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Quality assessment of beetroot from storage

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Summary

Beetroot was stored in four different clamps until mid-May in two seasons and the quality of pickled sliced roots from the clamps was satisfactory, provided pickling was done by mid-April.

The results indicated that the length of the storage period influenced quality to a greater extent than the type of clamp in which the roots were stored.

Clamps with the roots covered with polythene were warmer than those with no polythene and in Season 2 this resulted in a loss of dry matter in roots in the former. Forced ventilation had little effect on the quality of the stored roots. Skin and flesh texture became tougher during the period of storage, but was not correlated with the texture after processing. Stored roots lost more pigment in Season 2 than in Season 1 and the colour of roots processed from storage on 26 May was still acceptable in Season 1 while in Season 2 the colour was not acceptable by the end of April. Flavour of roots processed from storage at any stage in Season 1 was acceptable, but those pickled after 29 April in Season 2 had an inferior flavour to those processed earlier.

In both seasons storage diseases did not develop to any extent until April; they were more prevalent where clamps were fan-ventilated.

Introduction

With increasing popularity of salads and cold meat dishes, sales of pickled beetroot are rising. Since most jars are sold in summer the bulk of the season's production has to be stored for 6 months with heavy capital commitment. It is desirable, therefore, to process roots in spring rather than in winter and for this reason it is essential to be able to store roots for a period before pickling.

Processors of beetroot have found that some roots were difficult to peel after a period of storage. This may be related to skin texture. In addition it is desirable not to use added colour in bottled beetroot and it would be useful if the pigment content of roots from storage was sufficiently high to give the product a good colour.

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Smith (1966) and Singh, Kapur & Mather (1952) have shown that beetroot can be stored for a number of weeks at 0–2°C. Chrimes (1970) has carried out extensive storage tests and found that straw-bale clamp storage gave results as good as cold storage up to early April provided the clamp was sufficiently narrow. Samples canned in brine and tasted in May 1968 and roots from an 18 ft wide straw bale compound clamp were judged worst; those from a 6 ft traditional straw and soil clamp were rated best, while roots from two other types of clamp were rated slightly below those from the traditional clamp. No objective figures for colour, texture and other quality factors were given.

In the present experiment roots from four different clamp types were tested a number of times in each of two seasons. Clamp temperatures were monitored throughout. Tests to determine dry matter content, flesh and skin texture, colour and amount of disease were carried out. Samples of roots were pickled and were evaluated for colour, texture and flavour after several months. Some slices were tested a year after processing.

Materials and methods

Clamping treatments

Clamps were 12 ft long, 6 ft wide and 5 ft high to the top of the ridge. Each clamp was supported by a double row of straw bales at the sides and ends. Stakes and cross wires held the bales in position. Triangular (1 ft² cross-section) ducts were placed 4 ft apart running lengthwise in the clamps having forced ventilation. The four clamping treatments were as listed below and abbreviations in brackets are used throughout the text, with F standing for fan and P for polythene.

- (1) Fan-assisted ventilation with an air flow of 10 ft³/min per ft² of floor area, i.e. 120 ft³/min per ton of beet (Clamp F).
- (2) As in (1) except that polythene sheeting was placed under the straw bales on top of the beetroot (Clamp FP).
- (3) Straw bales, no polythene, no fan (Clamp S).
- (4) Straw bales with polythene as in (2), no fan (Clamp P).

The fan was connected to a time switch and the operating time was from 2200 to 0600 each night, i.e. when air temperatures were generally lowest and relative humidity highest. A frost thermostat was connected to the system which turned off the fan if the air temperature dropped below 2°C.

Time of clamping and sampling

Freshly-harvested roots (cultivar, Bikor) were clamped on 19 December in 1969 and on 22 December in 1970. The experiment was terminated on 19 June and 9 June in the respective seasons. Three samples of about 24 lb each were taken at random from each clamp at 3–4 week intervals during the storage periods. The samples

were used both for quality and disease testing in the fresh state and also for pickling. There were seven sampling dates in the first season, i.e. 19 December (start of clamping), 14 January, 17 February, 12 March, 17 April, 4 May and 26 May and six in the second season, i.e. 12 January, 4 February, 11 March, 6 April, 29 April and 18 May. These dates will be referred to as sample dates 1-7 Season 1 and 2-7 Season 2 throughout the text.

Clamp temperature

Temperatures were measured daily in each clamp. When the clamps were being built a 5 in diameter plastic pipe was placed parallel to the ground in each clamp about two-thirds the way up from the bottom. A number of 2 in diameter holes were drilled in each pipe to allow air from the clamp to enter. A max.-min. thermometer was attached to a wooden rod which was pushed down the pipe and left there overnight. The end of the pipe was packed with straw. Each morning the rods were removed and the temperatures quickly recorded.

Processing of beetroot

Roots were precooked in a stationary retort for 30 min at 116°C and were then carborundum peeled. After slicing they were packed in jars with vinegar and were processed in a continuous water bath at 82°C for about 25 min. The jars then proceeded to a cooling section where they were cooled in cold water for 25 min.

Chemical tests

Dry matter content (DM). Five roots from each sample were rapidly comminuted in a high speed mincer. A sub-sample was taken and dried to constant weight in a vacuum oven at 70°C and 560 mmHg.

Pigment content. The betanin content of different samples of stored beetroot was measured. 5 g of comminuted material was extracted with 4 × 40 ml portions of distilled water in a high speed blender. The extracts were combined and made up to 200 ml with distilled water. One part of this solution was diluted with four parts of distilled water and the absorbance was measured in a Bausch and Lomb spectrophotometer at 538 nm. No correction for impurities in the juice (as described by Nilsson, 1970) was made, since the measurements were intended only as an index of large differences in pigment content.

Physical measurements

Texture evaluation. Texture of the skin and flesh was tested with a Kramer shear press fitted with a standard test cell and a 5000 lb proving ring, using 30 and 100 g sample sizes respectively for skin and flesh. To prepare samples, circular slices of the roots were made. The skin (and a small amount of the flesh) was 'nicked' off the outside of

the circle with a No. 7 cork borer giving small uniform segments which were then sheared. The internal parts of the circles were diced ($\frac{1}{8}$ in) and sheared giving a measure of flesh texture. Texture measurements were also made on the pickled roots (200 g diced samples).

Colour. The colour of roots was monitored throughout the storage period on a Hunter colour difference meter fitted with a 2 in specimen port. A sample constituted a slice from each of five beetroots which were then tested and the mean calculated. Similar tests were carried out on processed roots and the slices were drained for 2 min before measurements were made. The colour of pickled roots left standing for 1 year after processing was also measured. Roots were assessed visually for colour by a panel and the results were compared with those obtained by the Hunter meter.

Incidence of disease

Roots taken at random from each clamp at each sampling date were examined visually for disease symptoms. Where necessary, microscopic examinations were made to determine what micro-organisms were associated with the diseased roots. In the first season the roots remaining in the clamps at the end of the experiment were divided into marketable and non-marketable, but in the second season a shortage of labour made this operation impossible.

Flavour evaluation

Samples of the processed roots were evaluated for flavour by taste panels in both seasons. Tests were made in September/October after which time slices had been bottled for 4-8 months. In the first season a six-member panel was asked to rate the samples as better or worse than standard in flavour using a five point hedonic scale. Roots pickled at time of clamping were used as standard and samples from subsequent picklings were compared with these. It is likely, of course, that the flavour of the pickled beetroot changed during storage to some extent, but the degree of change should be small compared to changes in non-pickled roots which were in the clamps during the same period. The following treatments were compared in Season 1:

Panel 1—Pickled roots from sample dates 1, 2, 3, 4, 5 Clamp F.

Panel 2—Pickled roots from sample dates 1, 4, 5, 6, 7, Clamp F.

Panel 3—Pickled roots from all clamps at sampling date 3.

Panel 4—Pickled roots from all clamps at sampling date 5.

Panel 5—Pickled roots from all clamps at sampling date 7.

In the second season no standard was used and a ten-member panel was asked to rank samples from best to worst for flavour. The rankings for each sample were added together and were referred to a range table (Kramer, 1963). Treatments compared in Season 2 were:

Panel 1—Pickled roots from sample dates 3, 4, 5, 6, 7, Clamp F.

Panel 2—Pickled roots from sample dates 3, 4, 5, 6, 7, Clamp FP.

Panel 3—Pickled roots from sample dates 3, 4, 5, 6, 7, Clamp S.

Panel 4—Pickled roots from sample dates 3, 4, 5, 6, 7, Clamp P.

Panel 5—Pickled roots from all clamps at sample date 3.

Panel 6—Pickled roots from all clamps at sample date 7.

Results

Clamp temperatures

Clamp temperatures were higher in Season 2 than in Season 1 for Clamps S and P. The forced airflow resulted in lower clamp temperatures in Season 2, but not in Season 1.

TABLE 1. Mean monthly clamp temperatures (°C) during the storage periods in each season

Clamping treatment	Jan.	Feb.	Mar.	Apr.	May	Grand mean
Season 1						
Clamp F	8	4	4	7	10	7
Clamp FP	7	5	4	7	10	7
Clamp S	9	4	5	8	11	7
Clamp P	9	5	4	7	11	7
Season 2						
Clamp F	6	6	6	7	8	7
Clamp FP	8	6	7	7	8	7
Clamp S	8	7	8	8	10	8
Clamp P	10	10	11	12	14	11

Dry matter

In the first season neither clamping treatment nor duration of storage affected the dry matter (DM) content of the roots; the grand mean value was 15.9%. Overall DM values were lower in the second season as indicated by a grand mean of 14.0%. In Season 2 roots from sampling dates 4 and 5 had lower ($P = 0.001$) DM values, 13.2 and 13.5% respectively, than roots from other sampling dates. Roots from Clamp P also had a much lower ($P = 0.001$) DM content, 13.1%, than those from the other clamps.

Pigment content

The pigment content of roots from different sampling dates in both seasons is given in Table 2.

TABLE 2. Pigment content (mg/100 g beetroot) at different sampling dates

Season	Sample date							F-test	Standard error
	1	2	3	4	5	6	7		
1	129	118	99	93	102	86	84	***	4.01
2	—	84	96	75	67	79	81	***	4.23

In Season 1 there was a loss of pigment with time. In Season 2 the range between the highest and lowest values was much less (Table 2). Pigment contents of roots from the clamps were different in Season 2 ($P = 0.05$) where roots from Clamp F had the most pigment and from Clamp P the least. There were no differences in Season 1.

Texture evaluation

The results (Table 3) show that the skin and flesh of roots became tougher during storage. In Season 1 toughening increased gradually during the storage period, while

TABLE 3. Shear values (lb force) for beetroot skin (30 g sample) and flesh (100 g sample) at different sampling dates

Season	Sample dates							F-test	Standard error
	1	2	3	4	5	6	7		
1 (skin)	706	753	824	904	855	867	935	***	13.1
2	—	796	803	772	784	927	995	***	15.2
1 (flesh)	1265	1304	1375	1418	1444	1404	1502	***	18.6
2	—	1266	1306	1300	1241	1392	1436	***	18.1

in Season 2 most toughening took place at the end of the storage period. In Season 1, clamping method had no effect on skin or flesh texture. In Season 2, skin texture of roots from Clamp P was softer ($P = 0.01$) than those from all other clamps.

Tests on the pickled roots showed that those processed at sampling dates 2, 6 and 7 in Season 1, and 4 and 5 in Season 2 were significantly firmer than those processed at the other times. There was no correlation between texture readings on the raw and processed roots.

Colour

Hunter L values for roots from the different clamping treatments at the various sampling dates were not different in either season and grand mean values were 19.3 and 19.4.

Reflectance measurements on the processed roots showed that roots pickled at sampling date 7 (the last) in Season 2 had the lightest colour (Table 4) as indicated by the highest L value. The colour of pickled roots in Season 2 was much worse than that in Season 1 (Table 4). Comparisons between visual observations and Hunter readings showed that low L values indicated good colour both on fresh and bottled roots. Correlations between visual panel response and Hunter 'a' and 'b' values were small which suggests that neither 'a' or 'b' was a good index of beetroot colour in this experiment. Different scales are required for fresh and processed roots, e.g. a fresh

slice with an L value of 17 has quite an acceptable colour while a processed root with an L value of 17 has a poor colour. The highest and lowest L values found for the many fresh slices tested were 21.3 and 16.8 respectively while for the bottled slices the figures obtained were 18.9 and 10.4.

TABLE 4. Hunter L values for pickled roots from different sampling dates

Season	Sampling date						
	1	2	3	4	5	6	7
1	12.3	12.4	14.2	12.0	12.0	11.8	14.6
2	—	—	15.1	15.5	14.4	17.3	17.6

The colour of pickled slices from sample dates 4 and 5 in Season 1 was measured one year later. The mean L value was 14.3 indicating an acceptable colour while the highest and lowest L values obtained for the large number of slices tested were 15.7 and 12.3 respectively.

Disease incidence

In both seasons, scab (*Streptomyces* spp.) was the most prevalent disease, though symptoms were mainly slight. This disease was present at the beginning of storage and did not increase in prevalence or severity during the experiment. The incidence of other diseases was negligible until March–April, when some rotting became evident and increased to the end of the experiment (Table 5). The fungi found associated with the storage rots, in order of prevalence, were species of *Fusarium*, *Gliocladium*, *Penicillium*, *Botrytis*, *Cylindrocarpon*, *Stemphylium* and *Cladosporium*, and there was also some bacterial rotting. In both seasons, greater numbers of diseased roots occurred in samples from Clamps F and FP than from Clamps P and S, and in the second season there was more disease in Clamp F than Clamp FP. When the roots remaining in the clamps were

TABLE 5. Percentages of diseased roots (not including scab) occurring at last four sampling dates in each season

Season	Sampling date	Storage treatment				Mean
		F	FP	S	P	
1	4	0	0	0	2	1
	5	5	2	2	0	2
	6	4	2	2	4	3
	7	19	10	0	5	8
2	4	0	0	0	0	0
	5	0	7	0	7	4
	6	6	0	0	0	2
	7	19	7	7	0	8

examined at the end of Season 1, Clamp F had most unmarketable roots (8%), Clamp P was next with 5%, while Clamps FP and S had 3%. This operation was not carried out in Season 2, but from the comparable levels of disease at the final sampling dates in both seasons it is likely that the overall amounts of waste were similar in the two seasons.

Flavour evaluation

In Season 1 there was no significant difference in the flavour of samples from Clamp F pickled on the different sampling dates (panels 1 and 2—see Experimental). When samples from the four clamps were compared only those bottled at sampling date 5 were different ($P = 0.05$), the sample from Clamp FP being significantly worse flavoured. Those tested from sample date 3 and from sample date 7 were not significantly different (Panels 3, 4 and 5). It should be noted, however, that in general the standard sample, i.e. that pickled at the first sampling date received a higher score than pickled slices from subsequent samplings.

Flavour scores for pickled roots (Season 2) are given in Table 6. These scores were obtained by adding the response of each panelist for a particular sample. Hence a low score indicates a good sample (ranked first or second by most panelists) and a high score a poor one. The figures in brackets (Table 6) indicate the relative position of each sample from best (1) to worst (6). Any sample with a flavour score outside the rank total range (see footnote Table 6) on the low side, e.g. 19, is significantly better than samples whose score is within or above the range, while a sample with a flavour score outside the range on the high side, e.g. 63, is significantly worse flavoured than samples whose score is within or below the range.

In Season 2 there were again no significant differences in the flavour of samples from Clamp F bottled on the different sampling dates (Table 6). However, samples

TABLE 6. Flavour scores* for bottled beetroot from different sampling dates for each of the four clamps—Season 2 (panels 1-4)

Clamp F		Clamp FP		Clamp S		Clamp P	
Sampling date	Flavour score	Sampling date	Flavour score	Sampling date	Flavour score	Sampling date	Flavour score
3	28 (1)	3	32 (4)	3	31 (3)	3	††19 (1)
4	30 (2)	4	31 (3)	4	37 (4)	4	28 (3)
5	31 (3)	5	29 (1)	5	24 (1)	5	44 (5)
6	42 (6)	5	30 (2)	5	26 (2)	6	29 (4)
7	39 (4)	6	38 (5)	6	39 (5)	6	27 (2)
7	40 (5)	7	††50 (6)	7	††53 (6)	7	††63 (6)

*Rank sums for ten tasters.

Rank totals required for significance at $P = 0.05 = 22-48$.

Rank totals required for significance at $P = 0.01$ (††) = 20-50.

pickled from the last sampling date in each of the other three clamps were significantly worse flavoured than those from the earlier sampling dates. Roots pickled from sampling date 3, Clamp P, were significantly better than those from subsequent samplings from that clamp (Table 6). In each test one sample was included twice under different codes to check the reliability of the panel. In each of the four panels the duplicate samples were rated closely together (Table 6).

Samples of pickled roots from the four panels were compared, but were not significantly different in either of the two panels (panels 5 and 6—see Experimental).

Discussion

The results of this experiment show that beetroot stored in clamps until mid-April can then be pickled to give an acceptable product. Length of time in storage seems to be more important than the type of clamp used. This is indicated by the fact that most of the significant differences obtained in the various tests done were between sampling dates rather than between clamps.

Season 2 was warmer than Season 1 and this is reflected in the clamp temperatures especially in the treatments with polythene. However, temperatures were not nearly as high as those recorded by Chrimes (1971) in larger clamps with polythene. The presence of a fan maintained a lower clamp temperature, but the effect on the quality of the roots was small. Differences in quality between treatments were more marked in Season 2 presumably due to the higher air temperature.

Clamp P (with polythene—without fan) had a much higher temperature than the other clamps in Season 2 and this had an adverse effect on some aspects of quality. Dry matter content of roots in this clamp was much lower indicating a higher rate of respiration and breakdown of carbohydrates. Pigment contents were lowest in Clamp P in Season 2 as indicated by absorbance values and skin texture readings were softer than in roots from other treatments. It is surprising, however, that the incidence of disease in Clamp P was relatively low in both seasons despite the higher temperature. It should be noted that the flavour of pickled roots from Clamp P was just as acceptable as those from other clamps. In general the quality of roots from the other three clamps was about equal, incidence of disease being the only aspect where differences occurred, and these differences arose only from April onward. Throughout the greater part of each storage period scab was the only prevalent disease and generally it was not severe enough to prevent processing of the affected roots.

The length of time roots were left in the clamps had an effect on some of the quality attributes tested. In Season 1, contrary to expectations, DM contents remained constant during the period of storage; it was felt that DM values might rise due to drying out of the roots, especially in the treatments having a fan. In Season 2, DM values generally fell during storage. This was probably caused by increased respiration in Season 2 due

to higher air temperatures. In any event drying out is obviously not a problem under the conditions tested in this experiment.

The pigment content as measured by absorbance fell during storage in both seasons, but levels dropped at an earlier stage in Season 2 probably due to higher air temperatures. Hunter *L* values on slices of roots from storage remained the same throughout the period and since the Hunter meter is designed to simulate the human observer (Hunter, 1958) this suggests that the colour of the roots did not change during storage. A possible explanation for this may be that the beetroot contains much more pigment than is required to saturate the eye. Depletion of this pigment to some extent should therefore not affect the colour. Hunter *L* values on roots pickled after different lengths of storage were very similar in Season 1 except for the last sampling date (26 May) where the colour had lightened to some extent but was still acceptable. In Season 2, *L* values were higher indicating poorer colour and roots pickled from the last two sampling dates (29 April, 18 May) had an unacceptable colour. This suggests that a combination of the pickling process and the higher air temperature during storage in Season 2 broke down pigment to the extent that colour was affected. Samples bottled in Season 1 and tested 1 year later still had a good colour and suggests that the pigment content does not change for a considerable time after pickling. The fact that different *L* values are associated with good colour in fresh and pickled slices (see Results) is worthy of mention. In the unprocessed state, slices were darker and the slice surface was slightly rougher than in the processed roots which could influence reflectance. In addition processed slices contained more liquid and had a more shiny surface than unprocessed ones which could also affect reflectance.

Shear values on the skin and flesh increased over the storage period in each season, but at no time did roots become too tough. The shear press reading before processing did not indicate the texture of the processed roots which varied considerably in a random way but was always acceptable.

The flavour of pickled roots was satisfactory and only those processed at the last sampling date (18 May) in Season 2 had a significantly worse flavour than those processed earlier in the storage period. The taste of the pickled roots was too acidic at this stage. In commercial practice it is unlikely that roots would be processed as late in the season as 18 May the date of the last sampling. It was encouraging that an appreciable increase in disease occurred only from April onward.

Conclusions

The length of time that roots were stored affected quality to a greater extent than the type of clamps used for storage.

The quality of roots from three of the clamps was very similar while those from the clamp with polythene and no forced air were somewhat inferior. In addition there was more disease in the clamps with airflow than in those without. Since the clamp without

polythene and airflow was also the cheapest to build it should be considered for future storage.

The colour, flavour and texture of roots pickled from storage was quite acceptable provided pickling was done before the middle of April.

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References

- CHRIMES, J. R. (1970) *Exp. Hort.* 21, 49.
CHRIMES, J. R. (1971) *Comm. Grow.* 3922, 400.
HUNTER, R. S. (1958) *J. Opt. Soc. Am.* 48, 985.
KRAMER, A. (1963) *Fd Technol., Champaign*, 17, 1596.
NILSSON, T. (1970) *Lantbr-Hogsk. Annlr*, 36, 179.
SINGH, K. K., KAPUR, N. S. & MATHER, P.B. (1952) *Indian J. Hort.* 9, 1.
SMITH, W. H. (1966) *Rep. Ditton Covent Garden Lab.* 14.

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