

Flavour Qualities of Frozen Sweetcorn are Affected by Genotype and Blanching*

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(Received 25 September 1995; revised version received 13 March 1996; accepted 24 June 1996)

Abstract: Peroxidase activity is used by the food processing industry as an indicator of adequacy of the blanching process and to predict off-flavour development in frozen food. Research reported herein showed that total peroxidase activity did not parallel flavour changes in frozen unblanched supersweet (*sh2*) or sugary enhanced (*su1/se*) sweet corn genotypes. Frozen corn-on-the-cob of 'Florida Staysweet' (*sh2*), 'Merit' (standard sweet—*su1*) and 'Bodacious' (*su1/se*), blanched and unblanched, was subjected to sensory evaluation and peroxidase analysis following frozen storage up to 12 months. Trained taste panellists rated the unblanched *sh2* and *su1/se* corn as acceptable up to 8 months of frozen storage. Kernels were cut from cobs after 0 and 12 months of storage. Proteins were extracted from acetone powders of kernels and separated by isoelectric focusing and native PAGE. Banding patterns differed according to genotype and storage duration. These results suggested molecular differences in peroxidase isozymes among the sweet corn genotypes which could be involved in off-flavour development. All genotypes contained a peroxidase isozyme having a molecular mass of 80 kDa and pI of 4.5. The *su1/se* and *sh2* genotypes produced an additional peroxidase band of 13.8 kDa. An additional peroxidase isozyme (pI 5.4) appeared in extracts from the *su1* genotype after 12 months storage. Although changes in total peroxidase activity may not predict flavour changes in all genotypes, the presence or absence of certain peroxidase isozymes may be useful in predicting off-flavour development in *su1* frozen corn.

Key words: peroxidase, isozymes, isoelectric focusing, sensory, blanching.

INTRODUCTION

Blanching has been used traditionally in vegetable processing to slow quality deterioration caused by enzyme activity (Joslyn 1949). Other benefits from blanching are colour stability, texture improvement, decrease in decay-causing organisms and removal of undesirable substances. Disadvantages include increased energy use in processing, water pollution and decreased nutritional value, especially loss of heat-labile or water-soluble vitamins (Togebly *et al* 1986; Polyak-Feher *et al* 1992; Selman 1994). There are reports that some vegetables

such as tomatoes, red and green peppers, onions, swedes, cucumbers, celery and mushrooms can be frozen for up to 12 months at -18°C without prior blanching and with no quality deterioration (Baardseth 1978; Kozlowski 1979).

The level of peroxidase activity is used commercially to monitor quality changes in frozen vegetables. Increases in peroxidase are thought to indicate deleterious changes in flavour, colour and texture in vegetables. Measurement of peroxidase is often performed prior to blanching as a reference for determining the adequacy of the blanching process (Brewer *et al* 1994). A 95% loss of enzyme activity following blanching is considered adequate (Baardseth 1978). Campbell (1940) found that unblanched standard sweet (*su1*) corn developed objectionable colour, flavour and odour during frozen storage. However, no evaluations have been performed for the new cultivars with shrunken2 (*sh2*) or

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sugary enhanced (*su1/se*) genotypes to determine quality changes in corn without blanching prior to freezing. Arthey (1978) reported that blanching time of 6 min or longer was needed for corn-on-the-cob because of enzyme activity in the cob. The objective of this study was to evaluate the effect of blanching or not blanching on the frozen quality and peroxidase activity in three genotypes of corn.

MATERIALS AND METHODS

Plant material

In 1993, sweet corn cultivars 'Merit', 'Bodacious' and 'Florida Staysweet', representing the genotypes *su1*, *su1/se* and *sh2*, respectively, were evaluated for quality and peroxidase activity. The corn was grown at the USDA South Central Agricultural Research Laboratory (Lane, OK, USA) following standard growing practices. Corn was harvested 18–20 days post-pollination and prepared immediately for freezing. Using a power driven band saw, the butt end of the ear was cut off and two 5-cm sections (cobettes) were cut from the centre portion of each ear. Husks and silks were removed by hand and the cobettes randomly selected for either blanching or not blanching. Cobettes to be blanched were placed in cloth mesh bags and submerged in boiling water for 8 min then placed in ice water (3°C) for 8 min, drained and frozen at –20°C. The frozen cobettes were stored in sealed polyethylene bags and waxed boxes at –20°C. Frozen samples were taken from each genotype and treatment for sensory evaluation and peroxidase analyses on months 0, 4, 8 and 12.

Sensory evaluation

At each time interval, 15–20 taste panellists evaluated the corn for flavour. Frozen subsamples were placed in perforated seal-a-meal plastic bags and cooked on 'high' for 6 min in a (750 kw) microwave oven, then served to panellists on number-coded paper plates. The panellists were asked to compare the number coded samples against a reference of microwave-cooked blanched *su1* sweetcorn (industry standard) for both off-flavour and overall acceptability. A 1–9 scale was used where 1 represented more off-flavour and not as acceptable as the *su1* reference and 9 represented less off-flavour than the *su1* reference and more acceptable than the *su1* reference (Larmond 1977). The experiment was treated as a completely randomised design. Mean sensory scores of treatments and storage days were combined and analysed using one-way ANOVA (SAS 1988). Factors analysed were genotypes within storage duration.

Peroxidase analyses

The total peroxidase activity was measured spectrophotometrically according to Vetter *et al* (1958) and reported as absorbance units per gram (abs units g⁻¹). Each treatment was replicated three times per storage month. Gel electrophoresis (isoelectric focusing, IEF) was conducted on corn from months 0 and 12 to evaluate peroxidase isozyme patterns on three genotypes of blanched and unblanched corn.

Prior to gel electrophoresis, protein extracts from corn kernel acetone powders were made into a powder-buffer paste according to previously described procedures (Abeles and Biles 1991). Ten grams fresh weight of tissue was used for each sample with 7 ml of 0.1 M KPO₄ (pH 6) to elute proteins from acetone precipitates. Liquid was extracted and centrifuged at 2000 × *g* and the supernatant was filtered using 0.45 µm filters. The protein extracts were applied to Pharmacia Phastsystem® and precast Pharmacia® IEF 3–9 or 4–6.5 gels. Protein samples were applied to the anode and middle portion of the gel and the proteins separated at 15°C using a prerun of 2000 V, 25 mA and 3.5 W for 75 accumulated V h (aVh); a loading run of 200 V, 2.5 mA and 3.5 W for 15 aVh and a separation phase of 2000 V, 2.5 mA and 3.5 W for 410 aVh. Isoelectric points (pI) were determined with the Pharmacia isoelectric focusing calibration kit. Gels were stained for peroxidase bands with 10 mM guaiacol and 10 mM peroxide as substrates. Electrophoresis was repeated three or more times.

Native-PAGE® (10–15% gradient gels) were also used to separate corn kernel peroxidase. Total proteins (4 µg per lane) were loaded and run according to the instructions provided by Pharmacia/LKB. Gels were stained for peroxidase activity as previously described. Non-denatured molecular weight markers were loaded and run simultaneously with the corn-kernel proteins. Non-denatured molecular mass markers (Sigma, St Louis, MO, USA) were α-lactalbumin (14 200 Da), carbonic anhydrase (29 000 Da), Albumin [chicken egg (45 000 Da)], albumin bovine monomer (66 000 Da) and dimer (132 000 Da), urease [jack bean trimer (272 000 Da)] and hexamer (545 000 Da). Lanes with native-PAGE markers were separated from the corn kernel protein lanes and stained with commassie blue. Relative mobility for the markers and peroxidase isozymes were measured and molecular mass determined by methods of Sigma Chemical Co.

RESULTS AND DISCUSSION

Cobettes of *sh2* and *su1/se*, blanched and unblanched, had better flavour and better overall acceptability compared with the reference (*su1*) until 8 months of storage (Fig 1). Preference for the *sh2* and *su1/se* genotypes was

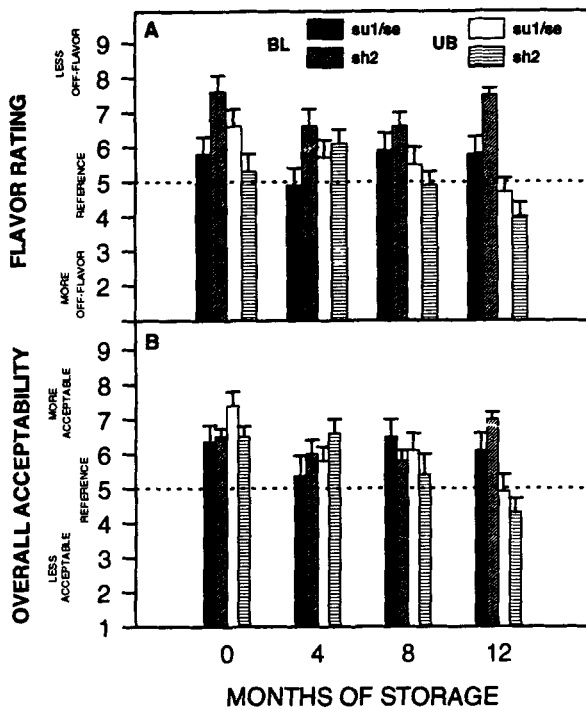


Fig 1. Flavour and overall acceptability ratings by taste panellists of sugary enhanced (*su1/se*) and supersweet (*sh2*) blanching (BL) and unblanching (UB) corn. The corn was stored for 0, 4, 8 and 12 months at -20°C . The dotted line represents the reference corn which was blanching standard sweet corn (*su1*). Bars represent means ($n = 30$) and standard error.

not surprising since both usually contain approximately twice the sugar content (primarily sucrose) as *su1* sweet corn (Juvik and LaBonte 1988). This coincides with a research report that *sh2* corn is suitable for processing (Garwood *et al* 1976).

At month 0, unblanching *su1/se* samples were rated as having less off-flavour compared with unblanching *sh2*

samples. At month 8, *su1/se* unblanching samples were rated as having better overall acceptability compared with unblanching *sh2* samples (Fig 1). Of the blanching samples, the *sh2* genotype was more acceptable than the *su1/se* corn. At month 12, ratings for unblanching samples fell below 5 for overall acceptability (unacceptable) while blanching samples were rated 6 and 7 (acceptable). In preliminary studies, 50 consumers rated unblanching *su1* corn as unacceptable after 8 months of storage while unblanching *su1/se* and *sh2* corn were acceptable until 8 months of frozen storage (unpublished). There are other research reports of acceptable flavour ratings of unblanching frozen vegetables. Unblanching carrots were acceptable for 10 weeks when stored at -18°C , while vacuum-packaged unblanching frozen carrots were acceptable for 43 weeks (Espinosa *et al* 1984). Unblanching swedes, onions and leeks were more acceptable after 15 months of storage than blanching samples (Baardseth 1978). The lower quality of blanching vegetables was probably due to loss of volatile oils during the blanching process (Kozlowski 1979).

Peroxidase activity was minimal in blanching samples (<4 abs units g^{-1}). Unblanching *su1* and *su1/se* were 35–50 abs units g^{-1} while *sh2* corn was 60–77 abs units g^{-1} up to 8 months of storage. We found peroxidase activity for unblanching *su1* corn slightly higher than that previously reported, (Vetter *et al* 1958). After 12 months of storage, activity declined to 43 abs units g^{-1} in *sh2* corn (Fig 2). Barrett and Theerakulkait (1995) and Baardseth (1978) also reported a decline in peroxidase activity in vegetables during frozen storage. The reason for this decrease is unknown. In our study, total peroxidase was not a good indicator of flavour changes in frozen corn-on-the-cob. Williams *et al* (1986) stated that total peroxidase might be used to monitor adequacy of the blanching process without being involved

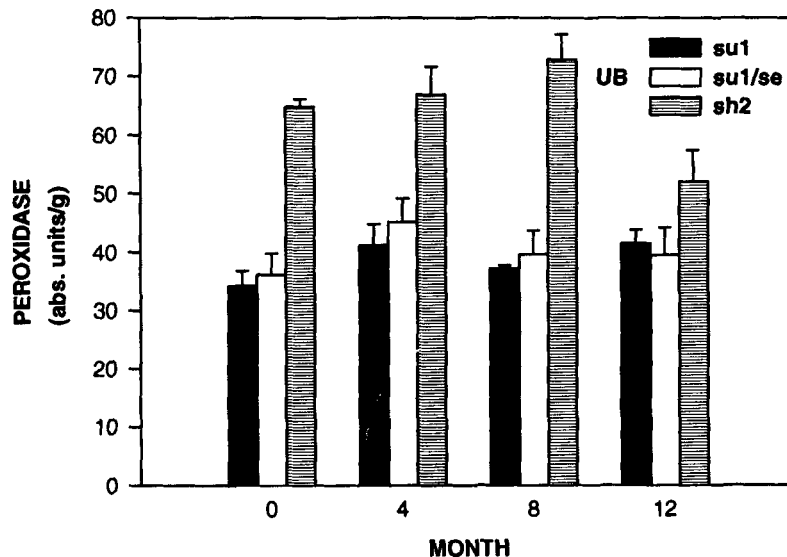


Fig 2. Total peroxidase activity of unblanching standard sweet (*su1*), sugary enhanced (*su1/se*) and supersweet corn (*sh2*) stored for 0 and 12 months at -20°C . Bars represent means ($n = 6$) and standard error.

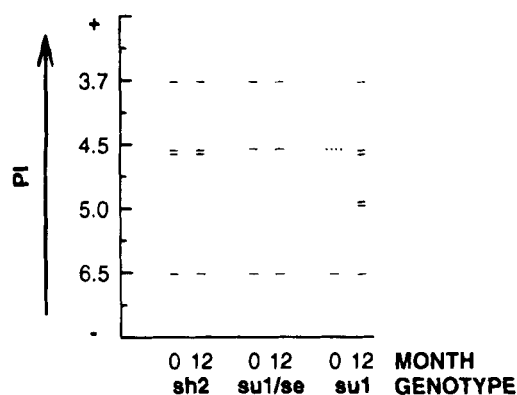


Fig 3. Electrophoresis gel patterns of the peroxidase isozymes of unblanched supersweet (*sh2*), sugary enhanced (*su1/se*) and standard sweet corn (*su1*) at 0 and 12 months of storage at -20°C .

in flavour deterioration. It has been reported that peroxidase, catalase and lipoxygenase are involved in off-flavour development (Wagenknecht and Lee 1958; Resende *et al* 1969). Joslyn (1949) found that peroxidase corresponded more closely to off-flavour than catalase. Recently, Barrett and Theerakulkait (1995) reported that lipoxygenase was a better indicator of flavour changes with frozen stored *su1* sweet corn than peroxidase. They found high levels of lipoxygenase activity at the beginning of frozen storage, then the levels declined in a pattern similar to that of the peroxidase activity described in our study.

In the gel-electrophoresis assay, two acidic bands (pI 3.7 and 4.5) from *sh2* and *su1/se* samples appeared in IEF-PAGE gels at month 0. One less acidic band (pI 6.0) was found for all three genotypes (Fig 3). The pI 3.7 band was not present in unblanched *su1* samples at 0 months storage. In contrast, protein extracts from *su1* corn stored 12 months expressed an additional peroxidase isozyme (pI 5.4).

Native PAGE showed a slow peroxidase band at 80 kDa from each genotype (gel not shown). However, *sh2* and *su1/se* expressed an additional peroxidase band (fast band) at approximately 13.8 kDa (gel not shown). Different banding patterns suggest differences in genetic expression of peroxidase in *su1* that is not expressed in the *sh2* or *su1/se* corn. The different isozyme being formed may possibly be responsible for off-flavour formation. Differences in peroxidase isozyme distribution have been reported in corn for a Hawaiian single cross hybrid and a Hawaiian hybrid plus *sh2* using polyacrylamide gel electrophoresis (Chenchin and Yamamoto 1973).

CONCLUSIONS

Taste panellists preferred the flavour of unblanched supersweet (*sh2*) and sugary enhanced (*su1/se*) corn over the blanched industry standard (*su1*) until 8 months of storage. These results indicate that unblanched supersweet and sugary enhanced corn might be kept in frozen

storage for up to 8 months without an excessive loss in flavour quality. Freezing *su1/se* or *sh2* corn without prior blanching would reduce energy use and processing costs yet retain more water-soluble vitamins. More research is needed, however, to determine the marketability and consumer acceptance of unblanched supersweet or sugary enhanced corn that has been stored frozen for more than 8 months. There was a change in peroxidase isozymes at month 12, with no change in total peroxidase activity. Further identification and purification of the isozymes that catalyse off-flavour reactions could be useful for the processing industry.

ACKNOWLEDGEMENTS

The authors thank Kim Collings, Sherry Winship and Shelia Magby for their technical assistance.

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