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Effect of Processing Techniques on the Quality and Acceptability of Young Carambola (*Averrhoa carambola*) Fruit Pickle

SALMAH YUSOF and KALAIVANI VENGRASALAM
Faculty of Food Science and Biotechnology
Universiti Pertanian Malaysia
43400 UPM Serdang, Selangor Darul Ehsan, Malaysia

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ABSTRAK

Potensi pengunaan buah-buah belimbing muda untuk penjerukan telah dikaji menggunakan kaedah konvensional rendaman garam dan penceluran. Buah-buah dijeruk dalam bentuk sebiji-sebiji dan terpotong tebal dan nipis. Kesesuaian setiap teknik telah dinilai berdasarkan kualiti dan penerimaan produk akhir. Sampel untuk analisis telah diambil pada peringkat-peringkat pemprosesan yang berbeza dan dikaji tentang kandungan asid askorbik, keasidan tertitrat dan tekstur; dan produk akhir turut didedah kepada analisis deria untuk dinilai tentang kerangupan, rasa, citarasa dan saiz yang disukai.

Tiada terdapat perbezaan bererti di dalam kualiti fisikal dan kimia bagi produk yang diperolehi dari kedua-dua kaedah; tetapi penilaian deria menunjukkan jeruk yang dipotong tebal dan disediakan secara penceluran telah digemari kerana ia lebih rangup. Walau bagaimanapun kajian penyimpanan menunjukkan jeruk tersebut menjadi lembik selepas satu bulan. Nilai keaktifan air jeruk ialah 0.94.

ABSTRACT

The potential use of young carambola fruits for pickle production was studied using the conventional salt-stock and the blanching methods. Fruits pickled were in the form of whole fruits and thick and thin slices. The suitability of each technique was graded based on the quality and acceptance of the final product. Samples for analysis were taken at different stages of processing and were analysed for ascorbic acid content, titratable acidity, and texture; and the final product was subjected to sensory analysis for evaluation on crunchiness, taste, flavour and size preference.

There was no significant difference in the physical and chemical quality of products obtained from both methods but sensory evaluation showed that the blanched, thickly sliced pickle was preferred for its crunchiness. However, storage study showed that the blanched pickle became soft after 1 month. The water activity of the pickle was 0.94.

INTRODUCTION

Malaysia now grows carambola for export. The total area grown in 1990 was about 973 hectares and the total production in 1990 was estimated to be about 51,000 metric tons (FAMA report 1989). It is a common practice during maintenance pruning of the tree to wrap only 30% of the fruit. The remaining fruits are discarded. Maintenance pruning is neccessary to remove unhealthy plant parts, reduce fruit numbers, balance growth and improve light penetration.

The discard normally consists of small, improperly shaped or shrivelled fruits; and since they are young fruits they are not suitable for processing into any other value-added products (Mohd Som and Adinan 1989). In the pickle industry, pickling has normally been carried out using the salt-stock method. The purpose of this study was to compare the quality and acceptance of products obtained using two different methods of pickle processing, namely a blanching method with the conventional salt-stock method. The blanching method has advantages in reducing the pickling time. However, the quality and acceptance of the product using this technique is still not known. The second objective was to determine the storage life of the product using the preferred or chosen technique.

MATERIALS AND METHODS

Young carambola *Averrhoa carambola* fruits were obtained from a farm in Cheras. Fruits chosen were 3.0 to 5.0 cm long and free from blemishes, insect bites or scab rot. After trimming and washing, the fruits were sliced vertically into 0.25 cm and 1.0 cm thicknesses. Some fruits were used as whole fruits.

For the coventional pickling method, prepared fruits were soaked in 15% brine solution and the concentration of the salt solution was monitored daily using a salometer. When the brining process was complete as indicated by the stabilisation of the salt concentration, the fruits were desalted with three changes of water. They were then soaked in water containing 0.4% alum (Etchells and Bell 1972) for 24 h. After the water had been drained, the fruits were arranged in bottles and pickling solution (syrup with 45% sugar, 0.2% alum and vinegar, pH 2.5) was added.

For the Quick Blanching method, the prepared fruits were blanched in water (70-80°C) for 5 min and cooled immediately. They were then soaked in water containing 0.4% alum overnight. Drained fruits were then placed in the pickling solution of a similar composition as in the conventional method except that it contained 0.4% salt.

Samples were taken at different stages of both treatments and analysed for vitamin C content using the dye titration method, titratable acidity (Ranggana 1977), texture using an Instron machine and colour using a Hunterlab colorimeter Model D25L. The final product was subject to sensory analysis for evaluation on crunchiness, taste, flavour and size preference (Larmond 1977).

Upon completion of the above experiment, it was found that the blanched, thick pickle was most acceptable. The 1-cm sliced pickles were again prepared using the blanching technique. They were stored at room temperature (28°C) and repeated observations were made on the colour, texture, titratable acidity and pH along with its general appearance for a period of one month. The water activity of the product was determined using the graphical interpolation method (Landrock and Proctor1951).

RESULTS AND DISCUSSION

Processing of Pickle

The daily changes in brine concentration were as recorded in *Fig. 1* and are typical of a conventional brining process where at the initial stage, the salt concentration would drop due to the dilution effect of the water extracted from the fruits. Enough salt had to be added every day to maintain the salt concentration at 15%. The amount of salt added was found to decrease day by day. The brining process was complete when the brine concentration reached equilibrium.

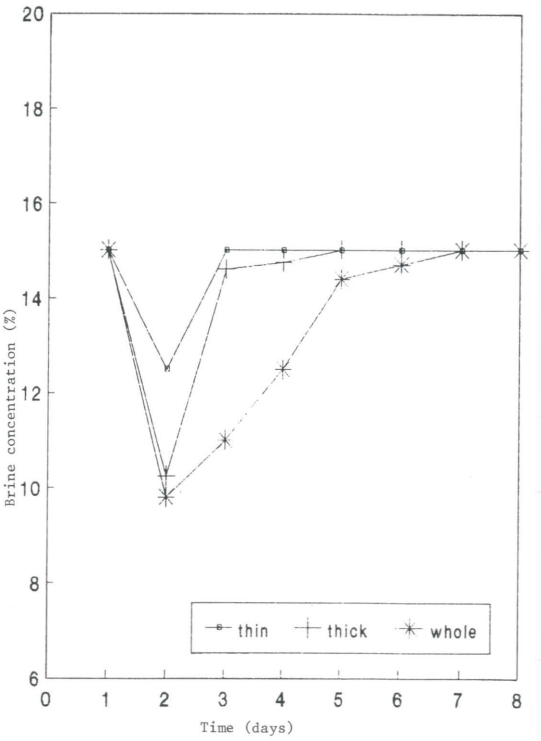

Fig. 1: Changes in salt concentration during fermentation

The rate of brining was fastest in thin sliced fruit (3 d), slightly slow in thick sliced fruit (5 d) and slowest in whole fruit (7 d). The difference in the rate was due to the difference in total surface area exposed to the medium which influenced the osmotic rate. This means that thin-sliced, thick-sliced and whole fruit required in total 4, 6 and 8 d respectively to be ready for the next phase, i.e. soaking in pickling solution. On the other hand, fruits prepared by the blanching method were ready for soaking on the same day.

Ascorbic Acid and Titratable Acidity

The results of ascorbic acid analysis are shown in Table 1. At the initial stage, the different techniques of processing seemed to influence the ascorbic acid retention to different extents. The loss of vitamin C by blanching was less than the loss during brining in the conventional method. Blanching retained about 77% of the ascorbic acid in the whole fruit while in the brined fruit the amount retained was only 30%. Fellers

TABLE 1
Changes in ascorbic acid content and titratable acidity at different steps of processing

fruit size	fresh fruit	blanching			conventional method		
		1	2	3	4	5	6
ascorbic acid (mg/100 g fruit)							
whole	5.17^{ax}	4.0^{bx}	1.33^{dx}	0^{dx}	1.5^{cx}	0^{dx}	0^{dx}
thick	5.17^{ax}	2.17^{by}	0^{dy}	0^{dx}	0.75^{ay}	0^{dx}	0^{dx}
thin	5.17^{ax}	0.50^{bz}	0^{cy}	0^{dx}	0^{cz}	0^{dy}	0^{dx}
titratable acidity (% oxalic acid)							
whole	0.22^{ax}	0.21^{bx}	0.21^{bx}	0.22^{ax}	0.18^{bx}	0.18^{bx}	0.18^{bx}
thick	0.22^{ax}	0.17^{by}	0.13^{by}	0.13^{by}	0.14^{by}	0.13^{bx}	0.15^{by}
thin	0.22^{ax}	0.06^{bz}	0.06^{bz}	0.06^{bz}	0.06^{bz}	0.06^{by}	0.06^{by}

Values are means of six determinations
Means followed by the same letter in the same column and row are not significantly different at $P < 0.05$

Note :
1 = after blanching
2 and 5 = after soaking in alum
3 and 6 = finished product
4 = after brining

TABLE 2
Changes in texture of fruit at different stages of processing

Fruit	texture (kg)						
	fresh fruit	blanching			conventional method		
		1	2	3	4	5	6
Whole	6.76^{a} (0.42)	4.97^{c} (0.59)	6.26^{b} (0.80)	5.8^{b} (0.63)	6.53^{b} (0.40)	6.7^{a} (0.10)	6.7^{b} (0.34)
Thick	4.26^{b} (0.43)	2.67c (0.66)	4.0^{b} (0.23)	3.80^{b} (0.26)	4.10^{b} (0.68)	4.5^{a} (0.40)	4.40b (0.63)
Thin	28.0^{a} (0.94)	16.77^{b} (0.74)	26.4^{a} (2.01)	24.8^{a} (2.27)	16.06^{b} (2.73)	24.0^{a} (2.36)	23.1^{a} (0.43)

Values are means of six determinations
Means followed by the same letter in the same column and row are not significantly different at $p < 0.05$.
(The numbers in parentheses are the standard deviations)

Note :
1 = after blanching
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3 and 6 = finished product
4 = after brining

(1960) reported 86% loss of vitamin C in desalted cucumber. According to Jones (1975), severe loss of nutrients occurred during brining due to leaching of the material into the brine.

Even though blanching could better retain vitamin C, this value was significantly less than the amount originally present in fresh fruit. In other words, blanching also causes reduction in the vitamin C content of foods. The extent of loss usually depends on the blanching method and on the way the product is prepared. The sliced fruits lost a higher amount of vitamin C than the whole fruits as sliced fruits had higher surface areas exposed to the blanching medium. However, both techniques of pickling finally resulted in an equal 100% loss of ascorbic acid in the finished products.

The acidity in carambola fruit was expressed as a percentage of oxalic acid. There was significant reduction in the acid content of sliced fruits after blanching and brining. The amount reduced in whole fruit was slight and insignificant, again as a result of leaching and the total surface area exposed.

Further processing (freshening and acidification) did not change the acidity of the fruit significantly. Despite the addition of vinegar in the acidification step, the acidity of the final products was low in both blanched and fermented sliced pickles. This could be possibly due to the acetic acid present in the pickle which was not detected using this titration method. Acetic acid is a volatile acid and it could have been volatilized during sample preparation.

Texture

The changes in texture during processing are shown in Table 2. Blanching and brining caused significant reduction in the firmness of prepared fruits. Reduction of firmness after blanching and brining could be related to ultrastructural changes as has been reported by earlier workers. Jewell (1979), in a light microscopy study of blanching effects on carrots, observed that blanched carrots had suffered some cell collapse and wall rupture when compared with the fresh tissue. At the ultrastructural level water blanching caused a loss of fine structural detail and pronounced separa-

TABLE 3
Changes in green (-a value) and yellow (b-value) colour at different steps of processing

fruit	fresh fruit	blanching			conventional method size		
		1	2	3	4	5	6
a-value							
Whole	-11.1^{ax}	-2.1^{bx}	-2.0^{cx}	-2.0^{c}	-1.7^{ex}	-2.0^{cx}	-1.9^{dx}
Thick	-11.1^{ax}	-1.9^{by}	-2.0^{bx}	-1.9^{cx}	-2.0^{by}	-2.0^{by}	-1.8^{dy}
Thin	-11.1^{ax}	-2.0^{bz}	-1.9^{cy}	-1.9^{cy}	-1.9^{cz}	-2.0^{bx}	-1.7^{dy}
b-value							
Whole	18.0^{gx}	19.5^{fy}	20.1^{ey}	20.5^{dx}	22.8^{bx}	23.4^{ax}	20.6^{bz}
Thick	18.0^{fx}	19.5^{ey}	19.5^{ey}	21.8^{a}	21.6^{by}	21.4^{dy}	21.5^{cy}
Thin	18.0^{gx}	20.5^{ex}	20.2^{fx}	21.7^{bx}	20.8^{dz}	21.5^{cy}	22.3^{ax}

Values are means of six determinations
Means followed by the same letter in the same column and row are not significantly different at $p < 0.05$.

Note :
1 = after blanching
2 and 5 = after soaking in alum
3 and 6 = finished product
4 = after brining

tion of cell walls in the region of middle lamella. Studies on the changes produced during pickling of cauliflower (Saxton and Jewell 1969) and onions (Jewell 1972) showed that brining (in 16% NaCl) produced a gradual degradation of the fine structural organisation within the cells which eventually left just a network of cells. According to Matz (1962), fermentation processes generally left the principal structural element intact but the semi-permeability of the cell membrane was destroyed, resulting in loss of cell turgor and crunchiness. These changes in structure might have resulted in the differences in firmness readings obtained.

Soaking of fruit in water containing alum or freshening of samples generally caused a marked increase in firmness of all samples. This increase in firmness may be due to the action of the trivalent aluminium ion which forms a complex with the pectic substances, particularly those in the middle lamella (Matz 1962).

The firmness of the finished product (after 1 week) was slightly lower than after freshening. This occurs similarly for both methods but varies with different sizes of fruit. This means that acidification of fruit might have resulted in the degradation of cell wall structures.

Colour

Colour is one of the important characteristics which adds to the aesthetic value of a product. Francis and Clysdale (1975) suggested that application of heat causes considerable loss of chlorophyll content. The major reason for this change has been attributed to the formation of phaeophytin from chlorophyll. The effects of processing on greenness or 'a-value'of pickle is shown in Table 3. There is significant reduction in 'a-value' of processed fruit compared with the fresh sample. Both the conventional and the blanched samples had the same effect but the blanched sample had slightly higher values than the fermented ones. This shows that blanching retains more chlorophyll than fermentation. Complementary to the loss in green colour, the 'b-value' or yellowness of sample showed significant overall increase throughout both processes, indicating that the colour of the fruit was becoming yellow.

Sensory Evaluation

Results of the sensory evaluation of pickles on flavour, colour, taste, crunchiness and size are shown in Table 4. The unique flavour of fermented pickle is usually attributed to lactic

TABLE 4
Sensory evaluation on flavour, colour, taste, crunchiness and size

sample	flavour	colour	taste	crunchiness	size
	6.70[a]	5.81[a]	6.16[a]	6.40[b]	6.28[b]
	(1.60)	(1.70)	(2.18)	(1.42)	(1.79)
	6.43[a]	5.72[a]	6.23[a]	6.46[a]	5.88[b]
	(1.23)	(1.44)	(2.00)	(1.18)	(1.62)
	7.27[a]	5.66[a]	6.86[a]	7.64[a]	7.10[a]
	(1.26)	(1.53)	(1.87)	(1.27)	(1.75)
	6.71[a]	5.61[a]	7.17[a]	6.22[b]	7.08[a]
	(1.86)	(1.26)	(1.64)	(1.64)	(1.72)

Means followed by the same letter are not significantly different at $p < 0.05$.
The numbers in parentheses are the standard deviations

Note: Sample 1 = thin slices (blanched)
2 = thin slices (conventional method)
3 = thick slices (blanched)
4 = thick slices (conventional method)

acid present after fermentation. In this case, the panelists were not able to detect any significant difference in flavour among the four samples. Perhaps the amount of fermentable sugar was low in the fresh fruit, resulting in low production of lactic acid; or most of the sugars have been washed off during desalting. The fact that the blanched thick pickle was rated slightly higher than the fermented pickle (even though not significantly different) showed that the panelists approved the flavour of this type of pickle.

In terms of colour, all the samples were rated quite low, indicating poor preference for the colour. The colour of thin slices were rated higher than that of the thick ones. There was no significant difference in the taste of all four samples. Both types of pickles had equally high ratings, showing, that they were both equally well accepted.

Blanched thick sliced pickle showed a significantly higher rating for crunchiness ($p < 0.05$) compared with other types of pickles. This response is in contrast to the result obtained from texture analysis (by Instron Universal Testing Machine) for firmness. This indicates that firm pickles may not neccessarily be crunchy. For size, the thick slices were preferred over the thin ones. The blanched thick-sliced pickle received the highest score even though the score was not significantly different.

Storage Study

Sensory data indicated that the blanched pickle was more acceptable. The results of storage study of the pickle conducted at room temperature (28°C) are shown in Table 5. Even though observations on general appearance were made every two to three d and data on the acidity and pH of pickling solution as well as colour and texture of product were recorded every week, only data obtained after 24 h and one month storage are presented to indicate real difference. The results showed that there were significant changes in texture and colour. The titratable acidity of the pickling solution decreased with a consequent increase in pH. The pickles and the pickling solution turned darker in colour. This was apparent from the lower L-value (lightness), greater a-value (greenness) and lower b-value compared with the freshly produced pickles. The decrease in the L-value followed by increase in the a-value after a one-month storage was due not to an increase in intensity of greenness by chlorophyll content but to an increase in darkness intensity.

TABLE 5
Changes in titratable acidity and pH of pickling solution and colour and texture of pickle during storage

	after 24 hours		after 1 month	
	1	2	1	2
Pickling solution				
titratable acidity (% acetic acid)	0.92[a]	0.95[a]	0.87[b]	0.89[b]
pH	2.58[a]	2.61[a]	3.0[b]	3.35[b]
pickle (Fruit)				
	-a b-	-a b-	-a b-	-a b-
colour	-2.7 21.4	-2.9 20.6	-4.8 16.5	-4.6 14.8
texture	4.1[a]	4.17[a]	2.5[b]	2.3[b]

Values are means of six determinations
Means followed by the same letter in the same column are not significantly different at $p < 0.05$.

Note: 1 = without preservative
2 = with preservative (sodium benzoate)

The effect was the same for pickles with or without preservative. According to Bhasin and Bhatia (1981), darkening of pickle products is directly related to the amount of iron and tannin in the vinegar. Black pickles may owe their colour to the formation of hydrogen sulphide by bacteria and combination with iron in the water to yield black ferrous sulphide (Frazier and Westhoff 1978).

It was also observed that the pickles became significantly soft after a one-month storage. It is unlikely that the softening was due to microbial activity since there were no apparent microbial changes in the product. Pederson (1979) stated that softening in pickle is usually associated with an enzymatic action and the source of the enzyme is usually from the fruit. Enzymes are more acid-tolerant than organisms. It is possible that blanching did not inactivate all the pectolytic enzymes, thus allowing it to act on the pectic materials of fruit tissues during storage.

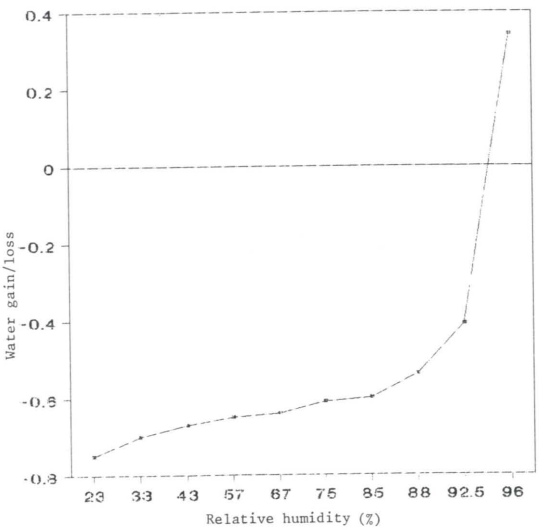

Fig. 2. Water gain/loss of sample after equilibration

Water Activity

The water activity value of product was about 0.94 (*Fig. 2*). The sugar in the pickling solution was not able to reduce the water activity of the pickle to a low value. Moulds were found on the surface of products that were placed under conditions of high humidity (92.5 and 96% relative humidity). The water activity value is important when one is considering the form and nature of packaging material for the product. Pickle cannot be packed dry. It has to be submerged in the pickling medium all the time to enhance its flavour.

CONCLUSIONS

This study shows that young carambola fruits which are normally discarded away can be made into a pickle. There was no significant difference in the organoleptic attributes in products produced by the two techniques. However, the blanching method seemed to produce pickle of higher crunchiness than the coventional method. The blanching method shortened the time of processing which was the main advantage of the process. Results of the storage study on the blanched pickles showed that the product became soft and the colour turned adversely darker upon storage. The water activity was high. Further studies need to be carried out with a view of improving the texture of the product.

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