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An Assessment of Processing Potential of Avocado Fruit [#]

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INTRODUCTION

Avocados are consumed principally as fresh fruit. However, because of the need to utilize surpluses and imperfect fruits, it has been of interest to process the fruit for extended shelf life time and marketability. Unfortunately, avocado is very sensitive to heating or freezing. The fruit develops off-flavors (Bates 1970) and discoloration (Golan *et al.* 1977) even after the minimal thermal treatment needed to destroy spoilage microorganisms and deactivate enzymes (Cruess *et al.,* 1951, Brown 1972, Garcia *et al.* 1976). Compounds involved in off-flavor and bitterness vary in polarity between neutral lipids to phospholipids (Bates 1970) and include l-acetoxy-2,4-dihydroxy-n-heptadeca-16-ene and 1,2,4-trihydroxy-n-heptadeca-16-ene (Ben-Et *et al.,* 1973). Likewise, freezing is detrimental to texture and flavor of whole avocado. Although rapid freezing of avocado slices by liquid freon (Smith and Winter 1970) or liquid nitrogen with proper pretreatment with ascorbic and malic acids (Hanson 1976) were claimed to produce an acceptable product, these procedures still wait for large scale implementation.

In practice, since the available mechanical equipment separates mashed pulp from the peel after manual removal of the seed, only mashed avocado can serve as a raw material for processing. Indeed, a frozen puree known as guacamole salad is the only avocado product of commercial relevance. This product can be stored for weeks frozen at —18 °C (Hester and Stephens 1970, Salomon *et al.* 1980, Scudamore-Smith 1984, Stephens *et al.,* 1957, 1958). Freeze-drying of guacamole salad and storage of the dry product under inert atmosphere of nitrogen did not apparently obliterate the need for refrigeration (Lime 1969 a, b; Gomez and Bates 1970). Sorber (1947) recommended the use of avocado puree as a flavor base for ice cream.

MATERIALS AND METHODS

Fruits of three avocado cultivars, Ettinger, Hass, and Fuerte, at different stages of maturation were used. The composition of the avocado mesocarp, which is the edible part of the fruit, varies with different cultivars and harvest season. Representative values were as follows: dry matter, 19.18 to 30.29%, fat 8.3 to 16.75%, protein 2.1 to 2.3%, carbohydrates 6.8 to 8.1%, mineral ash 0.7 to 1.2 %, the higher values belonging to the fruits harvested toward the end of the season.

Frozen avocado salad base.

The avocado paste was prepared on an industrial scale which comprised washing, cutting, stone removal, pulping, formulation, and mixing. Immediately after preparation, one kg paste was dispersed into polyethylene bags. Excessive air was removed and the bags were promptly sealed and frozen at -18 °C. Occasionally, some recipes were repeated in the laboratory from 2-5 kg fruit using a bench top mixer. Periodic chemical analyses and organoleptic evaluations of the product were made at intervals during 40 weeks of frozen storage.

Fatty acid analyses.

The peeled avocados were dried into cubes (1.5 cm), frozen 24 hours at -18°C, and then lyophilized. 15 grams of lyophilized avocado was extracted with petroleum ether in a Soxhlet apparatus under a nitrogen atmosphere. The extracted oil was dried over anhydrous Na_2SO_4, and the solvent was removed under vaccuo. After hydrolysis, the fatty acidsi as methyl esters, were determined by gas chromatography, as described (Sklan *et al.,* 1971).

Peroxide value, TEA value, and free fatty acid value were determined as described (Pearson 1970). The browning of the frozen avocado paste was quantified after thawing a sample at ambient temperature for 2 hours, extraction with water (10 ml distilled water were thoroughly mixed with 10 g avocado mixture for 10 minutes, and filtered), and determination of the OD at A.=450.8 nm.

Fermented dairy-avocado product.

Fresh avocado paste, milk (3%) fat, homogenized, heated at 90°C for 20 minutes, and cooled at ambient temperature), and dairy starter culture were blended at room temperature. Two hundred mL portions of the mixture were poured in glass jars closed with loosely fitting aluminum lids. The jars were incubated at 42 °C for the thermophilic starter, and at 32 °C for the mesophilic starter. After 4 hours incubation, the jars were cooled at 4°C and stored at this temperature for further evaluation. At specified times, pH value and titratable acidity were measured. For measurement of titratable acidity, 10 g of material was diluted with 40 mL deionized water and titrated with 0.1 N NaOH to pH 8.1.

RESULTS AND DISCUSSION

Frozen avocado salad base. The aim of this study was to define the characteristics of a frozen avocado salad base prepared by blending fruit flesh with acidulants, stabilizer (water binder), salt, and flavors. The general composition of the blend is summarized in Table 1. The presence of an acidulant is needed since the chemical and microbiological stability of this product is enhanced by increasing the acidity. The water binding agent prevents the separation of watery phase upon thawing. Indeed, after frozen storage, control samples of thawed avocado pulp became mushy with separation of water, while the formulated mixture retained a butter-like consistency. It was noted, however, that consistency problems due to syneresis in the thawed product were alleviated to some extent in control samples (no stabilizer) of mature Hass avocados of 28-30 % dry matter, as compared to samples prepared from less concentrated fruits.

Table 1. The composition of the avocado salad base.

Constituent	%
Avocado pulp	90-98
Ascorbic acid or ascorbyl palmitate	0.5-0.7
Citric acid	0.06-0.2
Fumaric acid	0-0.04
Stabilizer (alginate or starch or guar gum)	0.2-0.5
Flavors (salt, sugar, dehydrated onion powder)	1 -2.5
Water	0 -8

Several compositional parameters of the frozen salad base were periodically monitored during a 40 week storage period. Thus the stability of the lipid fraction was estimated by the fatty acid composition and by the development of oxidation products. Fatty acid composition of avocado varies with type of cultivar, stage of ripening, anatomical region of the fruit, and geographical growth location. Typical composition of the Hass fruits used in this work is shown in Table 2, and this was found unchanged after 40 weeks storage. Neither development of oxidation products as judged by free fatty acid, peroxide value, and TEA tests, could be detected during storage (Table 3). Seemingly, the oxidative deterioration is only marginal to the quality of frozen avocado puree, if any. Virtually the same results were obtained using formulations with a natural antioxidant such as ascorbic acid, or with synthetic antioxidants such as ascorbyl palmitate, BHA, or BHT (0.075%), as additives. No indication of rancidity could be detected by organoleptic tests. This observed stability of lipid fraction could be due to the high content of natural antioxidants as tocopherols in avocado (3mg/100g) (Biale and Young, 1971).

Table 2. Fatty acid composition of avocado.

Fatty acid	%
Palmitic acid (16:0)	20.82
Palmitoleic acid (16:1)	11.80
Stearic acid (18:0)	1.05
Oleic acid (18:1)	51.0
Linoleic acid (18.2)	14.01
Linolenic acid (18.3)	1.32

Table 3. Changes of the lipid fraction with storage time.

Storage time (weeks at −18 °C)	Peroxide value[a]	Free fatty acids[b]	Thiobarbituric acid value[c]
0	0.1	0.14	0.051
1	0.0	0.13	0.053
2	0.0	0.15	0.060
4	0.0	0.19	0.111
7	0.0	0.18	0.069
11	0.1	0.20	0.129
15	0.1	0.20	0.052
20	0.0	0.23	0.075
30	0.1	0.25	0.065
40	0.0	0.28	0.066

a) milliequivalent peroxide/kg oil
b) % as oleic acid
c) mg malonaldehyde/kg oil

Polyphenol oxidases (PPO) (Kahn 1975) are among the enzymes most destructive to the quality of the avocado products. Mashing avocado pulp brings the phenolic substrates in intimate contact with PPO enzyme and atmospheric oxygen, resulting in accelerated browning of the product at ambient temperature. In the frozen product, browning can be controlled, in addition to the low temperature, by the higher acidity [the relative activity of avocado polyphenol oxidase decreases from 100% at pH 4.8 to about 20% at pH 3.5 (Knapp 1965)], and eventually by the addition of 0.03% sodium bisulfite (Bates 1968). It was also reported that the infiltration of calcium salt into whole avocados suppressed polyphenol oxidation after 30 days storage, as compared to controls (Van Rensburg and Engelbrecht 1986).

In the present study, the tendency to discoloration of the frozen paste was monitored by the extent of browning after thawing, as reflected by the absorption (O.D.) at 450.8 nm. The results of a typical experiment (Table 4) show that the extent of browning is primarily a function of fruit variety, Hass and Fuerte being more refractive to changes in color. It was noted that some thawed samples prepared from Hass or Fuerte varieties were still acceptable even after 72 hours at +5°C.

Table 4. Changes of physical properties of the product with storage time.

Storage time (weeks at −18 °C)	pH value	Viscosity Brookfield (cpoise)	O.D. (λ=450.8 nm) E*	F*	H*
0	4.51	35×10^3	0.15	0.05	0.05
1	4.49				
2					
4					
7	4.52	35×10^3	0.15	0.08	0.07
11					
15	4.52				
20					
30	4.50		0.2	0.1	0.1
40	4.51	35×10^3	0.3	0.1	0.1

*E—Ettinger var., F—Fuerte var., H—Hass var.

The bacteriological quality of the avocado spread is of major concern since this a nonsterile product which is consumed uncooked. The adjusted acidity is the major means in controlling microbial growth. While the pH of the ripened fruit is around 5.8, adjustment with acid to pH values of ca. 4.5 still gave an acceptable flavor and also a reduced susceptibility to spoilage. The reduction of pH below 4.5 overwhelms the typical, delicate, nutty avocado flavor of the spread and decreases the acceptability of the product.

Typical bacteriological counts of the industrial product, as shown in Table 5, indicate that an acceptable safe product can be manufactured.

The summary of our tests indicates that an avocado mixture prepared on industrial scale had excellent characteristics that were well preserved even after 9 months in frozen state.

Fermented dairy-avocado product.

On appearances, the association of avocado with yogurt could be beneficial. Yogurt is an attractive "health food", and its supplementation with fruit is common. Likewise, yogurt with vegetables may appeal to consumers who are nutrient-conscious. The avocado contains important nutrients, including fiber, minerals, and vitamins, which can complement the desirable features of yogurt. In addition, it was hypothesized that the inclusion of avocado in yogurt may protect the fruit against browning. Therefore, we appraised a yogurt-like product with avocado, made from fresh avocado paste, milk, and dairy starter culture. The homogeneity of the product was improved by addition of a stabilizer (such as gelatin 0.2-0.4%). Two freeze-dried bacterial starter culture preparations were separately tested: a mesophilic culture consisting of a *Streptococcus cremoris,* and a mixed thermophilic culture consisting of *Streptococcus thermophilus* and *Lactobacillus bulgaricus.* Time of fermentation averaged 4 hours. The rate of developing acidity was monitored and it was found unaffected by the presence of avocado in the mixture (Figs. 1 and 2).

Table 5. Changes of microbiological quality of the product with storage time.

Storage Time (weeks at −18 °C)	Total Plate Count	Coli counts per gram	Yeasts and Moulds
0	4200	< 10	430
1	7800	< 10	520
2	5300	< 10	1320
4	8300	10	950
7	11100	< 10	730
11	3200	< 10	350
15	3500	< 10	320
20	4100	< 10	610
30	10300	10	600
40	7100	< 10	730

With the thermophilic starter which required an incubation temperature of 42 °C, the product had a dominant cooked avocado off-flavor. Unfortunately, even with the mesophilic starter which required a lower incubation temperature of only 32 °C, the combined flavors of avocado and fermented milk were not particularly attractive. Furthermore, the incorporation of avocado in yogurt did not alleviate the tendency for browning. After 48 hours storaged at 4 °C, the fermented mixture exhibited a clear darker upper layer which became broader in time.

In conclusion, it seems that joining avocado and yogurt cannot serve as an industrial outlet for former.

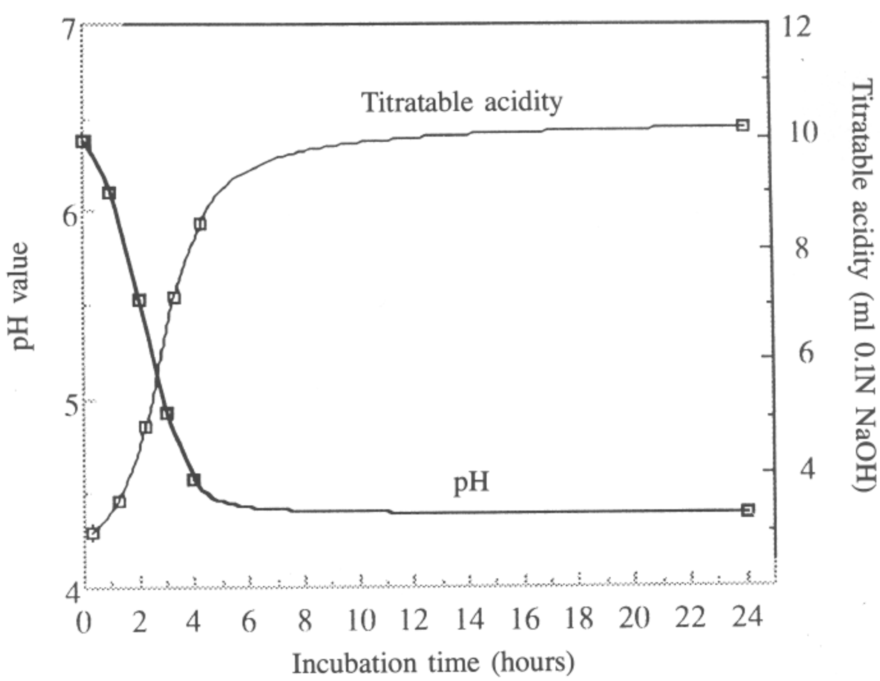

Fig. 1. The fermentation rate of avocado yogurt with mesophilic culture.

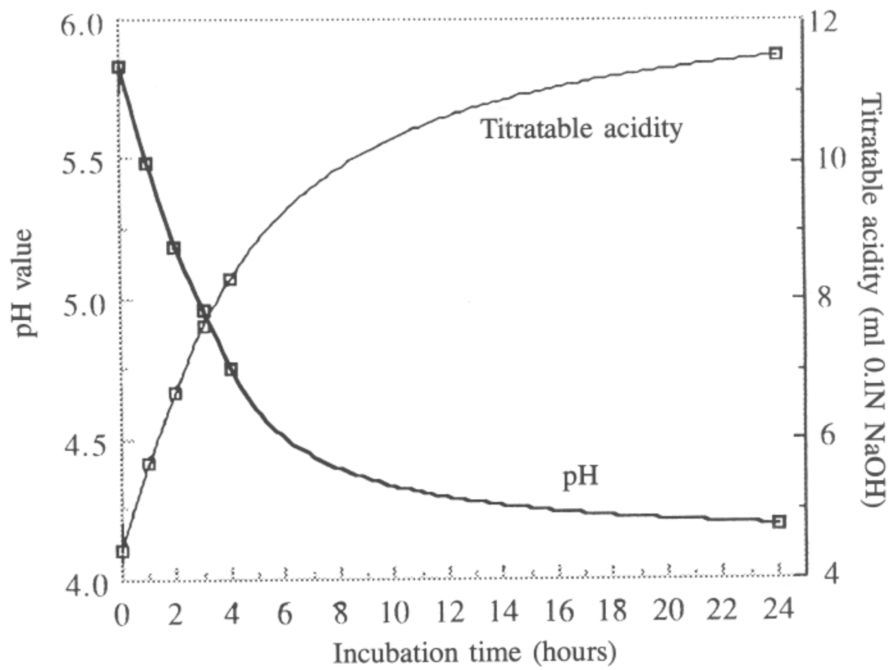

Fig. 2. The fermentation rate of avocado yogurt with thermophilic culture.

References

Bates, R.R, 1968. The retardation of enzymatic browning in avocado puree and guacamole, Proc. Florida State Hort. Soc., 81: 230-235.

Bates, R. P., 1970. Heat-induced off-flavor in avocado flesh, J. Food Sci., 35:478-482. Ben-Et, G., A. Dolev A., and C. Tartarsky, 1973. Compounds contributing to heat-induced bitter off-flavor in avocado, J. Food Sci., 38: 546-547.

Biale, J. B., and R. E. Young, 1971. The avocado pear in: The biochemistry of fruits and their products (A C Hulme, ed) vol. 2, pp. 6-24, Academic Press, London & New York, 1971.

Brown, *B.* I., 1972. Isolation of unpleasant flavor compounds in the avocado *(Persea americana).* J. Agric. Food chem. 20: 753-757.

Cruess, W. V., A. Gibson, and J. Brekke, 1951. Avocado products experiments. Canner 112 (2) 11-12; 18; 112(3) 14, 16, 20.

Garcia, R., J. Andrade, and C. Rolz, 1976. Effect of temperature and heating time on the detection of off-flavor in avocado paste. J. Food Sci. 40: 200.

Golan, A., Y. Sandovski, V. Kahn, 1977. Evaluation of browning potential in avocado mesocarp, J. Food Sci., 42: 853-855.

Gomez, R. F, and R. *P.* Bates, 1970. Storage deterioration of freeze-dried avocado puree and guacamole, J. Food Sci., 35: 472-475.

Hanson, L. R, Commercial Processing of Fruits. Noyes Data Corp. London 1976, pp. 276-282.

Hester, O. C, and T. S. Stephens, 1970. Development and preliminary test of a frozen avocado salad base, J. Rio Grande Valley Hort. Sci., 24: 176-180.

Kahn, V. 1975. Polyphenol oxidase activity and browning of three avocado varieties. J. Sci. Fd. Agric. 26: 1319-1324.

Knapp, F. W. 1965. Some characteristics of eggplant and avocado polyphenol oxidase. J. Food Sci. 30: 930-936.

Keppler, J. G., M. M. Horilex, P. W. Meijboom, and W. H. Feenstra, 1967. Isolinoleic acids responsible for the formation of the hardening flavor. J. Am. Oil Chem. Soc. 44: 543-544.

Lime, B. J., 1969 a. Preparation and storage studies of freeze-dried avocado salad, Food Technol., 23: 317-320.

Lime, B. J., 1969 b. Autoxidation of fatty acid lipids and carotene of freeze-dried avocado salad, Food Technol., 23: 171-174.

Pearson, D., 1970. The Chemical Analysis of Foods, 6th Edn. London, J & A Churchill Salomon, G. E. A., I dos S. Draetta, M. laderoza, V. L. P. Ferreira, M. P. Soler,

1980. Industrial processing of avocados for production of edible products, Boletim

do Instituto de Technologia de Alimentos, 17: 147-180.

Sklan, D., R. Volcani, P. Budowski, 1971. Formation of octadecadienoic acid by rumen liquor of calves, cows and sheep *in vitro,* J. Dairy Sci., 54: 515-519.

Scudamore-Smith, P. D., 1984. The utilization of avocado as frozen savoury spread, Food Technology in Australia, 36: 375-378.

Sorber, D. G. 1947. Frozen fruit in ice cream. Ice Cream Field 49 (4) 24, 61-62.

Smith, L. M., and F. H. Winter 1970. Research on avocado processing at the University of California. Calif. Avocado Soc. Yearbook 54: 79-83.

Stephens, T. S., B. J. Lime, F. P. Griffiths, 1957. Preparation of a frozen avocado mixture for guacamole, J. Rio Grande Valley Hort. Sci., 11: 82-89.

Stephens, T. S., B. J. Lime, F. P. Griffiths, 1958. The effect of thickening agents in reducing the watery separation of frozen and thawed guacamole products, J. Rio Grande Valley Hort. Sci., 12: 81-87.

Van Rensburg, E., and A. H. P. Engelbrecht, 1986. Effect of calcium salts on susceptibility to browning of avocado fruit, J. Food Sci., 51: 1067-1068.