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EFFECT OF SHELLING METHOD ON DEHYDRATION AND REHYDRATION CHARACTERISTICS OF GREEN PEAS

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Abstract. Peas shelled in a stationary viner showed a higher percentage of skin breakage, higher drying rate, considerably higher sulphur dioxide content and lower chlorophyll conversion to pheophytin, higher rehydration ratio, and were ranked higher for colour and flavour than CSIRO shelled peas. Storing peas at −10°F for 90 days before dehydration did not significantly affect their quality. In general, the CSIRO sheller produced lower quality dehydrated peas than the Chisholm Ryder Stationary Viner.

It is apparent from the nature of vining equipment that peas are subject to skin damage, such as bruising and tenderization during the vining process. Moyer *et al.*[1] reported that peas were tenderized during vining to a degree dependent upon the speed of the beaters. Thus higher beater speed gave rise to substantial tenderization, and peas so treated gave different maturometer readings before and after vining. Their varietal trials showed maturometer readings to decrease with increase in viner speed. Nortje *et al.*[2] observed that hand shelled peas had the highest maturometer values, followed by those from a laboratory sheller, while factory-hulled peas showed the lowest maturity readings.

Casimir *et al.*[3] observed that the rigid structure of peas underwent alterations during vining, resulting in a change in the size grade distribution of commercially vined peas. Mitchell[4] found that the percentage of blanched peas, which sink in brine was greater for vined peas than for hand shelled peas, indicating that viner damage resulted in elimination of gas during blanching. Thus maturity grades, as judged by brine flotation method, were also influenced by the method of shelling.

Comparison of various vining machines and different shelling methods showed[3] that canned peas which were vined in a chisholm ryder stationary viner had 24.8% damaged pea seeds, whereas the hand shelled product contained only 5.6% damaged peas. Variations in such figures could be expected to result from variations in variety, level of pea maturity, method of vining, type of vining machine used and finally the viner beater speed. While the results of Casimir *et al* provide a general picture of the type of damage arising from vining, the extent of such damage could be expected to vary widely depending upon the conditions under which the vining operation was performed.

In view of the findings regarding skin damage and other changes in the physical structure of peas during vining procedures, the present experiment was designed to examine the effects of shelling method, pricking, final moisture content, freezing prior to dehydration, and storage time on the quality of dehydrated peas.

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Materials and Methods

Green peas (*Pisum sativum* var. Edgell Freezer) were mechanically moved and divided into two equal batches. Pods from one batch of vines were hand picked, washed and shelled using the CSIRO pea sheller.[5] The CSIRO pea sheller consisted of a pretreatment section and a shelling section. The pretreatment section was a steam box through which the pods were conveyed on a perforated belt. Wet steam was distributed by perforated pipes placed above and below the belt. The speed of the belt determined the duration of the steam treatment and was adjusted according to the suture toughness of the pods. After leaving the steam chamber, pods passed through a cold water spray to the shelling section on a vibratory conveyor. Peas were squeezed out of their pods as the pods were drawn between the rollers. The empty pods were discharged to waste. Some pods which had been presented blunt end first or were too short for proper alignment in the first vibratory conveyor were not nipped by the rollers but fell, together with the shelled peas, through a feed gap to the second vibratory conveyor. The channels and the feed gap were narrower in the second than in the first shelling section. Thus small pods as well as the large pods were aligned and passed to the second set of rollers. Most of the blunt ended pods rejected in the first section had turned 180 degrees and travelled with their sharper stem-end foremost to the second set of rollers. All the shelled peas fell through the second feed gap. The remaining vines were passed through a chisholm ryder stationary viner and washed. Both samples of pea seeds were analysed for maturometer index,[1,2] and for bruised and broken skins.

A sample of the peas from the stationary viner was steam blanched for 2 min, sulphited by dipping for 40 sec. in a solution of 0.7% sodium sulphite and 0.9% sodium carbonate at 140°F and frozen stored in polyethylene bags at −10°F for 90 days, then dehydrated and stored in tinplate containers at ambient temperature for 270 days. The remaining stationary-vined peas were blanched and sulphited; half of the peas were pricked using the CSIRO pea pricker,[6] while the other half remained unpricked. All the samples were then loaded onto trays (on lb/ft^2) and dehydrated in a cross flow 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 drying the moisture content was reduced to approximately 8%. Net weight of the peas was determined initially and at 20 min intervals during the drying operations. A portion of unpricked peas was further dehydrated in a through-flow dehydrator[8] at 150°F for 4 hr to a final moisture content of approximately 5%. All samples were then stored in air in tinplate containers at ambient temperature for 360 days.

Peas from the CSIRO sheller were also blanched, sulphited, divided into two lots for pricking and dehydrated to 8% moisture content. Samples of pricked and unpricked dried peas were further dehydrated to 5% moisture content.

The samples were analysed for moisture content,[9] sulphur dioxide content,[10] chlorophyll conversion to pheophytin[11] and colour, immediately after dehydration and at regular intervals upto 360 days storage. For colour determinations, Hunterlab readings[12] were made on a thick paste made by mixing 35 ml of water to 25 g of ground dehydrated peas. Dehydrated pea samples were boiled in water for 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. Rehydrated peas were organoleptically evaluated for colour and flavour. Dehydrated peas, and samples frozen before dehydration together with fresh and frozen controls, were presented to a panel of 8 judges. Fresh control were acquired from the market at the time of each analysis, 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.[9] For flavour ranking the samples were served hot. The pricking variable was not taken into consideration for organoleptic evaluation of the samples.

Results and Discussion

Effect of Shelling Method on Drying Rate. Drying rate of peas obtained by the two different shelling techniques was almost the same upto a drying time of approximately 80 min, but on prolonged drying, the peas shelled in the stationary viner dried slightly faster than the peas from the CSIRO sheller. As the peas obtained from the stationary viner had a lower maturometer index due to the damage inflicted on the peas during the vining operation (in agreement with the observations of Moyer *et al.*[1] and a higher percentage of broken and bruised skins than the peas from the CSIRO sheller (Table 1), therefore, these allowed a faster rate of water removal.

Effect of Pricking on Drying Rate. Samples from both the shelling treatments showed a significant advantage of pricking in terms of drying rates. It was also observed that in case of peas from the CSIRO sheller, the higher initial drying rate of pricked peas compared with unpricked samples was maintained upto the end of the dehydration process. However, with the peas from the stationary viner, the difference in drying rate diminished as drying progressed, possibly due to the fact that initial damage to the peas during shelling enabled drying to continue at lower moisture levels and at a rate above than that for unpricked peas from the CSIRO sheller, and comparable to that for pricked peas from the latter machine.

TABLE 1. EFFECT OF SHELLING METHOD ON MATURITY INDEX AND SKIN DAMAGE OF PEAS.

Shelling method	M.I. *	Broken skins(%)	Bruised skins (%)
CSIRO sheller	308 **	2	Nil
Stationary viner	240 **	41	17

* M.I. maturometer index, ** mean of four maturometer readings.

Peas shelled by either method and subsequently pricked dehydrated to a lower final moisture content than the corresponding unpricked peas. This is in agreement with the published data.[13,15] It has also been observed that stationary vined and pricked peas dehydrated to a lower final moisture content (6.8%) than the peas shelled with CSIRO sheller and pricked before dehydration (7.4%). Thus although similar pricking treatments were followed for both the pea samples, the peas which received more physical damage to the skins or cotyledons during shelling, dehydrated to a lower final moisture content than the peas that were pricked but did not receive any other physical injury during the shelling operation.

Effect of Freezing on Drying Rate. Peas frozen before dehydration were found to have a moisture content lower than dehydrated control samples from either shelling method, and lower than peas from the CSIRO sheller that were pricked prior to dehydration. It would thus appear that freezing storage for 91 days and then thawing the peas before dehydration results in fracture of cell walls to accelerate the drying rate and leads to a lower final moisture content in a fixed drying period. It was not determined whether these changes were confined to the skin or to the cotyledon structure in general.

Effect of Secondary Drying on the Quality of Dehydrated Peas. Moisture content of unpricked peas from both the shelling treatments were almost identical after the second dehydration process, although dehydrated peas from the stationary viner contained lower final moisture content after primary dehydration than the peas from the CSIRO sheller. Moisture content of pricked peas after both drying steps was only 0.07% lower than unpricked peas indicating that pricking is of only marginal benefit, when prolonged and drastic dehydration processes are employed. Effect of pricking and two-stage drying on the moisture content of peas from the stationary viner was not examined due to lack of raw material.

TABLE 2. EFFECT OF SHELLING METHOD, PRICKING, FREEZING, DEHYDRATION AND STORAGE ON SULPHUR DIOXIDE CONTENT, CHLOROPHYLL CONVERTION TO PHEOPHYTIN AND REHYDRATION RATIOS OF PEAS STORED AT AMBIENT TEMPERATURE.

Shelling method and predehydration treatment	Storage time (days)														
	0			90			180			270			360		
	SO_2[1]	CC[2]	RR[3]	SO_2[1]	CC[2]	RR[3]	SO_2[1]	CC_2	RR[3]	SO_2[1]	CC[2]	RR[3]	SO_2[1]	CC[2]	RR[3]
Stationary viner*	888	41.8	3.80	752	48.9	3.60	65[illegible]	64.0	3.48	600	67.0	3.50	568	68.8	3.51
Stationary viner+ pricking	880	42.0	3.85	760	47.9	3.60	648	65.6	3.48	584	67.7	3.50	568	69.2	3.48
Stationary viner**	864	41.3	3.80	720	53.8	3.60	624	69.4	3.58	584	69.9	3.55	552	70.3	3.54
Stationary viner+freezing***	—	—	—	720	41.7	3.40	648	61.6	3.43	600	64.7	3.41	560	72.2	3.41
CSIRO sheller*	520	64.1	3.12	424	65.7	3.03	392	88.8	3.03	336	88.9	3.04	288	89.1	3.03
CSIRO sheller+pricking*	544	63.9	3.50	424	65.1	3.40	400	87.5	3.35	336	87.9	3.30	296	88.0	3.28
CSIRO sheller**	552	62.9	3.12	416	65.7	3.10	376	84.2	3.08	320	86.3	3.10	280	87.6	3.08
CSIRO sheller+ pricking**	512	63.3	3.50	424	66.6	3.40	392	83.9	3.30	312	85.8	3.35	272	87.7	3.31

1. Sulphur dioxide content (ppm) 2. Chlorophyll conversion to pheophytin (%), 3. Rehydration ratio *Dried in a cross circulation dehydrator for 6 hours (final moisture content approx. 8%). **Dried for 6 hours in a cross circulation dehydrator and for further 4 hours in a through flow dehydrator (final moisture approx. 5%). ***Shelled,blanched and sulphited peas were stored at —10°F for 90 days prior to dehydration.

Effect of Shelling Method on Chlorophyll Conversion and Objective Colour Measurements of Dehydrated Peas: Chlorophyll Conversion. Chlorophyll conversion to pheophytin in dehydrated peas derived from the CSIRO sheller was substantially higher than in peas from the stationary viner and this difference in conversion was maintained during storage for one year at ambient temperature (Table 2). A similar difference in sulphur dioxide levels was observed between peas from the two shelling methods (Table 2). This may be explained by the fact that although both the samples were sulphited under identical conditions, yet they showed a difference of nearly 300 ppm, of sulphur dioxide content when analysed immediately after dehydration. The sample from the stationary viner had a higher sulphur dioxide content than the peas from the CSIRO sheller. However, sulphur dioxide content decreased in the dehydrated peas from both the shelling treatments during one-year storage at ambient temperature. It is known that sulphur dioxide checks the conversion reaction[16] consequently there was a greater amount of chlorophyll conversion to pheophytin in samples containing lower amount of sulphur dioxide and *vice versa* (Table 2).

It was also noticed that dehydrated peas from the CSIRO sheller, after rehydration, had skins much greener than the cotyledons—improper distribution of sulphur dioxide in these peas, while the peas from the stationary viner showed almost similar colour (greenish colour) of both skins and cotyledons.

Objective Colour Measurements. In agreement with the results of chlorophyll conversion, the samples from the stationary viner had higher—a values (i.e. more negative or more green colour) than the peas from the CSIRO sheller. Peas from both the shelling treatments, stored at ambient temperature for 360 days, showed decreases in the—a values. However, the decreases were comparatively greater in the CSIRO shelled peas than in the stationery vined samples.

The correlation coefficient (r) relating percent chlorophyll conversion to various Hunterlab indices were computed[17]. A statistical analysis of the computed data showed highly significant relationships between percent chlorophyll conversion and decreases in—a,—a/L,—a/b and $(a^2+b^2)^{\frac{1}{2}}$ indices (Table 3).

Effect of Shelling Method and Pricking on Rehydration of Dehydrated Peas. Peas shelled in the stationary viner in general showed higher rehydration ratios than peas from the CSIRO sheller (Table 2). Since the only difference between the unpricked samples of peas the method of shelling ; therefore, it would appear that greater rehydration ratios in vined peas were due to the higher degree of skin damage.

Peas shelled in the stationary viner and frozen for 90 days at—10°F, prior to dehydration, showed a rehydration ratio intermediate between untreated dried peas derived from the two shelling treatments.

Pricking before dehydration resulted in small increases in rehydration ratios of samples derived from the stationary viner ; while samples from the CSIRO sheller showed a significant increase, compared to unpricked samples, due to lower initial level of skin damage (Table 2).

Ambient temperature storage for 360 days resulted in over all reductions in the rehydration ratios, the major decrease occurring in first 90 days storage. These reductions are in general in agreement with losses in sulphur dioxide, increases in chlorophyll conversion and poor subjective evaluations of stored samples, i.e. decrease in over all quality.

Subjective Evaluation of Rehydrated Peas. Results of subjective evaluations in terms of desirable pea colour (Table 4) show that the shelling method has a marked influence on the visual colour since, at each storage period, peas from the stationary viner were considered more desirable than those from the CSIRO sheller. These findings are in agreement with the analysis for chlorophyll conversion. On rehydration the dehydrated peas were considered less desirable than fresh peas as well as peas that had been stored at — 10°F for the same time as the dehydrated samples.

Peas from both shelling treatments dehydrated to 5% final moisture content were considered to have a colour as desirable as, or better than, samples dehydrated to only 8% final moisture content with the exception of samples analysed on 180 days storage interval. In general, these results were also in agreement with analyses for chlorophyll conversion.

Peas frozen for 90 days at— 10°F before dehydration were considered more desirable than non-frozen dried samples at all storage intervals except 90 days storage (i.e. just after dehydration of the frozen sam-

TABLE 3. RELATIONSHIP BETWEEN PERCENT CHLOROPHYLL CONVERSION AND COLOUR INDICES OF DEHYDRATED PEAS STORED FOR ONE YEAR.

Relationship	Correlation coefficient (r)
Percent chlorophyll conversion vs value L	0.350 N.S.
Percent chlorophyll conversion vs value—a	0.865 ***
Percent chlorophyll conversion vs value b	—0.161 N.S.
Percent chlorophyll conversion vs index—a/L	—0.842 ***
Percent chlorophyll conversion vs index—a/b	—0.833 ***
Percent chlorophyll conversion vs index $(a^2+b^2)^{\frac{1}{2}}$	—0.735 ***

N.S. non-significant. *** highly significant.

TABLE 4. SUBJECTIVE EVALUATION OF REHYDRATED PEAS IN ORDER OF DESIRABLE PEA COLOUR AND FLAVOUR AFTER AMBIENT TEMPERATURE STORAGE FOR DIFFERENT LENGTHS OF TIME.

Evaluation for	Shelling method and predehydration treatment	Storage time (days)											
		90			180			210			360		
		Total rank	Mean rank	Rank order	Total rank	Mean rank	Rank order	Total rank	Mean rank	Rank order	Total rank	Mean rank	Rank order
Colour													
	Frozen (control)	8	1.00	1	16	2.00	2	19	2.38	2	8	1.00	1
	Fresh (control)	16	2.00	2	8	1.00	1	8	1.00	1	30	3.75	4
	Stationary viner**	25	3.13	3	40	5.00	5	36	4.50	4	19	2.38	2
	Stationary viner*	31	3.88	4	31	3.88	4	36	4.50	4	33	4.13	5
	Stationary viner, frozen, dried***	40	5.00	5	25	3.13	3	21	2.63	3	29	3.63	3
	CSIRO Sheller**	50	6.25	6	50	6.25	6	52	6.50	5	47	5.88	6
	CSIRO sheller*	54	6.75	7	54	6.75	7	52	6.50	5	56	7.00	7
Flavour													
	Stationary viner**	14	1.75	1	16	2.00	1	41	5.13	5	31	3.58	3
	Stationary viner*	23	2.88	2	35	4.38	2	20	2.50	2	39	4.88	5
	Fresh (control)	23	2.88	2	16	2.00	1	26	3.25	3	17	2.13	1
	Stationary viner, frozen, dried***	30	3.75	3	37	4.63	3	27	3.38	4	32	4.00	4
	Frozen (control)	33	4.13	4	16	2.00	1	8	1.00	1	24	3.00	2
	CSIRO sheller**	48	6.00	5	50	6.25	4	48	6.00	6	40	5.00	6
	CSIRO sheller*	53	6.63	6	54	6.75	5	54	6.75	7	41	5.13	7

* Dried in a cross circulation dehydrator for 6 hours (final moisture content approximately 8%). ** Dried for 6 hours in a cross circulation dehydrator and for further 4 hours in a through-flow dehydrator (final moisture content approx. 5%). *** Shelled, blanched and sulphited peas were stored at—10°F. for 90 days prior to dehydration.

ples). However, the frozen and then dried samples were compared at each storage period with dehydrated peas that had been on storage at ambient temperature for 90 days more than the frozen, dehydrated samples, thus direct comparisons and subjective evaluations cannot directly be related to storage time.

Evaluations in terms of desirable pea flavour also showed that samples derived from the CSIRO sheller were inferior to all other samples (Table 4). Rankings of fresh and frozen control peas showed no clear trend with time except that as storage time increased, rehydrated samples were considered less and less desirable compared to the control samples.

Overall, rankings in terms of desirable flavour were in fair agreement with those of desirable colour, althugh it is very difficult without the use of adequate masking to determine to what extent colour interfered in rankings for flavours. Other investigators, however, have shown that there is usually some correlation between off-colour and off-flavour.[18]

Conclusion

It is apparent from the overall observations that lower quality dehydrated peas were produced by shelling with the CSIRO sheller as compared to the peas shelled with Chisholm Ryder Stationary Viner. However, CSIRO sheller produced a high percentage of peas free of skin breakages and lesions ; therefore, CSIRO shelled peas are not suitable for dehydration, but these may be suitable for processing by methods other than dehydration e.g. canning, freezing, etc.

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