Electronic Journal of Polish Agricultural Universities is the very first Polish scientific journal published exclusively on the Internet, founded on January 1, 1998 by the following agricultural universities and higher schools of agriculture: University of Technology and Agriculture of Bydgoszcz, Agricultural University of Cracow, Agricultural University of Lublin, Agricultural University of Poznan, Higher School of Agriculture and Teacher Training Siedlce, Agricultural University of Szczecin, and Agricultural University of Wroclaw.

ELECTRONIC JOURNAL OF POLISH AGRICULTURAL UNIVERSITIES

2004
Volume 7
Issue 1
Series FOOD SCIENCE AND TECHNOLOGY

JAWORSKA G., KMIECIK W., SŁUPSKI J. 2004. EFFECT OF TECHNOLOGICAL MEASURES ON THE QUALITY OF CANNED BANANA DESSERTS **Electronic Journal of Polish Agricultural Universities**, Food Science and Technology, Volume 7, Issue 1.
Available Online http://www.ejpau.media.pl

EFFECT OF TECHNOLOGICAL MEASURES ON THE QUALITY OF CANNED BANANA DESSERTS

Grażyna Jaworska, Waldemar Kmiecik, Jacek Słupski
Department of Raw Materials and Processing of Fruit and Vegetables, Agricultural University of Cracow, Poland

ABSTRACT

The banana fruit (yellow peel with brown flecks) were used for producing canned banana desserts. In first part of the investigation 17 samples were considered for various pre-treatment methods of bananas. Sliced bananas were blanched (at 80-82°C for 120 s) or soaked (24 h) in sugar syrup (10%, 30% and 50%) with L-ascorbic (0.2%) or citric (0.8-1.0%) acids, acid sodium sulphite (0.2%) and calcium chloride (1%). On the basis of the first part of the experiment, the best combinations were selected for further investigation. In the second part of the experiment the determinations concerned the effect of technological measures on the level of physico-chemical indices and on the sensorial traits of the bananas. In this part of investigetion all the applied methods of pre-treatment of banana slices ensure the production of good quality canned products. The applied calcium chloride had the most favourable effect, improving the hardness and sensory quality.

Key words: canning, blanching, soaking, additions, physico-chemical indices, sensory quality

INTRODUCTION

Difficulties arise in the processing of bananas. They are subject to rapid browning owing to damaged cells exposed to the action of oxygen. Among various pre-treatment measures this occurs during the peeling and slicing of fruit [5, 7] Numerous technological measures are used to preserve the natural colour of the product. The most important of them is blanching, which inactivates the enzymes responsible for the formation of substrates characterized by the undesired colouration [5]. The change of colour can also be prevented by the

addition of acidic sodium sulphate, citric acid, or L-ascorbic acid [4]. In processing bananas, especially those of full consumption ripeness, it is difficult to ensure the proper shape and hardness of slices [7]. In this case the addition of calcium salts, most frequently calcium chloride or calcium lactate, is applied [1, 11]. The calcium compounds, however, may unfavourably affect the sensory value of the product, above all its taste or aroma [4].

For the populations of numerous tropical countries bananas are among the least expensive though more important food products, while in Europe they are used as a delicious dessert fruit. Most of the banana harvest is consumed in the fresh market. A small part only is used in the processing industry although the possibilities of using this fruit for preserves are fairly wide [7, 28]. The flesh of bananas can be used for pulps, jams, chips, or flour. It can also be used as a component of mixed-fruit juices, addition to yoghurts, or in the mashed form as a component of cream cakes [16, 20]. In general, the industrial processing of bananas is conducted in the countries where these fruits are produced. In the present work, an attempted was made to use bananas which were not sold as dessert fruit and owing to the degree of their maturity were not suitable for further storage. It should be stressed that in large ripening stores these are quantities frequently exceeding a few to several tons weekly.

The aim of the work was to elaborate the technology of utilizing bananas of full consumption maturity for the production of canned products of the dessert type. The level of basic physico-chemical indices and the sensory quality were accepted as the criteria in evaluating the final products.

MATERIALS AND METHODS

Materials

The investigated material consisted of fresh bananas of full consumption maturity from the Ecuadoriean Gold firm. The intensely yellow peel with brown flecks and the delicious and aromatic fruit flesh, though of weakened consistency, manifested the maturity. Acording to the colour index system of the United Brands Company the stage of ripeness of bananas were the stage 7 [28]. The fruit were used for the preparation of pasteurized banana desserts.

Technological procedures

The technological experiment consisted of two stages. First, such technological measures and additives were examined which permitted obtaining the best quality of preserved bananas. The aim of applied treatments was to ensure the stability of colour, fruit hardness, and removal of gas substances. The preliminary processes should also ensure a final product ready for direct consumption or for the preparation of salads, cocktails, ice cream, cakes, or other desserts. The basic criterion of evaluation was sensorial analysis. The kinds of samples taken into consideration at the first part are given in Table 1.

Table 1. The kinds of samples analysed in the first part of the experiment

Symbol of sample	Pre-treatment methods before canning	Composition of solution (%)				
		sucrose	citric acid	L-ascorbic acid	calcium chloride	acid sodium sulphite
0	-	-	-	-	-	-
B1	blanching in water	-	-	-	-	-
B2	blanching	10	1	-	-	-
B3	blanching	30	1	-	-	-
B4	blanching	30	1	-	1	-
B5	blanching	30	0.8	0.2	-	-
B6	blanching	50	1	-	-	-
M1	soaking	-	1	-	-	-
M2	soaking	-	1	-	1	-
M3	soaking	-	1	-	-	0.2
M4	soaking	-	0.8	0.2	-	-
M5	soaking	10	1	-	-	-
M6	soaking	30	1	-	-	-
M7	soaking	30	1	-	1	-
M8	soaking	30	1	-	-	0.2
M9	soaking	30	0.8	0.2	-	-
M10	soaking	50	1	-	-	-

The bananas were peeled, the ends of fruit being cut off, after which they were cut into slices about 8-9 mm thick. At this stage the yield of edible part in relation to whole fruit weight was determined. The banana slices were blanched or soaked in sugar syrup. The ratio of the mass of the bananas to that of solution for blanching and soaking, the concentration of sucrose in these solutions, and the parameters of the discussed measures were determined on the basis of preliminary experiments. Blanching was carried out in a kettle of stainless steel, a metal basket with banana slices being placed in the kettle. The ratios of the banana mass to that of the bath were 1:5. For samples the blanching time was so determined as to reduce the enzymatic activity of the raw material by at least 80% and to induce the shrinkage of slices, this showing the removal of gaseous substances. These conditions were met in the procedure of blanching at 80-82°C for 120 s. In the discussed experiment the cooling stage was omitted, the cans being filled with warm slices. During the 24-hour soaking of banana slices, with gentle stirring at intervals of a few hours, in the concentrated solution of sucrose various additives were used while the ratio of fruit weight to that of the syrup was 6.4:5. After blanching or soaking the losses in weight of the raw material were determined.

The prepared banana slices were preserved in cans, 0.32 dm^3 in volume. The stock of bananas was 200 g, the solution constituting 40% of the preserve, i.e. 133 g. In all the samples investigated a solution of the following composition was used: 35.0% sucrose, 0.8% citric acid, 0.2% L-ascorbic acid, and water to 100%. Since the slices of fruit, especially after blanching, were delicate and easily stuck together, about 50% of the solution was poured first into the cans. The fruits were then packed and the remaining part of the solution added. This procedure permitted the removal of air from the preserve. The temperature of the solution was about 80°C. The pasteurization conditions were experimentally determined, the selection of parameters being tested in a thermostat. The following procedure of conservation was used: increasing the temperature to the pasteurization level – 10 min, the pasteurization at 80-82°C – 12 min, the cooling of canned products to 35°C – 8 min. After complete cooling and drying, the cans were placed in an air-conditioned chamber at about 10°C, where they remained to the time of evaluation.

In the technological process of producing banana preserves tap water of 14°N hardness was used for blanching, soaking, and preparing the brine.

On the basis of the first part of the experiment, the best combinations were selected for further investigation. For the selected objects the effect of preliminary processing, preservation, and storage of preserves on physico-chemical discriminants and sensorial traits of the desserts was determined. Table 2 contains the kinds of samples analysed in the second part of the experiment. In the second part of the investigation the parameters of blanching, soaking, and pasteurizing were the same as in the first part. The preserved banana desserts were stored in an air-conditioned chamber at about 10°C to the time of their evaluation.

Table 2. The kinds of samples analysed in the second part of the experiment

Symbol of sample	Pre-treatment methods before canning	Composition of solution (%)				
		sucrose	citric acid	L-ascorbic acid	calcium chloride	acid sodium sulphite
1	blanching	30	0.8	0.2	-	-
2	blanching	30	0.8	0.2	1	-
3	soaking	50	0.8	0.2	-	-
4	soaking	50	0.8	0.2	1	-
5	soaking	50	1	-	-	-
6	soaking	50	1	-	1	-
7	soaking	50	1	-	-	0.2
8	soaking	50	1	-	1	0.2

Analitical procedures

At the first part of the investigation sensorial analysis was used in evaluating the effect of preliminary processing on the quality of canned banana desserts. The analysis was carried out after 1-month storage of the preserves. The sensory evaluation was conducted in a five-score scale by a team of five experts who met the basic requirements with respect to sensory sensitivity according to ISO 3972 [12]. The evaluation was carried out in conditions agreeing with the ISO 6658 [14] recommendations, a standard chart elaborated by the authors of the work being used by the experts. In the evaluation the traits taken into consideration included external appearance, colour of theliquid phase, colour of fruits and their consistency, aroma, and taste. The figure

obtained by dividing the sum of scores given to the individual sensorial traits – multiplied by significance factors – by the sum of the significance factors was accepted as the general estimate.

Sensory analysis was also used in the second part of the experiment in comparing the quality of preserved banana desserts after a 6-month storage. At this stage of the investigation the determination of selected indices of the chemical composition and texture profile analysis composition were also determined. Three lots of the raw material and blanched or soaked fruits were subjected to texture profile analysis, eight measurements being carried out for each lot. The analysis was conducted in a Stable Micro System apparatus, TA-XT2 model, according to the XT.RA Dimension V3.7J program. The method consisted in double pressing of banana slices about 9 mm in thickness to a depth of 6 mm with a SMS P/45 roll moving at a rate of 2 mm/s. The results of the hardness and adhesiveness determinations are given in the work.

The level of selected indices of the chemical composition was determined in the raw and processed material (after blanching or soaking) and in the cans after 6-month storage, using methods given in AOAC [2]. Analyses concerned dry matter (32.064), total sugars (32.041), total acids calculated into citric acid (32.043), and active acidity (32.016). Vitamin C was determined using the ISO/6557/2 [13] method, total polyphenols using the Folin-Ciocalteau reagent [27], the peroxidase activity using the spectrophotometric method given by Cano et al. [5], protopectins and pectins using the spectrophotometric method [18]. For the determination of calcium dry mineralization was carried out at 450°C in a Naberthem furnace, model L 9/S 27, and followed by wet mineralization in HNO_3 and HCl solutions. The mineralized samples were diluted with deionized water and filtered. The content of calcium in the solution was determined using a Philips PU 9100X spectrophotometer. In samples containing sodium bisulphate the content of free and bound SO2 was also determined [22]. All the determinations of physico-chemical indices were carried out in four replications each in two parallel samples.

Statistical analysis

The results of measurements of the physical traits of banana slices, of analyses of chemical composition, and of the sensory evaluation were statistically verified using the Snedecor F test and Student‘s t test. The least significant difference (LSD) was calculated for the probability level of the error at p=0.05 for the sensory evaluation (total score) and at p=0.01 for the measurements of physical traits and discriminants of the chemical composition.

RESULTS AND DISCUSSION

The results of sensorial analysis carried out after the first part of the investigation are given in Table 3. In the control sample (0), smooth even surface, appropriate consistency, and indifferent fragrance and taste characterized the slices of banana. The drawback that disqualified this preserve was that the slices were not fully immersed in the brine. This was the effect of inadequate deaeration resulting in the change of colour, which was bluish, pink, or pink-violet, while the immersed slices were light yellow. A similar drawback, though less intense, was observed in preserves produced from slices soaked in solutions without sugar (M1, M2, and M4), apart from a sample with acid sodium sulphite added (M3). Blanching and soaking, particularly in sugar syrup, brought about the shrinking of slices. The surface of blanched slices was slightly shredded and the consistency soft on the surface, yet inside it was like that of unprocessed banana. Soaked slices preserved their shape very well; but their consistency was slightly weakened in comparison with the control sample. It was also assessed as being particularly valuable that slices blanched or soaked in a sugar solution did not float on the brine surface. The colour of slices processed in sucrose solutions of 30% and 50% concentrations was good. In the samples, above all those prepared without sugar or with its 10% addition, darker spots appeared in the centre of some slices. It should be stressed that the discoloration did not always unfavourably affect the general appearance of the product, hence in the second part of the experiment it was decided to evaluate it with respect to its attractiveness for the consumer. The aroma of all the samples was typical of banana yet the preserves prepared from blanched slices were characterized by a more intensive scent. The best taste was found with products of blanched slices and those treated with sugar solutions of 30% and 50% concentrations.

Table 3. Results of the sensory evaluation of canned banana desserts after first part of the investigation

Quality discriminant	Conversion factor	Symbol of sample according to table 1																
		0	B1	B2	B3	B4	B5	B6	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
External appearance	3	4.3	3.5	3.3	3.4	3.4	3.4	3.0	3.5	4.0	3.5	3.5	3.5	3.5	4.2	3.5	3.5	3.7
Colour of the liquid phase	1	2.8	4.0	4.0	4.0	4.0	4.0	4.0	3.2	3.2	3.2	3.2	3.8	3.8	3.8	3.8	3.8	3.8
Colour of fruits	4	1.0	3.8	3.8	4.3	4.3	4.5	4.5	2.0	2.0	4.0	2.0	4.1	4.3	4.3	4.8	4.5	4.4
Consistency	3	4.1	3.8	3.7	3.7	4.2	3.7	3.0	3.3	3.8	3.3	3.3	3.4	3.5	4.0	3.5	3.5	3.7
Aroma	4	4.2	4.5	4.5	4.5	4.5	4.5	4.5	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Taste	5	3.9	4.2	4.2	5.0	5.0	5.0	5.0	4.1	4.1	3.9	4.1	4.3	4.5	4.5	4.2	4.3	4.8
Total score	20	3.43	4.02	3.98	4.27	4.35	4.32	4.16	3.46	3.60	3.79	3.46	3.98	4.08	4.26	4.09	4.07	4.22
LSD p= 0.05		0.098																

The blanching parameters used in the work can be determined as soft. Giami [10] blanched plantain in boiling water for 3 min. Garcia et al. [9] used 7-minute blanching of bananas, while Cano et al. [7] boiled whole peeled banana fruits for 11 min prior to freezing. Soaking fruits in various solutions is an old technological measure of improving colour, consistency, and taste. Baths of short duration, taking several seconds to a few minutes, were applied by Agar et al. [1] to kiwi slices before storing them in controlled atmosphere, by Garcia et al. [9] in the production of banana puree, and by Giami [10] before freezing plantain. The soaking of fruits in concentrated sugar solutions for a few to several hours is known as the process of osmotic dehydration. This method of treating raw materials is used prior to the final processing, most frequently before drying. Among other consequences it inhibits the activity of polyphenolooxidase and preserves the aroma [23], hence it is particularly suitable for banana fruits [25].

On the basis of the discussed part, the following samples were selected for further stages of the investigation: blanched in a 30% sucrose solution (in sensorial analysis the total score was 4.27-4.35) and soaked in a 50% sucrose solution (4.22 score) with an addition of citric acid, L-ascorbic acid, calcium chloride, and acid sodium sulphide.

The presented results permit determination of the effect of blanching or soaking banana slices in sugar syrup with various additives on selected physico-chemical traits of the slices subjected to the above treatments. The chemical composition and sensorial traits of banana desserts preserved by pasteurization in airtight containers were also determined.

The chemical characteristics of fresh bananas and selected discriminants of their texture are given in Tables 4. In the evaluated banana fruits at full consumption maturity the content of dry matter, total sugars, polyphenols, and pectin and protopectin was within the limits given in the literature [7, 6, 8, 17, 26]. The content of total acids and vitamin C was in the lower level of the cited values, this showing an advanced degree of ripeness [6, 17, 26]. The level of calcium was distinctly lower than the average values [19, 26].

The usable part of the banana cut into slices constituted 63.3% of the weight of intact fruits. From the remaining 36.7% the peel constituted 34.2% and the cut off fruit ends 2.5%. Thus the peel-pulp ratio was 0.52, this also confirming the full maturity of the investigated banana fruits [17].

As expected, the blanching and soaking treatments reduced the weight of the fruits 8 and 14%, respectively, owing to the transport of water and with it of soluble compounds to the syrup. However, the decrease in weight after soaking was fairly insignificant. In the case of banana slices 10 mm in thickness, soaked for 36 hours in syrup of 50° Brix Sankat et al. [25] recorded a 24% decrease in fruit weight. For apples and plums dehydrated for 24 hours in syrup of 65% sucrose concentration Jarczyk et al. [15] found a weight decrease of 31 and 33%, respectively.

The treatment of slices led to significant changes in the level of analysed discriminants of the chemical composition (Table 4). In comparison with the raw material the content of dry matter in blanched fruit increased about 5% and in soaked ones 23-26%. At the same time in the above groups of treatments moisture content was reduced from 292 g H_2O/100 g DW to 274 and 214 g H_2O/100 g DW on the average, i.e. 6 and 27%. According to Sankat et al. [25] and Panagiotou et al. [21], a decrease in moisture content in the order of even 60-70% can be expected after osmotic dehydration. For the discussed groups of treatments 5-6% and 23-26% increases were noted in the level of sugars and 13-17% and 39-61% in that of acids, respectively. In relation to the raw material a significant decrease in active acidity was also observed in soaked and blanched samples.

Table 4. The level of selected physico-chemicals indices (g/100 g) in fresh and prepared bananas (regarded as the intermediate product)

Physico-chemicals indices	Raw material	Symbol of samples according to table 2								LSD p= 0.01
		blanching in solution		soaking in solution						
		1	2	3	4	5	6	7	8	
Dry matter	25.52	26.82	26.71	31.42	32.07	31.81	31.96	31.72	32.04	0.509
Total sugars	20.92	22.09	21.89	26.00	25.97	25.92	26.31	25.68	26.08	0.771
Total acids	0.23	0.27	0.26	0.32	0.33	0.35	0.36	0.37	0.37	0.028
Active acidity, (pH)	5.07	5.00	4.94	4.81	4.72	4.68	4.62	4.60	4.61	0.120
Protopectin	0.57	0.54	0.53	0.53	0.57	0.50	0.54	0.52	0.53	ns
Pectin	0.17	0.14	0.16	0.15	0.17	0.16	0.16	0.15	0.17	ns
Polyphenols	0.40	0.37	0.38	0.50	0.56	0.48	0.53	0.51	0.57	0.042
Vitamin C, mg/100 g	7.2	9.8	10.0	29.8	34.8	5.4	5.4	5.9	5.9	1.55
Calcium, mg/100 g	1.19	1.14	9.04	1.16	19.40	1.21	19.65	1.18	19.13	1.172
Peroxidase activity ΔA_{485} min^{-1} g^{-1}	1.51	0.25	0.16	0.32	0.16	0.33	0.18	0.30	0.16	0.095
Hardness, N	39.65	20.33	24.10	20.97	29.16	19.26	29.08	19.79	29.55	1.986
Adhesiveness, N	7.38	3.71	3.98	3.61	2.90	3.21	2.18	4.43	2.19	0.437

The treatments of blanching and soaking brought about only slight quantitative changes in the protopectin and pectin content, hence the differences between the processed slices and the raw material were statistically non-significant. It should be stressed, however, that the two treatments reduced the weight of fruits 8 and 14% while increasing the level of dry matter. After the calculation of results into dry matter, decreases were recorded in the content of these compounds, reaching 10-22% in blanched samples and 21-30% in soaked ones. On the one hand this suggests the dilution of these compounds with sucrose of numerous other agents and, on the other, some losses, which could have been effected by increased temperatures or acidic hydrolysis.

Differences in the level of vitamin C between the fresh banana and the intermediate product were significant, depending on the addition of L-ascorbic acid to sugar syrup during the pre-treatment of slices. In samples 5-8, without L-ascorbic acid additives, the content of vitamin C was reduced 18-25%. In blanched samples with L-ascorbic acid added (samples 1 and 2) the content of vitamin C increased 36-69% and in slices soaked with L-ascorbic acid added (samples 3 and 4) the increased content was 3-4 times higher than the quantity recorded in the raw material.

As mentioned above, the content of calcium in fresh bananas was low. This low level of calcium, approximating 1 mg/100 g, was maintained in samples 1, 3, 5, and 7, no statistical differences being observed between them. In blanched samples with added calcium chloride the content of this element increased almost 7 times and in samples soaked with the addition of this compound about 15 times.

Enzymatic activity is a significant element affecting the sensory quality of banana preserves and especially their colour, aroma, and taste. Cano et al. [5] observed high activity of polyphenylooxidase and peroxidase characterizing banana fruits. In the present work the activity of peroxidase was accepted as a measure of the activity of enzymes on the basis of its greater resistance to inactivation and its regeneration capability [3, 5]. Thus if the activity of this enzyme were significantly reduced, it would be highly probable that the activity of the remaining enzymes might be considerably limited. The blanching treatment led to an 83-89% decrease in peroxidase activity, while that of the 24-hour soaking in sugar syrup with additives 78-89%. It is worth stressing that in all the samples with calcium chloride added this activity was found in the lower limits of the values.

In samples 7 and 8 acid sodium sulphite was used as an additional antioxidant. After a 24-hour exposure of banana slices to this compound 24.6-24.9 mg of the total SO_2 content and 20.2-20.4 mg of free SO_2 were recorded.

Physical traits of banana slices blanched and soaked in sugar syrup significantly changed in relation to the raw material. Their hardness was reduced 39-49% after blanching and 25-51% after soaking. The hardness of bananas pre-treated with an addition of sodium chloride was significantly higher than the remaining samples. This finding is confirmed by the investigations conducted by Camire et al. [4] and Giami [10]. In the case of

adhesiveness the differences were even greater, the most favourable effect of the pre-treatment being noted in samples soaked with an addition of calcium chloride.

The canning and 6-month storage of banana desserts induced changes in all the analysed discriminants of the chemical composition (Table 5). Probably the changes were to the highest degree induced by the use of solution of a rich content of sugars, citric acid, and ascorbic acid. In comparison with intermediate products, the content of dry matter and total sugars increased 14% and 20-21%, respectively, in canned products from the blanched raw material and by 5-6% and 12-15% in canned bananas from the soaked material. In referring the results to dry matter the level of sugars after pasteurization increased 6-9% in comparison with intermediate products while the average content of sugars in dry matter rose from 82% to 88%. In spite of a greater percentage increase in the content of dry matter and sugars, the level of these discriminants was lower in canned products from the blanched raw material than in those from the soaked bananas. In final products a considerable increase in total acidity and a reduction of active acidity were also observed. The value of pH was at a level of 3.94-4.14, being lower in products from the soaked raw material, particularly in solutions with added acid sodium sulphate. Total acidity ranged from 0.50 to 0.57 g/100 g fresh matter, exceeding by 85-96% that in the blanched intermediate product and by 50-59% in that soaked in solutions with various additives. Depending on the sample, the level of protopectins decreased during conservation and storage 9-21%. The products from the raw material soaked in the solution of calcium chloride contained more protopectin but the differences were not always statistically significant. The losses of protopectins were accompanied by increases in the content of pectins 18-87%, showing partial hydrolysis of protopectins to pectins.

Table 5. The level of selected physico-chemical indices (g/100 g) in canned banana desserts

Physico-chemicals indices	Symbol of samples according to table 2								
	blanching in solution		soaking in solution						LSD p= 0.01
	1	2	3	4	5	6	7	8	
Dry matter	30.50	30.56	33.27	33.66	33.48	33.78	33.50	33.78	0.788
Total sugars	26.82	26.46	29.77	29.74	29.20	29.56	29.39	29.62	1.032
Total acids	0.50	0.51	0.51	0.52	0.54	0.54	0.56	0.57	0.025
Active acidity, (pH)	4.14	4.02	4.09	4.00	3.97	3.99	3.96	3.94	0.071
Protopectin	0.44	0.42	0.47	0.48	0.44	0.49	0.42	0.47	0.049
Pectin	0.26	0.28	0.28	0.26	0.24	0.22	0.22	0.20	0.039
Polyphenols	0.48	0.46	0.53	0.53	0.50	0.52	0.55	0.55	0.059
Vitamin C, mg/100 g	75.1	77.2	86.2	83.9	72.1	72.2	73.9	73.8	3.92
Calcium, mg/100 g	1.95	12.22	2.06	20.30	2.01	19.96	1.96	19.65	1.611

The canned products obtained from the blanched raw material (samples 1 and 2) contained 0.46-0.48 g polyphenols in 100 g fresh matter, this constituting a 21-30% increase in the content of those compounds in relation to the intermediate product. It may be supposed that in the banana slices the reactions of enzymatic and non-enzymatic browning could have occurred after the blanching treatment. Their products reacted with the Folin-Ciocalteau reagent used in determining polyphenols [24]. In the preserves produced from soaked material the average content of polyphenols was 0.53 mg/100 g fresh matter, i.e. 13% more than in the preserves discussed above. In these products slight changes ranging from -5 to +8 were observed after conservation and storage.

The canning of banana slices in solution containing 0.2% of L-ascorbic acid induced increases 2.5 – 13 times in the level of vitamin C in the final product. No pronounced differentiation was found in the level of vitamin C between the particular preserves. With an average content of 76.8 mg in 100 g fresh matter the deviations ranged from -6 to +12%. The greatest content of this vitamin was recorded in the preserves whose preliminary processing of slices included an addition of L-ascorbic acid (samples 1-4).

After canning and storage the level of calcium rose by 0.3-3.2 mg/100 g of the product (1.0 mg/100 g on the average). The increased level was caused by the use of hard water for preparing the solution.

Table 6. Results of the sensory evaluation of canned banana desserts after second part of the investigetion

Quality discriminant	Conversion factor	Symbol of samples according to table 2							
		from bananas blanched				from bananas soaked			
		1	2	3	4	5	6	7	8
External appearance	3	3.3	4.0	3.5	4.3	3.4	4.5	3.0	4.4
Colour of the liquid phase	1	4.0	4.0	3.8	4.1	3.9	4.1	3.8	4.1
Colour of fruits	4	4.4	4.4	4.4	4.4	4.1	4.5	4.3	4.5
Consistency	3	4.0	4.5	3.8	4.1	3.8	4.5	3.8	4.3
Aroma	4	4.8	4.8	4.8	4.8	4.6	4.6	4.5	4.5
Taste	5	5.0	5.0	4.6	4.6	4.7	4.7	4.3	4.3
Total score	20	4.39	4.56	4.26	4.46	4.18	4.54	4.04	4.39
LSD p = 0.05		0.144							

The sensory quality of all canned banana slices (Table 6) was more than good. Differences between the investigated samples were slight though statistically significant. Canned products from blanched slices obtained a general scoring 4% higher on average (samples 1-2) than those from soaked slices (samples 3-8). A very good taste and better consistency characterized the desserts from blanched slices, although their surface was ragged, this negatively affecting the external appearance of the slices. The quality of products from slices soaked in solutions with ascorbic or citric acids (samples 3-6) was not inferior to the products discussed above. A significantly lower estimate, however, was obtained by preserves from the slices soaked in a solution of acid sodium sulphate. This additive above all deteriorated the taste of the banana. In a general evaluation, all the canned desserts from slices whose preliminary processing included the addition of calcium chloride (samples 2, 4, 6, and 8), obtained significantly higher scores than the products without this additive (samples 1, 3, 5, and 7). The mean score of samples 2, 4, 6, and 8 was 6% higher than that of samples 1, 3, 5, and 7. Calcium chloride improved the consistency and external appearance of preserved slices, without deterioration of the remaining sensory traits.

CONCLUSIONS

As the results of first part of the investigation show, the treatments of blanching or soaking are necessary to produce canned banana desserts of appropriate sensorial quality. Of the proposed additives the best effects were achieved by the use of sugar solutions at a concentration of 30% and 50% with citric acid, L-ascorbic acid, calcium chloride, and acidic sodium sulphite. In the second part of the work it was found on the basis of the quality of final products that all the methods of preliminary treatment of banana slices ensure good quality of the obtained canned desserts. Of the additives used calcium chloride was determined as having the most favourable effect. This compound improved the hardness and adhesiveness of intermediate products, increasing the level of calcium and the sensory quality of the preserved fruit.

REFERENCES

1. Agar I. T., Massantini R., Hess-Pierce B., Kader A. A., 1999. Postharvest CO_2 and ethylene production and quality maintenance of fresh-cut kiwifruit slices. J. Food Sci. 64, 433-440.
2. AOAC, 1984. Official Methods of Analysis. Association of Official Analytical Chemists, 14th ed., Arlington, Virginia, USA.
3. Aparicio-Cuesta M. P., Mateos-Notario M. P., Rivas-Gonzalo J. C., 1992. Sensory evaluations and changes in peroxidase activity during storage of frozen green beans. J. Food Sci., 57, 1129-1131, 1143.
4. Camire M. E., Ismail S., Work T. M., Bushway A. A., Halteman W. A., 1994. Improvements in canned lowbush blueberry quality. J. Food Sci. 59, 394-398, 415.
5. Cano M. P., de Ancos B., Lobo M. G., 1997. Improvement of frozen banana (*Musa cavendishii*, cv. Enana) colour by blanching: relationship between browning, phenols and polyphenol oxidase and peroxidase activities. Z. Lebensm. Unters. Forsch. 204, 60-65.
6. Cano M. P., de Ancos B., Matallana C., Cámara M., Reglero, G., Tabera J., 1997. Differences among Spanish and Latin-American banana cultivars: morphological, chemical and sensory characteristics. Food Chem. 59, 411-419.
7. Cano M. P., Marin A., Fúster C., 1990. Freezing of banana slices. Influence of maturity level and thermal treatment prior to freezing. J. Food Sci. 55, 1070-1072.
8. Fernandes K. M., de Carvalho V. D., Cal-Vidal J., 1979. Physical changes during ripening of silver bananas. J. Food Sci. 44, 1254-1255.
9. Garcia R., de Arriola M. C., de Porres E., Rolz C., 1985. Process for banana pure preserwation at rural level. Lebensm. Wiss. Technol. 18, 323-327.
10. Giami S. Y., 1991. Effects of pretreatments on the texture and acorbic acid content of frozen plantain pulp (*Musa paradisiaca*). J. Sci. Food Agric. 55, 661-666.

11. Gorny J. R., Hess-Pierce B., Kader A. A., 1999. Quality changes in fresh-cut peach and nectarine slices as affected by cultivar, storage atmosphere and chemical treatments. J. Food Sci. 64, 429-432.
12. ISO/3972, 1998. Sensory analysis – Methodology – Method of investigating sensitivity of taste. International Organization for Standarization, Geneve 20, Switzerland.
13. ISO/6557/2, 1984. Fruits, vegetables and derived products – determination of ascorbic acid content. Part 2: Routine methods. International Organization for Standarization, Geneve 20, Switzerland.
14. ISO/6658, 1998. Sensory analysis – Methodology – General guidance. International Organization for Standarization, Geneve 20, Switzerland.
15. Jarczyk A., Witter M., Matuska D., 1994. Charakterystyka składu chemicznego i tekstury wybranych owoców odwodnionych osmotycznie i utrwalonych różnymi metodami [Characteristic of chemical compounds and texture of osmotically dehydrated fruits preservated of diffrent methods]. Przem. Ferm. Owoc.-Warzyw. 38, 9, 22-25 [in Polish].
16. Kania-Lentes P., 1999. Owoce egzotyczne w cukierni [Exotic friuts in confectionery]. Prz. Piekar. Cukier. 3, 36.
17. Lal R. K., Garg M., Krishnan P. S., 1974. Biochemical aspects of the developing and ripening banana. Phytochem., 13, 2365-2370.
18. Lopez-Andreu F. J., Esteban R. M., Molla E., Carpena O., 1988. Influencia del sistema de nutricion en la calidat de los frutos de tomate. II. Carotenoides, acido askorbico, substancias pecticas y flavonoides. An. Edafolo. Agrobiol. 47, 1191-1198. [in Spanish]
19. Monro J. A., Halloway W. D., Lee J., 1986. Elemental analysis of fruit and vegetables from Tonga. J. Food Sci. 51, 522-523.
20. Ndiege I. O., Budenberg W. J., Lwande W., Hassanali A., 1991. Volatile components of banana pseudostem of a cultivar susceptible to the banana weevil. Phytochem., 30, 3929-3930.
21. Panagiotou N. M., Karathanos V. T., Maroulis Z. B., 1998. Mass transfer modelling of the osmotic dehydration of some fruits. International J. Food Sci. Technol., 33, 267-284.
22. PN-90/A-75101/23, 1990. Przetwory owocowe i warzywne. Przygotowanie próbek i metody badań fizykochemicznych. Oznaczanie zawartości dwutlenku siarki [Fruits and vegetables products. Measurements of sulphur dioxide]. Polski Komitet Normalizacji i Miar, Warsaw [in Polish].
23. Ponting J. D., 1973. Osmotic dehydration of fruits – Recent modyfications and applications. Proc. Biochem., 8, 18-20.
24. Robards K., Prenzler P. D., Tucker G. Swatsitang P., Glover W., 1999. Phenolic compounds and their role in oxidative processes in fruits. Food Chem., 66, 401-436.
25. Sankat C. K., Castaigne F., Maharaj R., 1996. The air drying behaviour of fresh and osmotically dehydrated banana slices. Int. J. Food Sci. Technol. 31, 123-135.
26. Souci S. W., Fachmann W., Kraut H., 1989. Food composition and nutrition tables 1989/90. Wissenschaftliche Verlagsgesellsschaft GmbH, Stuttgart.
27. Swain T., Hillis W. E., 1959. The phenolic constituens of prunus domestica. J. Sci. Food Agric. 10, 63-69.
28. Tanada-Palmu P., Jardine J., Matta V., 1999. Production of banana (*Musa cavendishii*) extract containing no polyphenol oxidase by ultrafiltration. J. Sci. Food Agric. 79, 643-647.

Grażyna Jaworska, Waldemar Kmiecik, Jacek Słupski
Department of Raw Materials and Processing of Fruit and Vegetables
Agricultural University of Cracow
122 Balicka, 30-149 Cracow, Poland
fax: 048 662 47 57
e-mail: rrgjawor@cyf-kr.edu.pl
