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EFFECT OF PEA SIZE AND STORAGE CONDITIONS ON THE QUALITY, DRYING RATE AND REHYDRATION CHARACTERISTICS OF DEHYDRATED PEAS

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Abstract. Both the size and maturity influenced drying rates and rehydration ratios of green peas. Less mature, smaller peas showed higher drying rates than larger or comparatively more mature peas. Although both samples were dehydrated to a similar moisture content, the smaller peas showed more complete rehydration. Both small and large peas immediately after dehydration contained similar levels of SO_2 and showed the same degree of chlorophyll conversion. Peas stored at 100°F, irrespective of size, showed adverse changes in all quality characteristics, while peas stored at −10°F or at room temperature showed only marginal differences with the exception of chlorophyll conversion. However, results of organoleptic evaluations revealed that as far as colour and flavour of the dehydrated peas were concerned, the peas stored at −10°F were superior to samples stored at ambient temperature or at 100°F.

Dehydration has become increasingly important as a food preservation method during recent years and promises to offer good prospects for simplifying food distribution methods through efficient inventory storage, reduced packaging requirements and transportation costs. Most of the work on dehydration of green peas has been carried out during the last 30 years[23,24,29,30]. It has been established that pea variety and maturity play an important role in controlling the quality of rehydrated green peas. Some workers observed that maturity was the most important single factor controlling the quality of processed peas. [10,11,14,17,18,25,27]. Many physical and chemical methods have been suggested for maturity measurement. However, only two methods viz. specific gravity and alcohol insoluble solids, have found practical utility in the pea processing industry. Various instruments have also been designed to measure by mechanical means the maturity of green peas[5,12,13,16,20]. The maturometer devised by Mitchell *et al.*[22] has been used in the present investigations.

Maturity determinations have also been carried out on the basis of peas size, as a rough measure to ascertain the maturity. Moyer *et al.*[24]. found the maturity of peas from a single harvest to increase with increasing size, but within any size the peas toughened on succeeding harvest days. Thus it was possible to obtain sieve size 4 (12/32 in dia) peas in the late season, which were harder and heavier in weight than size 5 (13/32 in dia) peas in the first harvest. This variation in single sieve size suggested that any measurement of maturity was an average value which varied with the percentage of tender and tough peas in the sample. Jodidi[8] suggested quality grading of size graded peas by brine floatation methods. Thus the USDA has formed the following standards for grades of frozen peas;[3] for grade A, the sinkers should not exceed 10% in a 13% brine, for grade B not more than 12% in 15% brine, and for grade C not more than 16% in 16% brine. Peas not suitable for grade C were classed as grade D.

The present investigations were undertaken to establish the relationships between pea size and maturity as related to dehydration, storage stability and rehydration characteristics of a particular pea variety.

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Materials and Methods

Green peas (*Pisum sativm* var. Edgell Freezer) were mechanically harvested and vined in a Chisholm Ryder stationary viner (CRSV) at Hawkesbury Agricultural College, Richmond, N.S.W. (Australia), and transported to the CSIRO Division of Food Research, North Ryde. After washing, the peas were size graded in a CSIRO size grader, and grades 4 (12/32 in dia), 5 (13/32 in dia), 6 (14/32 in dia) and 7(15/32 in dia) were selected for the experiment. Size grades 4 and 5, and size grades 6 and 7 were combined to form composite samples of small and large peas respectively. Both samples were tested for maturity using the maturometer[22] and the extent of physical damage due to the vining operation, in terms of broken and bruised skins on representative samples of each size grade, determined (Table 1).

Graded peas were steam-blanched for 2 min, sulphited for 40 sec in a solution of 0.7% sodium sulphite and 0.9% sodium carbonate at 140°F, loaded onto trays (1 lb/ft^2) and dehydrated in a cross circulation dehydrator. Drying conditions were 200°F dry bulb and 101°F wet bulb for the first 20 min, and then 150°F dry bulb and 92°F wet bulb for a total drying time of 6 hr. during which the moisture content was reduced to approximately 8%. The net weight of peas was determined initially and at 20 min intervals during the drying operation.

Dried peas were stored in sealed 8 oz tinplate cans at 100°F, ambient temperature (approx. 70°F) and —10°F. Immediately after dehydration, and at intervals up to 360-day storage, samples were analysed for moisture content[2], sulphur dioxide content,[28] chlorophyll conversion to pheophytin,[6] and colour.[7] For colour determinations, 35 ml water was added to 25 g ground dehydrated-peas to form a thick paste and used for Hunterlab readings. The dehydrated pea samples were boiled in water for up to 30 min and then held in water initially at 212°F for a total

contact time with water of 60 min. for the purpose of calculating rehydration ratios. The rehydrated peas were organoleptically evaluated for colour and flavour. Samples derived from dehydrated samples stored at three different temperatures and sample frozen before dehydration together with fresh and frozen controls, were presented to a panel of eight judges. Fresh controls were acquired from the local market at the time of each analysis and size graded as described above, while frozen controls were taken from the original samples stored at — 10°F. Both control samples were boiled for 10 min before presentation to the judges.

The judges were asked to rank the samples in order of 'desirable pea colour' and 'desirable pea flavour'. For flavour ranking the samples were served hot. Large and small size grade peas, together with their appropriate control samples, were evaluated separately.

Results and Discussion

1. *Effect of Pea Size on Drying Rate.* The drying rate curves of both small and large peas are shown in Fig.1. The initial moisture contents of the large peas was lower than that of the small peas due to differences in size and maturity (Table 1), which is in agreement with the work of Nortje *et al.*[26]. This difference was observed up to drying time of 90 min. As the drying progressed the moisture content of the small peas decreased more rapidly than that of the large peas due to the higher drying rate, caused either by a higher surface area to volume ratio or a greater degree of skin breakage in small compared to large peas. The drying rate of ungraded peas of maturometer index (M.I.) 248, from a different batch to those used for size grading, was higher than those of either size grades up to approximately 60 min drying time, but the final moisture content of ungraded peas was intermediate between that of graded samples.

2. *Effect of Peas Size and Storage Conditions on the Quality of Dehydrated Peas.* (a) Retention of Sulphur dioxide: Although both small and large peas were sulphited under similar conditions, large peas contained slightly higher levels of SO_2 than small peas when analysed immediately after dehydration (Fig.2). The loss of SO_2 during storage was almost identical for both small and large peas, irrespective of storage time or storage temperature. The SO_2 content decreased with increased storage time, and losses at 100°F were much greater (50% loss) than at room temperature or at—10°F. Sulphur dioxide levels decreased rapidly up to 90 days at 100°F, but further losses were almost linear with time for a further 270-day storage, while peas stored at - 10°F and at room temperature decreased in SO_2 content at a more uniform rate. Greater losses in SO_2 content of peas stored at 100°F may be explained by the higher storage temperature, in agreement with the observations of Legault *et al.* [15]

(b) Chlorophyll Conversion to Pheophytin: Chlorophyll conversion studies were made on rehydrated peas as extraction of chlorophylls from rehydrated peas was more complete than from dehydrated peas.

When analysed immediately after dehydration, both small and large peas showed similar levels of chlorophyll conversion (42.6 and 42.7% respectively). Both small and large peas showed the greatest increase in percent chlorophyll conversion during the first 90 days storage compared to the total conversion during storage for 360 days. Small peas stored for 90 days at 100°F and at room temperature showed approximately 10% higher conversion than large peas stored at these temperatures, in accordance with the obervations of Caldwell *et al.*[4] but with prolonged storage beyond 90 days this difference was reduced, particularly at 100°F (Fig. 3). Samples stored at 100°F, irrespective of their size grade, showed higher discoloration as compared to the samples stored at ambient temperatures; and the samples stored at—10°F were observed to be the greenest amongst the processed peas. This is in agreement with the observations of Nury and Brekke.[19]

TABLE 1. EFFECT OF PEA SIZE ON MATUROMETER READINGS AND SKIN DAMAGE DURING SHELLING.

Pea size	Maturo-meter index	Broken skins (%)	Bruised skins (%)*
Large	350	29	21
Small	243	43	13

*Mean of 4 maturometer readings.

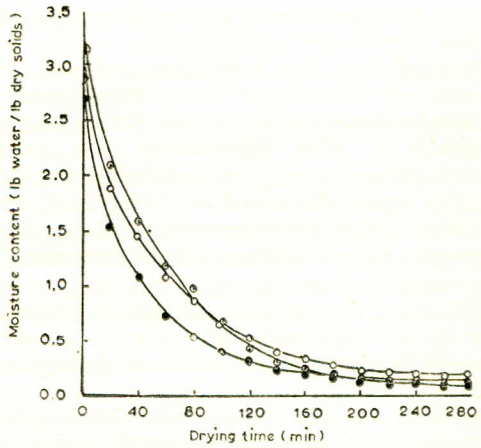

Fig. 1. Drying rate curves of graded and ungraded peas ○ Large; ● small; and ⊙ ungraded.

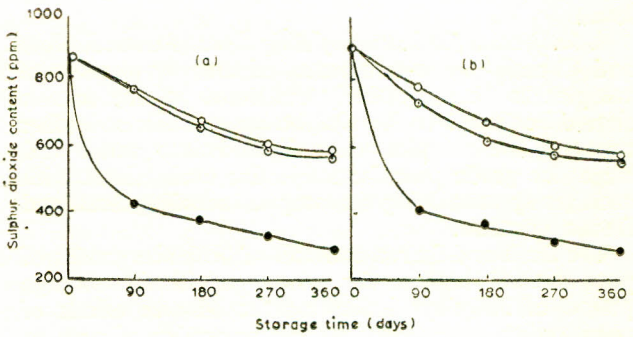

Fig.2. Changes in sulphur dioxide content of small and large dehydrated peas during storage for one year at various temperatures: (a) small peas; (b) large peas; ○ – 10°F storage; ⊙ room temprature storage; and ● 100°F storage.

(c) Colour and Colour Difference Measurements: When colour measurements were recorded after 90-day storage, both small and large size samples stored at 100°F had considerably lower—a (greeness) values as compared to samples stored at—10°F or at room temperature. The values decreased in a similar manner in all samples during subsequent storage pericds.

Correlation coefficients (r), relating percent chlorophyll conversion to various Hunterlab values and indices, (Table 2) showed highly significant relationships with the exception of the relationship between chlorophyll conversion and L values.

3. *Effect of Pea Size and Storage Conditions on Rehydration of Dehydrated Peas.* Small peas gave higher rehydration ratios than large peas when analysed immediately after dehydration, in agreement with their higher percentage of broken skins (Table 1). Rehydration ratios decreased with increased storage time at 100°F and at room temperature for both small and large peas (Fig. 4) although the change with large peas was much greater. Samples of large peas stored at — 10°F showed very little change in rehydration ratio up to 360 days, while the ratio for small peas stored at—10°F decreased as much as during storage at 100°F.

A statistical analysis of the data for rehydration ratio for small and large peas showed highly significant results for the effect of pea size (at 0.1% level) and storage temperature (at 1.0% level), while the effects of storage time were significant at the 5% level.

4. *Subjective Evaluation of Rehydrated Peads.* Kefford and Christie[9] have recommended that the number of samples to be subjectively evaluated in one session should be from 3 to 8. On the basis of this and other reports[1] the samples were divided into small and large size grade peas for subjective evaluations, with each group containing six samples including fresh and frozen controls.

The fresh and frozen controls of both size grades of peas ranked highest for colour uptill the storage period of 360 days indicating the adverse effects of dehydration operation. Both size grades of peas at each storage interval ranked in the following order:

Fresh control——frozen control——stored at —10°F— frozen dried—stored at ambient temp—stored at 100 F (Table 3). Minor variations from the above trend in small size grade peas were noted at some storage intervals, but in general the results were in agreement with objective colour and pigment analysis (2b and 2 c), while the effect of storage temperature on colour degradation has already been discussed (2b).

Flavour evaluations of various samples showed rank order somewhat similar to rank orders for pea colour. Flavour evaluations, in case of large size peas, were well defined and exactly the same rank position was maintained throughout the storage studies as was observed on the first analysis, while the small size peas showed marginal flavour differences within the small size group, hence the samples changed their rank position quite oftenly during the storage studies. (Table 4).

Both the control samples ranked higher in flavour evaluations than the processed peas, while samples

TABLE 2. RELATION BETWEEN PERCENT CHLOROPHYL CONVERSION TO PHEOPHYTIN AND COLOUR INDICES OF DEHYDRATDD PEAS.

Relationship			Correlation coeff.(r)
% Chlorophyll conversion vs	value	L	—0.360*
-do-	value	a	÷ 0.961†
-do-	value	b	—0.685†
-do-	value	a/L	—0.928†
-do-	value	a/b	—0.923†
-do-	index	$(a^2+b^2)^{\frac{1}{2}}$	—0.915†

*Singificant at 5% level.
†Significant at 1% level.

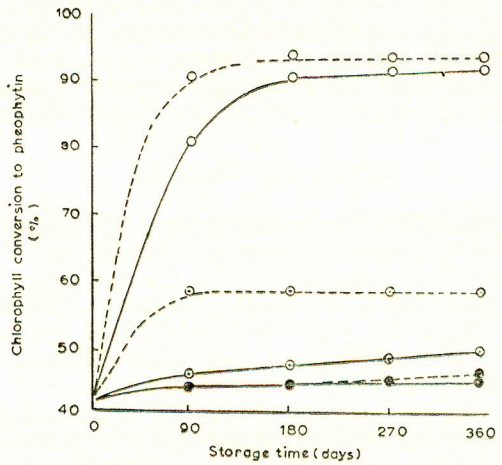

Fig. 3. Effects of storage time and temperature on chlorophyll conversion to pheophytin in large and small dehydrated peas: large; small lines; ○ stored at 100°F; ⊙ stored at room temperature; and ● stored at · 10°F.

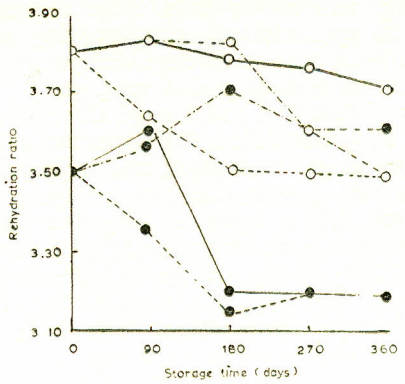

Fig. 4. Changes in rehydration ratio of small and large dehydrated peas during one year's storage at room temperature: ○ small; ● large; —/room temperature storage; - - -100°F storage; and —·—·— 10°F storage).

stored at 100°F irrespective of their size grade, were markedly inferior, possibly due to lipid oxidation or the presence of volatiles from browning reactions. It is possible, of course, that the judges might have been biased in their flavour evaluations by their reactions to the colour of those samples stored at 100°F although the extent to which this might have occurred is somewhat difficult to determine.

Dehydrated samples, of both the size grades of peas stored at—10°F, were marginally better than samples

TABLE 3. SUBJECTIVE EVALUATION OF REHYDRATED PEAS IN ORDER OF DESIRABLE PEA COLOUR AFTER STORAGE AT DIFFERENT TEMPERATURES FOR DIFEERENT LENGTHS OF TIME.

Pea size	Sample and storage temp	Storage time (days) 90 Total rank	90 Mean* rank	90 Rank order	180 Total rank	180 Mean* rank	180 Rank order	270 Total rank	270 Mean* rank	270 Rank order	360 Total rank	360 Mean* rank	360 Rank order
Large	Fresh, control	8	1.00	1	8	1.00	1	10	1.25	1	8	1.00	1
	Frozen, control †	18	2.25	2	16	2.00	2	15	1.88	2	22	2.75	3
	Dried, —10°F	23	2.88	3	26	3.25	3	28	3.50	3	19	2.38	2
	Frozen, dried ‡	31	3.88	4	40	5.00	5	36	4.50	5	38	4.75	5
	Dried, ambient temp	43	5.38	5	30	3.75	4	31	3.88	4	33	4.13	4
	Dried 100°F	45	5.63	6	48	6.00	6	48	6.00	6	48	6.00	6
Small	Fresh, control †	40	5.00	5	16	2.00	2	8	1.00	1	8	1.00	1
	Frozen, control	8	1.00	1	8	1.00	1	16	2.00	2	25	3.13	3
	Dried, —10°F	27	3.38	3	30	3.75	4	27	3.38	3	18	2.25	2
	Frozen, dried‡	16	2.00	2	26	3.25	3	30	3.75	4	40	5.00	5
	Dried, ambient temp	29	3.63	4	40	5.00	5	39	4.88	5	29	3.63	4
	Dried, 100°F	48	6.00	6	48	6.00	6	48	6.00	6	48	6.00	6

*Averages of eight judgements.
†Control samples stored for 90 days at —10°F, then boiled before ranking.
‡Stored for 90 days at —10°F prior to dehydration, analysed immediately after dehydration, 90,180 days and finally after 270 days.

TABLE 4. SUBJECTIVE EVALUATION OF DEHYDRATED PEAS IN ORDER OF DESIRABLE PEA FLAVOUR AFTER STORAGE AT DIFFERENT TEMPERATURES FOR DIFFERENT LENGTHS OF TIME.

Pea size	Sample and storage temp.	Storage time (days) 90 Total rank	90 Mean* rank	90 Rank order	180 Total rank	180 Mean* rank	180 Rank order	270 Total rank	270 Mean* rank	270 Rank order	360 Total rank	360 Mean* rank	360 Rank order
Large	Frozen, control†	18	2.25	1	11	1.38	1	8	1.00	1	14	1.75	1
	Dried, —10°F	20	2.50	2	16	2.00	2	25	3.13	2	22	2.75	2
	Fresh, control	22	2.75	3	22	2.75	3	25	3.13	2	29	3.63	3
	Frozen, dried‡	24	3.00	4	36	4.50	4	26	3.25	3	33	4.13	4
	Dried, ambient temp	37	4.63	5	36	4.50	4	38	4.75	5	34	4.25	5
	Dried, 100°F	47	5.88	6	48	6.00	6	40	5.75	6	36	4.50	6
Small	Fresh, control	11	1.38	1	28	3.50	3	26	3.25	3	18	2.25	2
	Frozen, control †	18	2.25	2	11	1.38	1	8	1.00	1	13	1.63	1
	Dried, —10°F	20	2.50	3	29	3.63	4	20	2.50	2	40	5.00	5
	Dried, ambient temp	34	4.25	4	37	4.63	5	41	5.13	5	21	2.63	3
	Frozen, dried‡	37	4.63	5	15	1.88	2	26	3.25	3	34	4.25	4
	Dried, 100°F	48	6.00	6	48	6.00	6	47	5.88	6	42	5.25	6

*Averages of eight judgements.
†Control samples stored for 90 days at —10°F, then boiled before ranking.
‡Stored for 90 days at—10°F prior to dehydration, analysed immediately after dehydration, 90, 180 days and finally after 270 days.

stored at ambient temperatures and were markedly superior to the samples stored at 100°F. However, on the basis of overall results, it may be concluded that the small size dehydrated peas were of a slightly lower quality than the large size dehydrated peas during a storage period of 360 days.

References

1. M.A. Amerine, R. M. Panghorn,and E. B. Roessler, *Principles of Sensory Evaluation of Foods.* (Academic, New York, 1965), p. 303.
2. J. C. Arthur, T.A. Mclemore, J.C. Miller, L.G. Jones and M.A. Sistrunk, Agr. Food. Chem., **3,** 151 (1955).
3. A.W. Bitting, *Appertizing or the Art of Canning; Its History and Development* (Tradepeess, San Francisco, California, 1937.
4. J. S. Caldwell, C.W. Culpepper, B.D. Ezell, M.S. Wilcox, and M.C. Hutchins, Canner, **103,** 13, 20, 30 (1946).
5. W. F. Christel, Canning Trade, **60,** 34 (1938).
6. W. C. Dietrich, Food. Technol., **12,** 428 (1958).
7. R. S. Hunter, J. Opt. Soc. Am., **48,** 985 (1958).
8. S. L. Jodidi, J. Franklin Inst. **223,** 593 (1937).
9. J. F. Kefford and E. M. Christie. Food Preserv. Quart., **20,** 47 (1960).
10. Z. I. Kertesz, Food Ind., **6,** 168 (1934).
11. Z. I. Kertesz, Agr. Expt. Sta. Bull. No. 233 (1935).
12. A. Kramer and H. R. Smith, Canner, **102,** 11 (1946).
13. A. Kramer, L. E. Scott, R. B. Guyer and L. E. Ide., Food Technol., **4,** 142 (1950).
14. F. A. Lee, J. Whitcombe and J. C. Hening, Fd. Technol. **8,** 126 (1954).
15. R. R. Legault, C. E. Hendel, W. F. Talburt and L. B. Rasmussen, Ind. Eng. Chem., **41,** 194 (1949).
16. L. J. Lynch and R. S. Mitchell, Physical measurement of quality in canning peas, CSIRO, Bull. No. 354 (1950).
17. L. J. Lynch and R. S. Mitchell, When to harvest canning peas. CSIRO, Circular No. 5-P (1955).
18. L. J. Lynch, R. S. Mitchell, and D. J. Casimir. Adv. Food Res., **9,** 95 (1959).
19. F. S. Nury, and J. E. Brekke, J. Food Sci., **28,** 95 (1963).
20. W. M. Martin, Canner, **84,** 108 (1937).
21. D. McBean, J. I. Pitt, and A. A. Johnson. Food Technol., **19,** 141 (1965).
22. R. S. Mitchell, D. J. Casimir and L. J. Lynch. Food Technol., **16,** 415 (1961).
23. J. C. Moyer, W. B. Robinson, H. R. Pallesen and D. B. Hand. Cornell Univ. Agri. Expt. Sta. J. Paper No. 1077 (1965).
24. J. C. Moyer, D. B. Hand, W. B. Robinson, R.S. Shallenberger and H. R. Pallesen, Factors in raw material and processing influencing the reconstitution of dehydrated peas. Quartermaster Food and Container Institute for the Armed Forces, Chicago. Project No. 7-84-06-032 (1959).
25. J. P. Neilsen, H. Campbell, C. S. Bohart and H. P. Masure, Food Ind. **19,** 479 (1947).
26. B. K. Nortje, C.J.B. Smith and K. J. Kotze. CSIRO Food Preserv. Quart. **23,** 52 (1963).
27. L. Ottosson Growth and Maturity of Peas for Canning and Freezing, Vaxtodling (Plant Husbandry), No. 9 (1958).
28. J. Shipton, CSIRO Food. Preserv. Quart., **14,** 54 (1954).
29. D. K. Tressler, Food Technol. **10,** 119 (1956).
30. Unilever Limited, New Zealand Patent No. 115249 (1958).