QUALITY CHANGES OF THE GREEN, CULINARY HERB, SHADO BENI (Eryngium foetidum LINN) DURING DEHYDRATION

By V. Maharaj* & C.K. Sankat**

ABSTRACT

The green, food flavouring/seasoning herb Eryngium foetidum Linn. also called "shado beni" or "bhandhanya" in Trinidad and Tobago and "cilantro" or "culantro" in Latin America was dried at temperatures ranging from 35 - 65 °C and under both natural and forced convection conditions. A dehydrated product is seen as a convenient alternative for using the fresh, green herb. The effects of various blanching pre-treatments on the quality of the herb at 55 °C were also studied viz: steam, water and alkali. Drying of fresh herb under natural convection at high temperatures of 55 °C and 65 °C resulted in an undesirable colour change from the green, typical of the fresh herb to olive brown or brown with sporadic greening. This paralleled an almost complete loss of the herb's volatile oil constituent which is over 82%. Chlorophyll and oil losses were reduced under forced convection drying conditions. Irrespective of drying conditions, loss of green colour was reduced by blanching in water or magnesium carbonate prior to drying at 55 °C. Compared to the unblanched herb, oil yield was unaffected by the blanching pre-treatments investigated.

1.0 INTRODUCTION

Shado beni (Eryngium foetidum Linn.) also called "bhandhanya" in Trinidad and Tobago, is a pungently scented, aromatic food flavouring/seasoning herb that grows naturally throughout Trinidad and Tobago, the other Caribbean islands and continental, tropical America [1]. The Vietnamese name "ngo gai" meaning thorny coriander, which aptly refers to the caulescent spinosely serrate leaves scented of coriander foliage [2]. The other common names of this herb in various countries are "chadron benee" (Dominica), "fitweed" (Guyana), "coulante" or "culantro" (Haiti) and "cilantro" or "culantro" (Latin America) [1].

Shado beni has considerable export market potential to immigrant West Indian populations in USA, Canada and Europe. Large quantities are sold in Central American and Colombian markets as it is a common ingredient in soups and stews. There is little information on the processing of this unique herb which is currently exported in the fresh state from Trinidad and Tobago to Canada, New York and London. The fresh herb, like all green leafy commodities, wilts and undergoes a deteriorative colour change from green to brown and hence it must be air freighted immediately after harvest. A possible alternative to the export of the fresh, green herb at a moisture content of 88% (wet basis) is the export of a dried, stable product. Dehydration, a simple method of preserving foods to extend their period of availability, has the added advantage of making handling, storage and distribution less difficult and more economical because of a reduction in weight and bulk.

In both herbs and spices, quality is determined by typical aroma. Koller [3] has reported the negative effect of high drying temperatures on the aroma retention of sage and thyme. Loss of green colour is also reported to occur during the dehydration of greenish commodities. The principal degradatory pathway of chlorophyll during the drying of greenish commodities by hot air is the replacement of its magnesium atom by hydrogen and the consequent formation of olive-brown pheophytins. Acids present in the fresh material or formed during heat processing

* *Graduate Research Assistant, Dept. of Mechanical Engineering, The University of the West Indies (UWI)*
** *Reader in Agricultural & Food Engineering, Dept. of Mechanical Engineering, UWI*

Pertinent discussion will be published in January 1997 West Indian Journal of Engineering if received by November, 1996.

are the major factors responsible for the removal of the magnesium ion from the chlorophyll molecule [4,5, 6].

The necessity of blanching commodities prior to dehydration so as to improve product quality has been recognised since 1929. Two methods commonly practised are steam and water blanching. According to Mackinney and Weast [4] and von Loesecke [7], blanching is necessary to prevent the formation of off-flavours, odours and colours. Blanching however, is reported to result in some degree of chlorophyll degradation with subsequent formation of pheophytin. The extent of chlorophyll degradation is related to the degree of blanching [4, 8]. Peroxidase activity is widely used as an index of blanching as peroxidase is the most heat stable enzyme found in horticultural commodities.

Considerable effort has been aimed at stabilising the colour of green commodities during thermal processing. The most widely reported method for the prevention of pheophytin formation is the addition of alkalising agents during processing, e.g., magnesium carbonate [9], ammonium carbonate and/or ammonium hydroxide [10, 11] and sodium carbonate [12].

Specific objectives of this study were therefore :-

1) Evaluation of the quality of shado beni dried at air temperatures of 35, 45, 55 and 65°C under both natural and forced convection drying conditions.

2) Evaluation of the quality of dried shado beni at 55°C under both natural and forced convection conditions subsequent blanching treatments of steam, water and alkali.

2.0 MATERIALS AND METHODS

300 g samples of fresh, green uncut herb were placed to a depth of 0.025 m in a wire-meshed tray (0.3 m x 0.3 m in dimension) and dried to near equilibrium at 35, 45, 55 and 65°C in an electric, natural convection (Blue M Stabil - Therm Gravity Oven, Blue M Electric Company, Blue Island Illinois, U.S.A) drier of internal dimensions 0.48 m (height) x 0.48 m (width) x 0.38 m (depth). The drying runs were repeated at the same temperatures but under forced convection conditions. For these experiments, air heated by an electrical resistance heater was passed upwards through a cylindrical glass drying chamber (290 mm in diameter). A wire-meshed basket into which the herb was placed was suspended in the drying chamber, from the underhook of a laboratory balance. The balance stood on a wooden, fixed support. (See **Figure 1**). Samples (260 g) of the uncut herb were placed to a depth of 0.09 m in the wire-meshed basket (of 250 mm diameter) and the herb was dried to near constant weight at temperatures ranging from 35-65°C. The velocity of the air through the basket containing the herb was 0.8 m/s. Because of the rapid shrinkage of the herb during drying the bed depth was reduced to approximately 0.03 m after only 15 min of drying at 35 - 65 °C.

Freshly harvested shado beni as well as the dehydrated products were analysed for their pH, chlorophyll and pheophytin contents. Analyses were carried out in duplicate and the resulting data analysed by the Analysis of Variance Method (ANOVA) using the GLIM system [13]. For pH determination, 5 and 2 g of fresh and dried herb samples respectively were blended with 40 ml of distilled water. Chlorophyll and pheophytin levels were evaluated by the modified spectrophotometric method of La Jollo et al. [14]. Chlorophyll was extracted with cold 80% acetone and pheophytin obtained through oxalic acid transformation. Both control and converted samples were kept in the dark at room temperature for 3 h. Absorbances were determined at 536, 558, 645, 649, 655, 662, 665, 666, 667 and 700 nm using 80% acetone as the blank. Total chlorophyll and pheophytin concentrations were calculated according to the equations of Vernon [15].

The effect of various blanching methods such as steam, water and alkali on the quality of shado beni dried at 55°C under natural and forced convection was also investigated. Blanching times were the minimum required for inactivation of the enzyme peroxidase and were pre-determined by the peroxidase test outlined by Greensmith [16]. 400 g of the uncut herb was blanched in steam at 96°C for 6 min. in a locally designed and fabricated cabinet type, steam blancher (See **Figure 2**). The steamed leaves were then cooled under ambient conditions (28°C) prior to drying at 55°C. For water blanching, 400 g of the herb was "quick-dipped" in boiling water at 100°C for 10 s (40 : 1 ratio of water to herb). Alkali blanching was carried

Figure 1: **The Forced Convection Laboratory Drying Apparatus**

out according to the modified procedure of Lioutas [9]. 400 g of the uncut herb was immersed for 10 s in 0.09% magnesium carbonate solution at 100°C (40 : 1 ratio of water to herb). The blanched herb was drained and cooled prior to drying at 55°C. A batch of the unblanched herb (serving as the control) was dried along with this at 55°C. For all treatments, the herb was dried to near constant weight and both fresh and dried shado beni were evaluated for pH, chlorophyll and pheophytin contents as previously described.

To evaluate the effect of the drying air temperature and blanching treatments on the oil content of shado beni dried under natural and forced convection conditions, separate studies were conducted. This was necessary as large samples of the herb had to be dried to ensure measurable oil yield. For forced convection drying, a Gallenkamp Oven (Gallenkamp, Leicestershire, U.K.) of internal dimensions 0.35 m (depth) x 0.41 m (width) x 0.46 m (height) was used. The oil content of the herb at a drier temperature of 35°C was not evaluated under forced convection as the minimum operating temperature of this drier exceeded 35°C. For natural convection drying, the Blue M oven previously described was used. Approximately 12 kg of the fresh herb was used for each treatment. Samples were dried to a moisture content of 10% (wet basis). The dried herb was then ground in a burr mill and the oil content of 100 g of the dried material was evaluated according to the method of Pearson [17]. For estimation of the herb's initial oil content, 250 g of the fresh herb was used. All chemical analyses were carried out in duplicate and the resulting data analysed by ANOVA.

3.0 RESULTS AND DISCUSSION

3.1 Colour, Pigment and pH Changes

Deleterious colour changes from green, typical of the freshly harvested shado beni to olive-green with signs of browning, to brown with traces of green occurred as the drying air temperature was increased from 35 - 65°C and under natural convection conditions. These undesirable changes in the colour of the herb reflected a significant decline ($P \leq 0.05$) in chlorophyll content (from an initial 1209 mg/100g DM for the freshly harvested herb). (See **Table 1**). This was accompanied by extensive pheophytin formation particularly at the higher air drying temperatures of 55°C and 65°C ($P \leq 0.01$). These changes paralleled a significant decline ($P \leq 0.001$) in pH from an initial value of 5.9 during dehydration. Shado beni dehydrated at 35°C (pH of 5.8) appeared olive - green with slight browning reflecting a 14.4% chlorophyll loss and a pheophytin concentration of 460 mg/100g DM. However, for

PRODUCT	% CHLOROPHYLL LOSS		PHEOPHYTIN mg/100g (DM)		pH		% ESSENTIAL OIL LOSS		COLOUR	
	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C	F.C
Fresh	0	0	0	0	5.9	5.9	0	0	Green	Green
Dried (°C) 35°C	14.4	2.2	460	162	5.8	5.6	65.6	-	Olive-green with browning	Olive-green
45°C	38.8	15.7	488	252	5.7	5.8	89.1	48.2	Brown-green	Olive-green
55°C	64.0	25.7	609	370	5.4	5.4	82.2	48.7	Olive-brown	Olive-green
65°C	73.0	27.1	684	462	5.3	5.4	89.1	54.3	Brown with sporadic greening	Olive-green with browning
	S.E.M[c] = 5.0 (8d.f.)		S.E.M[c] = 45.2 (8d.f.)		S.E.M[c] = 0.03 (8d.f.)		S.E.M[c] = 11.5 (7d.f.)			
Levels of significance Drying condition	***		***		NS		**			
Temperature	***		**		***		NS			
Drying condition x Temperature Interaction	*		NS		*		NS			

a denotes natural convection
b denotes forced convection
c denotes standard error means

* $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

N.S Not significant

Table 1: **Chemical Properties of Fresh and Dried Shado Beni dried at 35 - 65°C under Natural and Forced Convection**

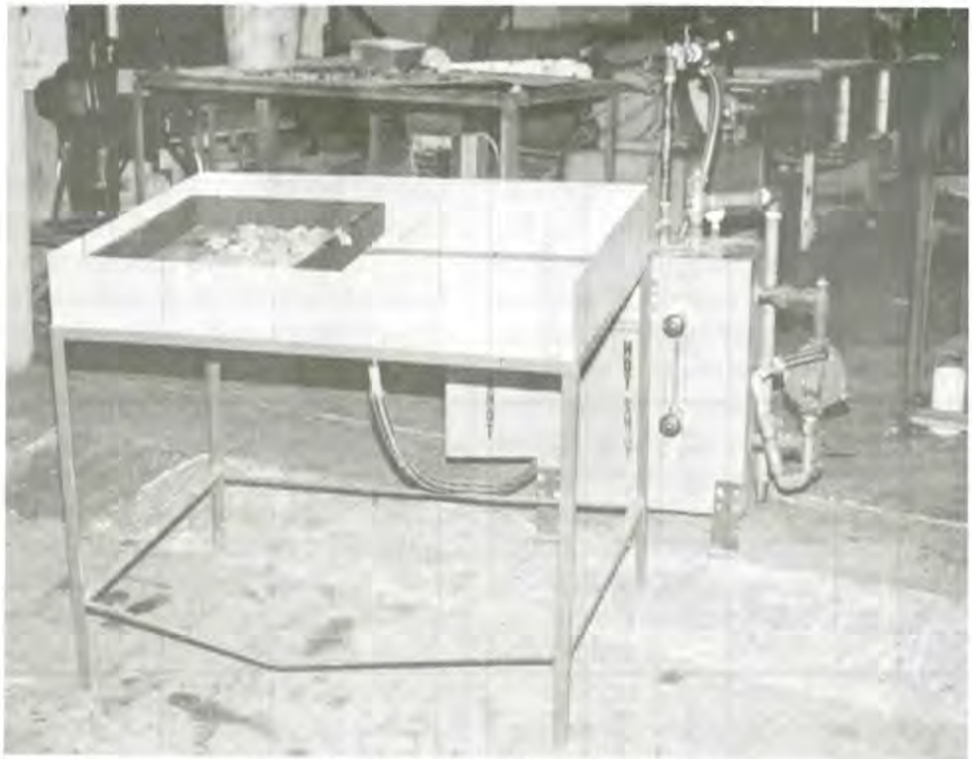

Figure 2: **The Cabinet, Steam Blancher**

shado beni dehydrated at 65°C an increase in acidity was noted (pH of 5.3) ($P \leq 0.001$) and the loss in green colour was severe. The resulting dehydrated herb, brown with sporadic greening reflected a substantial loss of 72.9% of its initial chlorophyll content and a high pheophytin content of 684 mg/100g DM. The results of this study are supported by the works of Sweeney and Martin [18] and Hudson et al. [19] who found that chlorophyll is converted to pheophytin at acidic pH's. Increased acid formation and increased susceptibility of chlorophyll to acid action favouring pheophytin formation is reported to occur during the heat processing of green commodities [6, 20, 21]. Rocha et al. [21] also found increased chlorophyll conversion to pheophytin with increasing drying temperature for basil dried at 35-50°C.

Unlike natural convection drying where the green colour of the herb was adversely affected by increasing the drying air temperature from 35 - 65°C, there was no significant difference in colour arising from forced convection drying at these temperatures (as measured by chlorophyll and pheophytin concentrations) amongst the dehydrated products. All products of dehydration were olive - green with some browning. Forced convection drying of shado beni at 35 - 65°C markedly reduced loss in chlorophyll (2.2 - 27.1% chlorophyll loss) resulting in greener dehydrated products compared to natural convection drying where losses ranged from 14.4 to as much as 73%. Browning, measured by pheophytin concentration was also significantly lower under forced convection drying conditions ($P \leq 0.001$) ranging from 162 - 462 mg/100g DM compared to 460 - 684 mg/100g DM under natural convection. (See **Table 1**). This may be attributed to reduced exposure of the herb to heat as well as increased drying rates under forced convection conditions. Drying times under natural convection were lengthy ranging from 99 h for the herb dried at 35°C to 48 h for the herb dried at 65°C compared to 29 h at 35°C and 4 h at 65°C under forced convection. Final moisture contents ranged from 1.3 - 7.3% d.b under natural and forced convection.

Consistent with previously reported results, changes in colour from green, typical of freshly

PRODUCT	% CHLOROPHYLL LOSS		PHEOPHYTIN mg/100g (DM)		pH		% ESSENTIAL OIL LOSS		COLOUR	
	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C[a]	F.C[b]	N.C	F.C
Fresh	0	0	0	0	5.9	5.9	0	0	Green	Green
Dried Steam blanched	51.2	62.3	534	455	5.5	5.5	78.3	68.4	Olive-brown	Olive-brown
Water blanched	2.7	11.0	0	0	6.1	6.1	87.8	66.5	Bright-green	Bright-green
$MgCO_3$ blanched	15.2	10.2	0	0	6.8	6.9	79.8	58.6	Dark-green	Dark-green
Unblanched (Control)	63.8	56.3	609	500	5.4	5.5	76.7	65.8	Olive-brown	Olive-brown
	S.E.M[c] = 5.5 (8d.f.)		S.E.M[c] = 49.1 (8d.f.)		S.E.M[c] = 0.04 (8d.f.)		S.E.M[c] = 5.4 (8d.f.)			
Levels of significance Drying condition	N.S		N.S		NS		**			
Treatment (Blanching effects)	***		***		***		NS			
Drying condition x Treatment (Blanching effects) Interaction	NS		NS		*		NS			

a denotes natural convection
b denotes forced convection
c denotes standard error means

* $P \leq 0.05$
** $P \leq 0.01$
*** $P \leq 0.001$

N.S Not significant

Table 2: Chemical Properties of Shado Beni when subjected to Various Pre-drying Treatments prior to Drying at 55°C

harvested shado beni, reflected by chlorophyll and pheophytin concentrations were directly related to changes in pH during dehydration. Untreated, unblanched (control) dehydrated shado beni under natural convection at 55°C declined significantly in pH ($P \leq 0.001$) from an initial value of 5.9 to 5.4 (See **Table 2**). Such herbs, olive - brown in colour, reflected a chlorophyll loss of 63.8% and a high pheophytin concentration of 609 mg/100g DM.

Compared to the unblanched (control) dehydrated herb, blanching in steam prior to drying at 55°C under natural convection did not markedly influence its appearance as differences in pH, chlorophyll and pheophytin concentrations were neglible. (See **Table 2**). However, blanching in water and magnesium carbonate prior to drying yielded superior products green in colour and showing no signs of browning. The water blanched dehydrated herb, with a pH of 6.1 was attractively bright green in colour with a chlorophyll loss of only 2.7%. This "brightening effect" is a result of the removal of air from the herb's surface and intercellular spaces [4, 11, 20]. The magnesium carbonate blanched dehydrated herb which increased in pH ($P \leq 0.001$) by 0.9 units (pH of 6.8), was dark green in colour with a chlorophyll loss of 15.2%. Sweeney and Martin [18] working on spinach, reported a 90% retention of chlorophyll at a pH of 6.8. Alkali salts are claimed to prevent or minimise pheophytin formation by neutralising plant acids released or formed during heat processing [6]. A similar trend was found amongst treatments for shado beni dehydrated under forced convection conditions. No significant differences with respect to pH, chlorophyll and pheophytin concentrations were found between similarly treated herbs dehydrated under natural and forced convection conditions.

3.2 Essential Oil Losses

The shado beni owes its characteristic odour and flavour to the aromatic oil inherent within its tissues. Yeh [22] reported an essential oil content of the fresh shado beni of 0.05 - 0.10% containing 72.7% of a mixture of 2, 4, 5-trimethylbenzaldehyde, 5-dodecanone and 4-hydroxy -3, 5-dimethylacetophenone.

The oil content of the fresh herb declined significantly ($P \leq 0.05$) from an initial value of 0.276% d.b during drying. As the drying air temperature was increased from 35°C to 65°C, the % loss of essential oil of the dried herb increased from 65.6 to 89.1%. (See **Table 1**). Statistical analysis revealed a significant decline in essential oil loss ($P \leq 0.05$) from 65.6% for the herb dried at 35°C to 89.1% for the herb dried at 45°C. No significant difference in oil loss was found between shado beni dried at the highest air drying temperatures of 55°C and 65°C i.e., 82.2% and 89.1%, respectively. Shado beni dried at 35°C, while showing a reduced oil content retained its characteristic odour as indicated by the pungency of the oil extracted. At the higher drying temperatures of 55°C and 65°C, deterioration of the herb's quality was observed as off odours were detected from the extracted oil. Similarly, drying of sage and thyme at a high temperature of 80°C was found unsuitable; while at 50°C drying, aroma loss was reduced [3].

Oil loss was reduced by drying under forced convection conditions ($P \leq 0.01$). All products of dehydration retained the characteristic piquant aroma typical of the fresh herb i.e., oil loss of 48.2 - 54.3%. (See **Table 1**). This is in contrast to the herb dried under natural convection where drying time was increased and oil loss was substantial exceeding 82% for the herb dried at 45 - 65°C. For such herbs the typical "shado beni" aroma was not retained.

For all treatments investigated and irrespective of drying condition i.e natural or forced convection there was a significant decline in the oil content of the fresh herb from an initial value of 0.460% d.b (0.050% wet basis) during dehydration at 55°C. Statistical analysis revealed no significant differences in oil yields amongst the treatments evaluated. Drying of shado beni under forced convection however, resulted in higher retention of its oil constituent compared to drying under natural convection conditions ($P \leq 0.01$). Blanching in steam, water or magnesium carbonate prior to drying under forced convection yielded products which, like the untreated dried herb, retained a moderate aroma typical of the pungently scented fresh herb. For such herbs the percent oil loss ranged from 58.6 - 68.4%. Drying of shado beni under natural convection on the other hand, yielded products having a faint "shado beni" aroma with a high oil loss of 76.7 to 87.8%. The greater retention of the essential oil constituent of the herb dried under forced convection compared to natural convection is probably attributed to the increased rate of drying under forced convection. This minimises the herb's exposure to heat resulting in reduced loss of its volatile oil constituent. Under natural convection, drying times ranged from 12 - 18 h while under forced convection, the drying times were considerably reduced and ranged from 3 - 4 h.

4.0 CONCLUSIONS

Irrespective of drying air temperatures, forced convection drying of shado beni resulted in greener products with increased retention of the herb's volatile essential oil constituent. Blanching of shado beni in water or magnesium carbonate prior to drying at 55°C under natural or forced convection minimised loss of the green colour, typical of the freshly harvested herb. For such herbs, browning as measured by pheophytin concentration was inhibited. Drying of the water or magnesium carbonate-blanched herb at 55°C and under forced convection as opposed to natural convection drying is strongly recommended. Under these conditions drying time is shortened and consequently loss of the herb's natural aroma reflected by its volatile oil content is considerably reduced. Further research needs to be conducted on the organoleptic evaluation of the dried herb.

REFERENCES

1. Morean, F. (1988). *"Shado Beni - A Popular Caribbean Seasoning Herb And Folk Medicine"*, F. Morean, Trinidad.

2. Kuebel, K.R. and Tucker, A.O. (1988). *"Vietnamese Culinary Herbs In The United States"*, Economic Botany, Vol. 42, No. 3, pp. 413 - 419.

3. Koller, W. D. (1988). *"Problems with the Flavour of Herbs and Spices"*, Proceedings of the 5th International Flavour Conference (Charalambous, G.,ed.), Elsevier Science Publishers, Amsterdam, pp. 123 - 132.

4. Mackinney, G. and Weast, C. A. (1940). *"Colour Changes In Green Vegetables"*, Industrial Engineering Chemistry, Vol. 32, No. 3, pp. 392 - 395.

5. Berset, C. and Caniaux, P. (1983). *"Relationship between Colour Evaluation and Chlorophyllin Pigment Content in Dried Parsley Leaves"*, Journal of Food Science, Vol. 48, pp. 1854 - 1857 & 1877.

6. Davidek, J., Velisek, J. and Pokorny, J., eds. (1990). *"Developments in Food Science 21, Chemical Changes in Food Processing"*, Elsevier Science Publishers, Amsterdam, pp. 302 - 378.

7. von Loesecke, H. W. (1955). *"Drying and Dehydration Of Foods"*, Reinhold Publishing Corporation, New York, pp. 88 - 133.

8. Dutton, H. T., Bailey, G. F. and Kohake, E. (1943). *"Dehydrated Spinach - Changes in Colour and Pigments during Processing and Storage"*, Industrial Engineering Chemistry Vol. 35, No.11, pp. 1173 - 1177.

9. Lioutas, T. S. (1989). *"Dried Green Vegetable and Method of Preparation"*, U.S. Patent 4,832,969.

10. Eheart, M. S. and Odland, D. (1973). *"Use of Ammonium Compounds for Chlorophyll Retention in Frozen Green Vegetables"*, Journal of Food Science, Vol. 38, pp. 202 - 205.

11. Woolfe, M. L. (1979). *"Effects of Heating on Foodstuffs"*, (Priestly, R.J., ed.), Applied Science Publishers, London, pp. 77 - 107.

12. Kaur, B. and Manjrekar, S. P. (1975). *"Effect of Dehydration on the Stability of Chlorophyll and B-Carotene Content of Green Leafy Vegetables available in Northern India"*, Journal of Food Science and Technology (India), Vol. 12. No. 6, pp. 321 - 323.

13. Baker, R.J. and Nelder, (1978). The GLIM System: Release 3, Numerical Alogarithm Group, Oxford.

14. La Jollo, F., Tannenbaum, S.R. and Labuza, T.P. (1971). *"Reaction at Limited Water Concentration. 2 Chlorophyll Degradation"*, Journal of Food Science, Vol. 36, pp. 850 - 853.

15. Vernon. L.P. (1960). *"Spectrophotometric Determination of Chlorophylls and Pheophytins in Plant Extracts"*, Analytical Chemistry, Vol. 32, No. 9, pp. 1144 - 1150.

16. Greensmith, M. (1971). *"Practical Dehydration"*, Food Trade Press, Ltd., London, pp. 157 - 162.

17. Pearson, D. (1976). *"The Chemical Analysis of Foods"*, Churchill Livingstone, London, pp. 289 - 293.

18. Sweeney, J.P. and Martin, M.E. (1961). *"Stability of Chlorophyll in Vegetables as affected by pH"*, Food Technology, Vol. 15, pp. 263 - 266.

19. Hudson, M.A., Sharples, V.J. and Gregory, M.E. (1974). *"Quality of Home Frozen Vegetables. II. Effects of Blanching and/ Cooling in Various Solutions on Conversion of Chlorophyll"*, Journal of Food Technology, Vol. 9, pp. 105 - 114.

20. Meyer, L.H. (1960). *"Food Chemistry"*, Reinhold Publishing Company, New York, pp. 218 - 292.

21. Rocha T., Lebert, A. and Marty-Audouin, C. (1993). *"Effect of Pretreatments and Drying Conditions on Drying Rate and Colour Retention of Basil (Ocimum Basilum)"*, Lebensmittel - Wissenschaft und - Technologie, Vol. 26, pp. 456 - 463.

22. Yeh, P.H. (1974). *"Essential Oils XVI. Oil of Eryngium foetidum, Linn."*, Journal of Chinese Chemical Society, Vol. 22, pp. 139 - 147. ■