks of storage at room temperature compared to the starting point

The ΔE* values calculated for samples stored at room temperature are shown in Fig. 2. All samples belong to the noticeable category. Sample 1 without color stabilizer and samples 3.C and 4.A are in the "hardly noticeable" category. In the case of the industrial sample (2) and sample 4.C, the color change is noticeable by eye. For Samples 3.A, 3.B and 4.B, the change was "clearly visionable", with values between $3.0 < \Delta E^* \leq 6.0$.

The same trend was observed for both the thermostatted and room temperature storage experiments, the medium dose resulting in the greatest color change, while the lower and higher doses were more effective in color retention.

Based on the data measured after 1 week of thermostatting, it can be concluded that the clarity factor did not change in one case (sample 4.C), but increased in the other samples, which means that the samples became lighter.

During 8 weeks of storage, both plant extracts were effective, just at different concentrations. Obviously, a longer storage period is needed to make final conclusions.

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3.4. Results of total polyphenol content

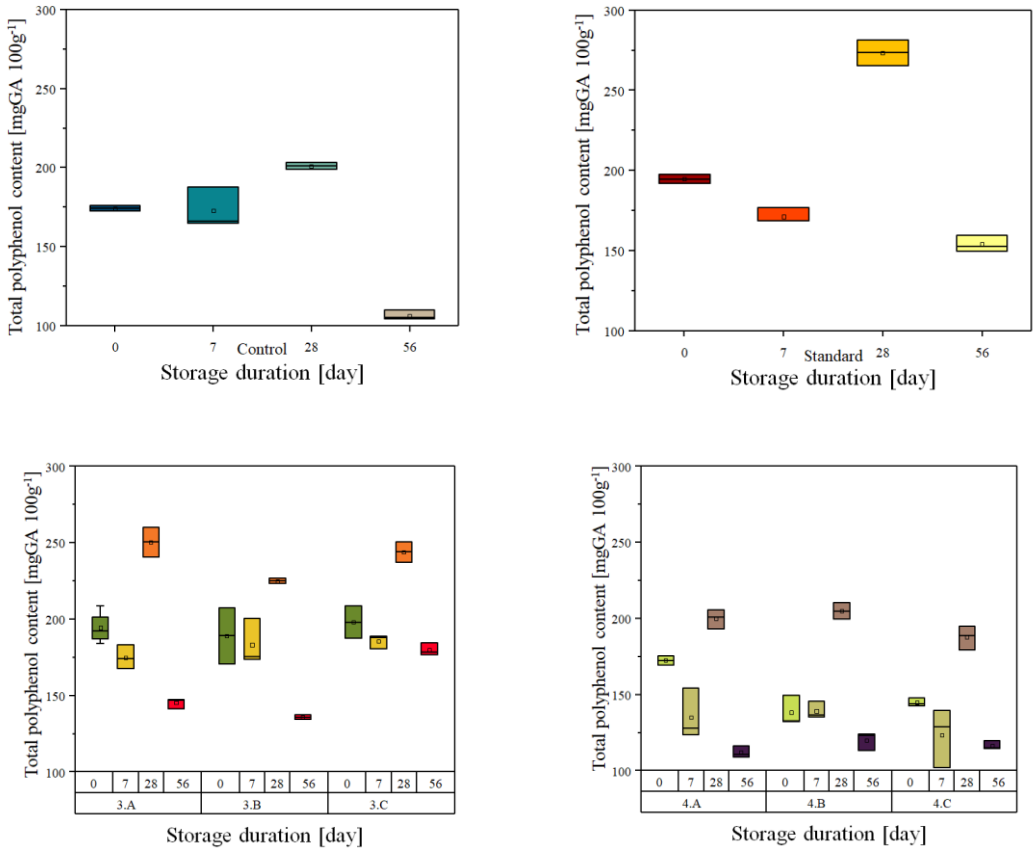

Figure 7: Total polyphenol content values change during storage

The sample with the lowest initial polyphenol content remained sample 4.B (138.11 mg $100g^{-1}$), while sample 3.C had the highest value at 197.7 mg $100g^{-1}$. Based on data collected after 4 weeks of storage, all samples showed an increase in polyphenol content (Fig.3). Sample 2 had the highest increase, with a 66.83 mg $100g^{-1}$ increase, resulting in the highest value of 273.3 mg $100g^{-1}$. After 4 weeks of storage, the sample with the lowest polyphenol content was sample 4.C at 187.6 mg $100g^{-1}$. Sample 1 showed the smallest increase in polyphenol content, with an increase of 26.87 mg $100g^{-1}$. Following 8 weeks of storage, a decrease in polyphenol content was observed in all samples. Sample 2 had the greatest decrease, with a drop in polyphenol content from 273.3 to 153.73 mg $100g^{-1}$, but still had the highest value among the post-storage values. Sample 1 had the lowest polyphenol content at 106.28 mg $100g^{-1}$. The smallest change was observed in sample 3.C, which had a decrease in polyphenol content from 243.88 to 179.74 mg $100g^{-1}$.

Bacchetti et al [14] have reported total polyphenol contents of 115-159 mg $100g^{-1}$ in different types of corn, which are similar to my results. On the other hand, Coco et al [15] measured higher levels of polyphenols, averaging 590 mg $100g^{-1}$, in frozen sweet corn samples over 10 months of storage. Zhang et al [16] published values ranging from 30.3-47.7 mg $100g^{-1}$, so the variability of polyphenol content is very high. The initial

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values were increased by the technology used, but as time passed, these components started to decompose, and a decrease was observed. Further experiments are needed to test the effect.

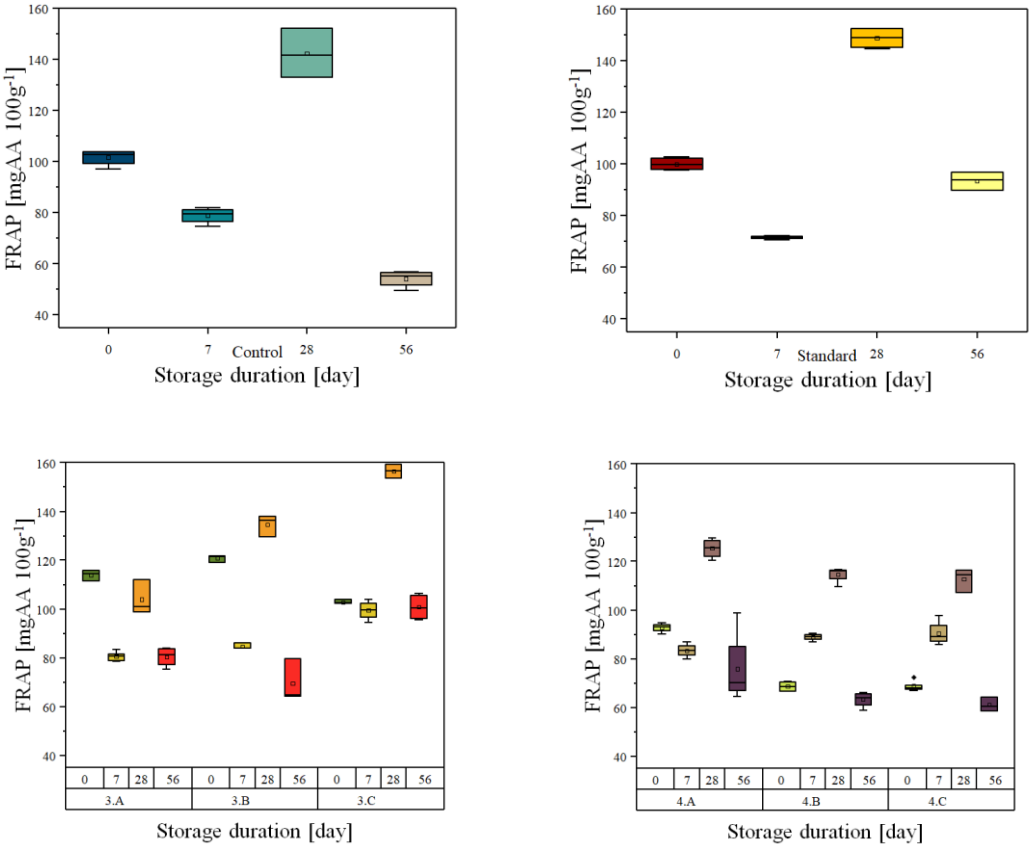

Figure 8: FRAP values change during storage

3.5. Results of antioxidant capacity

In the antioxidant capacity study, the sample with the highest initial value was sample 3.B (120.77 mgAA 100 g^{-1}) and the sample with the lowest initial value was sample 4.B (68.7 mgAA 100 g^{-1}). Data collected after one week of thermostation showed decreased antioxidant capacity values for samples 1, 2, 3, and 4.A (Fig.4). Sample 3.B showed the greatest reduction in antioxidant capacity with a reduction of 36.19 mgAA 100 g^{-1}. A minimal decrease in antioxidant capacity was observed for sample 3.C, decreasing from 102.85 mgAA 100g^{-1} to 99.48 mgAA 100g^{-1}. After 1 week of thermostation, sample 3C showed the highest antioxidant capacity value and sample 2 the lowest (71.51 mgAA 100 g^{-1}). Increased antioxidant capacity was observed in two samples, 4.B and 4.C, with values of 20.21 mgAA 100g^{-1} and 21.57 mgAA 100g^{-1}, respectively, above initial values.

From the initial antioxidant capacity values, sample 4B showed the lowest value at 68.7 mgAA 100g^{-1} and sample 3B showed the highest value at 120.77 mgAA 100g^{-1}. All samples showed an increase in antioxidant capacity after 4 weeks of storage, except sample 3A. Sample 3C showed the greatest increase in antioxidant

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capacity from 102.85 to 156.52 mgAA $100g^{-1}$. A minimal increase in antioxidant capacity was observed for sample 3B, increasing from 120.77 to 134.65 mgAA $100g^{-1}$. Only sample 3A showed a decrease in antioxidant capacity with a decrease of exactly 10 mgAA $100g^{-1}$, with this sample showing the lowest value after 4 weeks of storage (103.94 mgAA $100g^{-1}$). All measurements taken after 8 weeks of storage showed a decrease in antioxidant capacity. Sample 1 showed the lowest measured parameter at 54.12 mgAA $100g^{-1}$ and sample 3C the highest at 100.76 mgAA $100g^{-1}$ showed. The greatest reduction in antioxidant capacity was observed in sample 1, with a reduction of 88.22 mgAA 100 g^{-1}. The least change was observed in sample 3A, which showed a decrease in antioxidant capacity from 103.95 to 80.41 mgAA $100g^{-1}$.
In the corn varieties analyzed by Zhang et al [16], the antioxidant capacity ranged from 19.16 to 32.42 mg $100g^{-1}$.

4. CONCLUSIONS

All test results indicate that acerola extract may be a viable alternative to ascorbic acid, which is currently used in canned sweet corn and bean mixes. More research is needed to do so, but it is already clear that there is a need for natural additives among consumers.

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