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Citrus and Pineapple Juices—

HIGH quality in fruit juices means optimum palatability and nutritive value, and attractive appearance. To meet these requirements a fruit juice must have a good balance of sweetness and acidity, a characteristic fruity aroma and flavour, a full body and smooth texture, a worth-while content of accessory food factors, a good colour, and a stable suspension of solids.

All of these properties depend upon chemical composition, but in the present state of knowledge it is possible to specify quality in fruit juices in chemical terms only to a limited extent. For instance, in citrus and pineapple juices, the ratio of soluble solids content to titratable acidity (Brix/acid ratio) is widely used as an index of quality, but it expresses only the balance between sweetness and acidity. It should be noted, however, that high soluble solids content is itself an important attribute of quality in fruit juices which are to be concentrated (Batchelor and Bitters 1954; Sites and Camp 1955).

CITRUS JUICES

Quality and chemical composition in citrus juices are largely determined by the nature of the raw materials from which the juices are prepared. The effects of raw materials may be discussed under a number of headings: variety, rootstock, maturity, cultural practices, climatic factors, and regional effects. Because it is the major product, more information is available about orange juice than about other citrus juices.

Variety

The properties of citrus fruits as raw materials for juice are profoundly influenced by their genetic make-up.

The Valencia Late is the variety of orange most widely used throughout the world for juice production, because of its desirable characteristics of good sugar–acid balance, high flavour, good colour, and freedom from bitterness. In Florida, the processing season is extended by the use of other varieties such as Pineapple and Hamlin, but the latter variety is less favoured because of low solids and inferior flavour (Tressler and Joslyn 1954*c*; Sites and Camp 1955; Wenzel and Moore 1955).

The Washington Navel variety provides high-quality fruit which are, however, unsuitable for juice because of bitterness in the processed juice (Kefford, Chandler, and Lynch 1952; Marsh 1953). The Shamouti orange of Palestine (Samisch and Ganz 1950) and loose-skinned oranges from India (Siddappa and Bhatia 1954) have similar properties. Bitterness in these juices is due to limonoid bitter principles (Kefford 1955), which are different from the flavonoid bitter principle of grapefruit.

The grapefruit juice industry has reached its highest development in Florida and Texas and there the favoured varieties are Duncan and Marsh Seedless (Tressler and Joslyn 1954*b*). There is now considerable interest in pink grapefruit juice from pink- and red-fleshed varieties such as Foster, Marsh Pink, and Ruby Red (Lime, Stephens, and Griffiths 1954).

The lemon juice industry in California is based largely on the Eureka variety with small proportions of Lisbon and Villa-franca (Tressler and Joslyn 1954*d*). Batchelor and Bitters (1954) found only small effects of variety and strain on citric acid yields.

Rootstock

While the genetic factors determining a variety have a predominating effect on the characteristics of citrus fruits, the quality is also greatly influenced by the rootstock on which the scion is grafted. This influence

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Influence of Raw Materials on Quality

is presumably exercised by a control of the supply of nutrients to the tissues of the scion.

In oranges, grapefruit, and lemons the highest contents of solids and acids are found in fruit grown on rootstocks of Trifoliate Orange or Trifoliate Orange × Sweet Orange crosses, and the lowest contents in fruit grown on rootstocks of Rough Lemon or Sweet Lime. Other rootstocks are intermediate in their effects on quality (Bartholomew and Sinclair 1951; Marloth 1950; Samisch and Cohen 1949; Sinclair and Bartholomew 1944).

However, the choice of a rootstock is often governed by horticultural considerations, such as susceptibility to root diseases, rather than by considerations of juice quality.

Rootstocks have an interesting specific effect on bitterness in Navel orange juice. Marsh (1953), working in California, classified several rootstocks as in the table below.

Similar observations were made in Australia by Kefford, Chandler, and Lynch (1952). In comparative tests of canned Navel orange juices, the least bitter juices came from Trifoliate Orange, Tangelo, and Cleopatra Mandarin rootstocks. Juices from Sweet Orange, East Indian Lime, and Sweet Lime rootstocks were intermediate in bitterness, and juices from Rough Lemon and Kusaie Lime rootstocks were most bitter. Even Valencia orange juices from Rough Lemon rootstocks were detectably bitter up to an advanced stage of maturity.

Maturity

The factor having perhaps the greatest individual effect on juice quality is the maturity of the raw material. During the maturation of oranges and grapefruit, the major changes in composition are a slow increase in soluble solids content and a fall in acidity (Harding and Fisher 1945; Harding and Sunday 1949, 1953; Harding, Winston, and Fisher 1940; Lime, Stephens, and Griffiths 1954; Wedding and Horspool 1955; Rygg and Getty 1955). In lemons the reverse process occurs, the acidity increasing and the sugar content decreasing (Bartholomew and Sinclair 1951).

Oranges are commonly considered to be mature when the Brix/acid ratio approaches 8, but this represents a minimum level for acceptable palatability (Baier 1954; Blondel 1952; Pennisi 1952; Sinclair and Bartholomew 1947). The Florida Citrus Code (Rouse and Atkins 1953) prescribes, for juices for the preparation of frozen orange juice concentrate, a minimum ratio of 11 and a maximum ratio of 19.

Effect of Rootstocks on the Quality of Navel Orange Juice

Rootstock	Bitterness	General Quality
Grapefruit	Absent at commercial maturity	Good
Trifoliate Orange	Disappears within a few weeks of commercial maturity	Excellent
Sweet Orange	Disappears late in the season	Fair
Sour Orange	Disappears late in the season	Fair
Navel Cutting	Disappears late in the season	Good
Rough Lemon	Never disappears	Poor

Changes in minor constituents also occur during the ripening of citrus fruits. Both the limonoid bitter principles in oranges and the naringin in grapefruit (Lime, Stephens, and Griffiths 1954) tend to decrease in concentration with advancing maturity. In Australian experience (Anon. 1947) there is a steady decline in the ascorbic acid content of Valencia orange juice with advancing maturity from August to February, but this trend is not apparent in Navel orange juice. Total pectin in orange juice decreases with maturity while pectinesterase activity may increase, then decline (Rouse and Atkins 1953).

Cultural Practices

The levels of major and minor plant nutrients under which citrus fruits are grown affect the amounts of soluble solids, acids, ascorbic acid, and inorganic compounds in the juices. Reviewing experience in Florida, Sites and Camp (1955) state that deficiencies in trace elements lead to poor quality. Variations in nitrogen supply have limited effects on quality, but low nitrogen levels tend to produce high acidities and high ascorbic acid contents (Jones *et al.* 1944; Jones and Parker 1947, 1951). Excess phosphate decreases soluble solids content, acidity, and ascorbic acid content (Sites and Camp 1955).

Pesticidal oil sprays decrease the soluble solids contents and acidity of citrus fruits but synthetic organic pesticides in general have less effect (Bartholomew, Stewart, and Carman 1951; Harding 1953). Spraying with 2,4-D to reduce fruit drop in grapefruit has no effect on juice composition (Stewart and Parker 1954). Copper sprays increase and lead arsenate sprays decrease the acidity of grapefruit (Deszyck, Reitz, and Sites 1952). Irrigation in excess or at unsuitable times reduces soluble solids content (Sites and Camp 1955). Fruit size, which is related to cultural practices, has an important bearing on juice composition. At maturity, smaller fruits tend to be higher in juice yield, soluble solids content, and acidity (Harding and Lewis 1941; Sites and Camp 1955).

Climatic Factors

Increased photosynthetic activity under conditions of sunshine and higher mean temperatures results in increased accumulation of soluble carbohydrates and ascorbic acid in citrus fruits (Sinclair and Bartholomew 1944). Thus the quality of citrus fruits is influenced by the climate in the locality of production and by the position of the fruit on the tree in relation to the amount of sunlight received.

In the northern hemisphere, oranges on the southern side of a tree are higher in solids and ascorbic acid than fruit on the northern side (Sites and Reitz 1949, 1950), and the position is reversed in the southern hemisphere. Moreover, exposed fruit are higher in solids and ascorbic acid than shaded fruit (Cohen 1953; Winston and Miller 1948).

Regional Observations

A large volume of information has been collected on the general composition of citrus juices in many countries, e.g. America (Bartholomew and Sinclair 1951; Tressler and Joslyn 1954), Central America (Munsell *et al.* 1949, 1950), Costa Rica (Van der Laats 1954), Israel (Samisch and Cohen 1949), Italy (Pennisi 1952), Algeria (Blondel 1952), Spain (Polo and Iranzo 1954), Montenegro (Gugusevic-Ristic 1954), Surinam (Spoon 1951), and India (Siddappa and Bhatia 1954). In general the quality characteristics of citrus varieties are consistent in different regions; the differences that are observed reflect the combined effects of the rootstock, climatic, and cultural factors that have been discussed.

PINEAPPLE JUICE

No less than in citrus juices, quality in pineapple juice depends upon the quality of the raw materials, and the relevant factors may be discussed under broadly similar headings.

Variety

Around 90 per cent. of world production of pineapple juice occurs in the Hawaiian Islands, where the predominant variety is Smooth Cayenne, which provides 90 per cent. of the crop. The remainder is made up of Hilo and a Hilo selection Anahula, which has superior bouquet and flavour (Cooke 1949). In tropical America where pineapples originated the main commercial variety is Red Spanish with some Smooth Cayenne in Puerto Rico and Mexico. Smooth Cayenne also predominates in Australia, but there are some plantings of Queen, which is the commercial variety in Malaya, where it is known as the Singapore Canning Pineapple (Ceri-

ghelli 1955). In French Guinea and the Ivory Coast (Hi 1949), in addition to Smooth Cayenne, a number of local varieties are grown: Baronne, Abacacci, Comte de Paris, Soussou, and Aboisso.

Miller (1951, 1953) and Miller and Schaal (1951) examined pineapples of the Smooth Cayenne, Abachi, Red Spanish, Queen, and Natal varieties grown in Florida and found Natal highest in soluble solids and Abachi highest in ascorbic acid with Queen next. Other varietal differences were not significant.

Nature of Raw Material for Juice

The pineapple is a monocotyledonous plant which first bears a single central fruit, known as the "plant crop". Subsequent fruits, borne on suckers from the main stem and called "ratoons", tend to be higher in sugars and flavour than plant crop fruits, but they are less uniform from plant to plant. Ratoon fruits too small for canning are particularly suitable for juice production.

Pineapple juice is, however, seldom made entirely from whole fruit. In Hawaii (Tressler and Joslyn 1954*a*) juice is produced from seven types of raw material comprising small fruit, cores, trimmings, eradicator meat, and juice drained at various points in the canning line. The juice from cores is lower in sugars, acids, and volatile flavouring constituents than the juice from the fleshy tissues, but cores contribute desirable "body" to the bulked juice.

In Australia (Seale 1953) the raw materials commonly used for juice production are cores, juice draining from crushed and diced pineapple, and skins with adhering flesh after the first eradication. These skins are milled and pressed under controlled pressure to avoid the extraction of undesirable flavours.

Mehrlich (Tressler and Joslyn 1954*a*) sets out the amounts of volatile flavouring constituents in various portions of pineapple fruits and Haagen-Smit *et al.* (1946) report the distribution of ascorbic acid and thiamin. Ascorbic acid is distributed in Australian pineapples in the following approximate amounts: 18 mg per cent. in the core, 16 mg per cent. in the flesh, and 24 mg per cent. in the skin (Seale 1953).

Santini (1954) found a higher phosphorus content in juice from eradicator meat than in juice from "cylinders" of the same fruit.

Maturity

As in citrus fruits, the maturation process in pineapples is accompanied by an increase in sugar content and a decrease in acidity. With advancing maturity from the green to the ripe stages, the total sugar content may increase from about 8 per cent. to 18 per cent. and the pH rise from around 3·3 to 4·1 (Seale 1953). Thus the Brix/acid ratio is greatly influenced by maturity and optimum maturity represents the stage at which maximum sweetness is approached but the acidity is not too low.

In pineapple juice the Brix/acid ratio commonly lies between 12 and 20. Hawaiian experience (Tressler and Joslyn 1954*a*) indicates that a pineapple juice having an acidity of 0·75 per cent. and a Brix/acid ratio of 20 is very highly acceptable. Juices more acid than 1 per cent. are sour unless the sugar content is very high.

In the field, maturity must be judged by means of fruit size and skin colour. After the fruit is cut, further maturity grading is possible in terms of flesh character. Thus white opaque fruit are high in acidity and low in volatile flavours; semi-translucent fruit have a good sugar–acid balance, good colour, and good characteristic flavour; translucent fruit are low in acidity, well-coloured, and rich in volatile flavour; yellow opaque fruit are richest in colour and carbohydrates and intermediate in flavour (Tressler and Joslyn 1954*a*, Tables 50 and 51).

There are also maturity differences within pineapple fruits, which form apically and require 3–4 weeks to differentiate fully. The lower portions are thus physiologically more mature than the upper portions and generally contain more soluble carbohydrates (Dupaigne 1953; Miller and Hall 1953). In 26 samples of Hawaiian pineapples the following values for the Brix of the juice were found: bottom quarter 17·4°, second quarter 15·9°, third quarter 14·4°, and the top quarter 12·2° (Tressler and Joslyn 1954*a*).

Climatic Factors

Quality and chemical composition in pineapple juice are greatly influenced by the climatic conditions under which the fruit is grown, fruit temperature being the most important individual factor. High temperatures favour high sugar content, low

acidity, and high contents of volatile flavours. Conversely, low temperatures favour low sugar content, high acidity, and low contents of volatile flavours. High day temperatures followed by low night temperatures during maturation of the fruit probably represent ideal conditions for high juice quality (Tressler and Joslyn 1954*a*).

In Hawaii, most of the pineapple juice is prepared from the summer crop (June–September) when the juices show relatively high Brix/acid ratios, moderately low acidities, good colour, and strong fruity aroma and flavour. In the winter crop, the Brix is lower, the acidity higher, and colour, flavour, and aroma are diminished.

In Australia similar differences are observed between summer and winter crops. Typical values (Anon. 1947; Seale, personal communication, 1954) for the bulk of processing pineapples are set out in the following table.

Seasonal Effects in Australian Pineapples

	Summer Crop (Feb.–May)	Winter Crop (June–Sept.)
Brix (°)	12–14	8·5 –10·5
Acidity (%)	0·7–0·8	1·1 – 1·2
pH	3·6–3·8	3·25– 3·35
Ascorbic acid in canned juice (mg%)	8·7	13·1

It will be noted that the ascorbic acid content of canned juice is higher for the winter crop than the summer crop. This is in line with the observations of Hamner and Nightingale (1946) and Haagen-Smit *et al.* (1946). But Mehrlich (Tressler and Joslyn 1945*a*) reports that the highest levels of ascorbic acid (20–25 mg per cent.) in Hawaiian pineapple juices are found in the spring and early summer harvests and the lowest levels (13–17 mg per cent.) in winter juices.

Hawaiian summer fruit is generally richer in volatile flavouring constituents (190 mg/kg) than winter fruit (15·6 mg/kg) and there are also some interesting qualitative differences (Haagen-Smit *et al.* 1945). In summer fruit the esters are largely ethyl esters, whereas in winter fruit they are almost entirely methyl esters. The low boiling fractions comprising ethyl acetate, ethyl alcohol, and acetaldehyde are much more abundant in summer fruit.

Some regional differences that have been observed in the composition of pineapple juice may be due largely to differences in fruit temperature during growth. In Hawaii, where pineapples are grown from sea-level up to elevations of 2000 ft, the fruit from low elevations is lower in acidity than the fruit from high elevations (Cooke 1949). Further, pineapples from Puerto Rico, where prevailing temperatures are higher, show higher average Brix/acid ratios than Hawaiian pineapples (Tressler and Joslyn 1954*a*). In the author's experience pineapples from New Guinea. another high-temperature region, are also low in acidity and the pH may be as high as 4·6.

Plant Nutrition

The quality of pineapple juice is considerably influenced by the level of nutrients available to the growing fruit. High levels of nitrogen and of potassium produce high acidities and the acidity is low when these elements are deficient. The potassium content (0·15 per cent.) of pineapple juice is high compared with the amounts of other cations (Tressler and Joslyn 1954*a*). The fact that the sodium content (0·0012 per cent.) is notably low makes pineapple juice a suitable constituent of low-sodium diets. Hamner and Nightingale (1946) found no correlation between the ascorbic acid content of pineapple juice and the status of nitrogen, potassium, or phosphorus in the plant.

There are thus many factors in the raw material which influence the quality and composition of pineapple juice. It is possible to control these factors to some extent by attention to cultural practices such as planting time and fertilization procedure. In Hawaii, synthetic plant hormones (α- and β-naphthalene acetic acids) are used to promote more uniform maturation of ratoon fruit (Cooke 1949), but no information is available on the effect on the quality of the juice. Then, finally, the characteristics of the juice may also be controlled by blending raw materials from different elevations, different ages of crop, etc., to give the desired quality and composition.

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Many inquiries have been received by the Division of Food Preservation and Transport on the possibility of freezing whole raw crayfish without affecting their quality when cooked.

The Freezing and Cold Storage of Raw Crayfish

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REAY (1950) and Reay and House (1951) reported that after lobsters had been quick-frozen and cold-stored raw the cooked flesh became abnormally soft and shrunken and adhered to the shell. They also considered the flavour was poorer than in pre-cooked lobsters of similar storage history, partly perhaps because of the activity of flesh enzymes which could be destroyed by heating. A method said to overcome the difficulty encountered in removing meat from the shell was described by Altenburg (1950); in this method the raw lobsters were given a brief immersion in boiling water before being frozen. No further information on the effect of freezing and storing raw crayfish was found in a survey of the literature, although Dreosti (1950) and van der Merwe (1953) published data on holding times and temperatures for the separated, frozen, raw tails, which form a substantial export trade both in South Africa and in Australia.

The experiments to be described here were aimed at assessing the effect on the quality of the edible meat of storage for 2 to 8 weeks at 0°F prior to cooking. Examination of the treated fish was largely organoleptic and, since it was done at a field station, was somewhat limited; the panel was untrained, and removal of samples depended on the availability of personnel. Despite these drawbacks, analysis of the data revealed statistically significant effects. Data on weight losses during storage, cooking, and thawing were also obtained.

MATERIALS AND METHODS

Thirty live crayfish (*Jasus lalandi*), $1\frac{1}{4}$–$1\frac{3}{4}$ lb in weight, from a February catch, were individually weighed and numbered, and divided at random into five groups each of six fish. Group I was boiled for 15 minutes in sea water, drained, and stored at 0°F. The remaining fish were frozen at 0°F and at successive fortnightly intervals one group (six fish) was removed, allowed to thaw for 16 hours at an air temperature of 40–50 °F, boiled in the same way as group I, and returned to storage. Thus the groups of raw fish received the following storage before cooking:

Group	I	II	III	IV	V
Storage (weeks)	0	2	4	6	8

After further storage for 8 and 12 weeks (chosen to represent typical trade storage practice) samples from each group were removed and thawed. The tail meat was then divided into $\frac{1}{2}$-in. cubes and submitted to the tasters. They assessed the samples for texture and flavour on a points scale of 0 to 5 (large scores representing high acceptability) and also ranked them for general acceptability. A freshly cooked crayfish was included in each test as a control.

To measure loss of weight each fish was weighed at fortnightly intervals during storage, after thawing, and again after cooking.

Organoleptic Assessment of Crayfish

	Mean Score				Mean Relative Score for General Acceptability	
	Flavour		Texture			
	8 Wk Storage	12 Wk Storage	8 Wk Storage	12 Wk Storage	8 Wk Storage	12 Wk Storage
Control	3·67	4·50	3·78	4·73	0·63	1·16
Group I	4·22	3·05	4·33	4·00	1·02	0·20
Group II	2·33	1·82	2·11	2·00	−0·12	−0·75
Group III	2·11	2·82	2·33	2·73	−0·49	−0·16
Group IV	2·11	2·68	1·44	2·82	−0·69	−0·10
Group V	1·67	2·46	1·89	2·59	−0·35	−0·35
No. of samples	9	11	9	11	9	11
S.E.	±0·42 (40 d.f.)	±0·35 (50 d.f.)	±0·44 (40 d.f.)	±0·31 (50 d.f.)	±0·21 (40 d.f.)	±0·20 (50 d.f.)

TASTERS' RESULTS

A preliminary statistical analysis, the data for which are not included here, showed that the tasters agreed in their levels of scoring and that samples differed significantly. The mean scores for flavour, texture, and general acceptability, on removal of the crayfish from the store after 8 and 12 weeks respectively, are shown in the table on this page. Means which are not within the same bracket are significantly different at the 5 per cent. level. The brackets have been arrived at by application of the procedure of Duncan (1951).

WEIGHT LOSSES

• *Weight loss during raw storage.*—Within the first 2 weeks of raw storage the fish lost approximately 2 per cent. of their weight, presumably owing to desiccation during freezing. Little change was observed subsequently, the average loss after 8 weeks being 3 per cent.

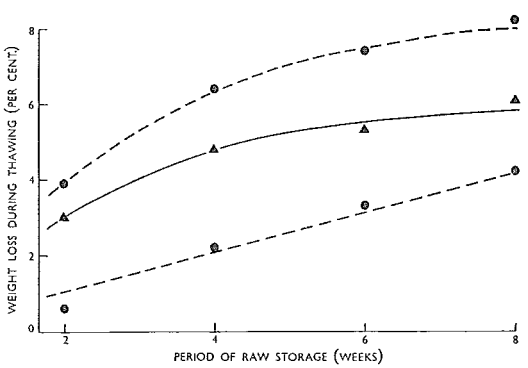
• *Weight loss during thawing of frozen raw crayfish.*—There appeared to be a highly significant relation between the amount of fluid lost during thawing and the time of raw storage. In the graph on this page the unbroken line represents the mean value for each group and the broken lines record the minimum and maximum losses recorded for single fish of the group.

• *Weight loss during cooking.*—The average loss for each group varied from 5 to 12 per cent. and bore no apparent relation to time of raw storage.

• *Weight loss during thawing of frozen cooked crayfish.*—The weight loss upon final thawing of the cooked frozen fish varied from 2 to 15 per cent. (mean 8 per cent.) and was not obviously related to the raw storage history.

DISCUSSION

Consideration of the results of the tasting tests shows clearly that control and group I fish were preferred and the others formed a homogeneous group. Information on shorter-term raw storage is not available but it is obvious that frozen storage of raw crayfish for two weeks at 0°F prior to cooking



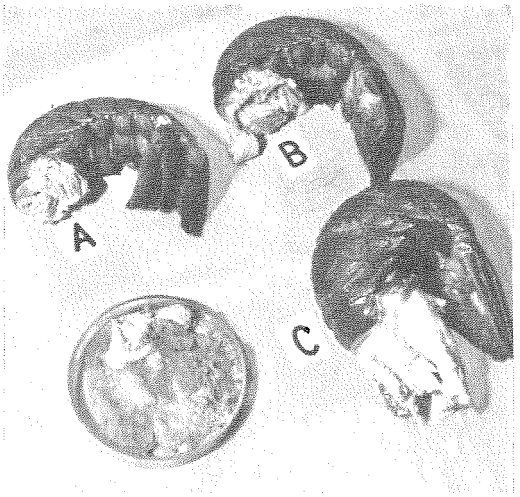
Weight losses during thawing, showing mean values for each group (full line) and maxima and minima (broken lines).

yielded an inferior product. Extension of the raw storage to 8 weeks had no further significant effect. Tasters were in general unable to differentiate between crayfish which had been cooked alive and stored at 0°F for 16–20 weeks (group I) and freshly cooked ones (control).

Identification of the factors responsible for the lower acceptability of raw frozen and cooked crayfish was beyond the scope of this experiment. It is of interest to note, however, that a portion of the cooked tail meat from crayfish frozen raw was badly broken up with a soft, mushy texture and considerable free liquid. The affected area was largely confined to the "butt-end" of the tail but occasionally extended with decreasing severity up to one-third of the length. Typical examples of this are shown in the illustration on this page, where the tails A and B are from cooked fish which had been stored raw for 2 and 6 weeks respectively. The dish contains semi-liquid flesh collected from the "butt-end" of the tails. This material was not submitted to the tasters. The tail C from a crayfish cooked alive is included for comparison. The nature of the texture breakdown strongly suggests proteolytic attack as suggested by Reay (1950), probably by visceral and stomach enzymes which have diffused into the tail flesh, possibly during thawing of the raw fish. The freedom from visible softening in the distal section of the tail flesh in whole frozen crayfish and in the flesh of separated, frozen tails affords further evidence to support Reay's views.

Of further interest is the fact that all the fish frozen raw were "loosenecks" (or "droptails") after cooking. This condition occurs when crayfish have passed through rigor before cooking, and fish so affected are not acceptable to the trade.

It is difficult to make a critical assessment of the significance of weight losses, since during the cooking, thawing, and handling individual variation within species covers a wide range (Reay 1950) and little is known of the factors involved. There does, however, appear to be a definite relation between the time of storage and the amount of fluid lost during the thawing of crayfish frozen raw, though it should be borne in mind that such losses may be derived from tissues other than muscle. The weight losses observed during the thawing of the fish which had been precooked before storage as well as those which were stored raw for some time before cooking were considerably higher than those reported by Reay (1950).



Cooked crayfish tails. A, *stored raw for* 2 *weeks at* 0°*F, thawed overnight, and cooked;* B, *stored raw for* 6 *weeks at* 0°*F, thawed overnight, and cooked;* C, *control, cooked raw. Petri dish contains autolysed protein recovered from "butt-ends" of tails* A *and* B.

ACKNOWLEDGMENTS

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*First presented to a meeting of Commission 4 of the International Institute of Refrigeration at Madrid from May 31 to June 5, 1954, and published in Annexe 1955–1 of its Bulletin.**

Influence of Water in Surface

THE state of water in the surface tissues of meat will be considered here in relation to three factors affecting the storage life of the product: evaporation of water, microbiological changes, and changes in bloom or appearance.

For meat which is cooled and stored at a temperature at or above the freezing point of muscle (−1°C), some loss of water is desirable in order to decrease the rate of growth of microorganisms in the superficial tissues, and probably also to reduce the loss of bloom or fresh appearance. It is almost impossible, however, to define precisely the effects of various rates of loss of moisture and, therefore, to state optimum rates for different classes of meat. The superficial tissues have diverse structures, some being bare muscle, some being muscle covered by a thin layer of connective tissue, and others consisting of connective tissue with varying thicknesses of underlying adipose tissue. At equilibrium temperature conditions and with a constant drying power of the air, the water content of the superficial tissues will vary with the rates of diffusion of moisture from the deeper tissues. The heterogeneous structures and moisture contents of the superficial tissues make it difficult, therefore, to predict storage behaviour in terms of either the rate of water loss per unit area or the drying power of the air.

For meat cooled and stored at a temperature below which microbial growth ceases, say −7°C, loss of moisture is not essential to the maintenance of an attractive appearance. Indeed, it may often result in considerable loss of bloom, which, when severe, may take the form of "freezer-burn" or irreversible desiccation of the exposed tissue.

* Reproduced here with the kind permission of the Institute.

EVAPORATION OF WATER

Properties of the Meat

The rate of evaporation from a surface is a function of $(P_s - P_a)$, where P_s is the partial pressure of water vapour in equilibrium with the surface of the tissues and P_a is the partial pressure of water vapour in the circulating air. With forced air circulation the rate of evaporation is proportional to $(P_s - P_a)$. The rate of evaporation is also a function of the rate and direction of air flow over the surface.

If it is assumed that there is a continuous aqueous phase at the surface, we may write

$$P_s = a_w P_s^*,$$

where a_w is the activity of water in the surface tissue and P_s^* is the saturation vapour pressure at the temperature of the surface.

Initially a_w is of the order of 0·993 in muscle (Scott 1936) but it tends to decrease as evaporation proceeds because the aqueous phase at the surface becomes a more concentrated solution. This decrease in a_w is not uniform over the whole surface. There is evidence that in thick exposed muscle the tendency for a_w to be decreased by concentration of the solutions at the surface is partly compensated by diffusion of solutes of low molecular weight away from the surface (Hicks 1936). Thus the a_w of parts of the surface is determined by the balance between the loss of water by evaporation, diffusion of water from lower levels to the surface, and diffusion of solutes away from the surface. The water content of the surface tissues is also affected by shrinkage, i.e. increasing concentration of insoluble matter and reduction of the volume of the aqueous phase.

By E. W. Hicks, W. J. Scott, and J. R. Vickery
Division of Food Preservation and Transport, C.S.I.R.O., Homebush, N.S.W.

Tissues on Storage of Meat

In a recent experiment with lamb stored for 10 days at 3°C and 84–85 per cent. R.H., Scott measured the a_w of some samples of surface tissue by isopiestic equilibration at 25°C. The results were as follows:

Source of Material	a_w
Connective tissue over fat on loin	0·862
Connective tissue between ribs	0·933
Connective tissue over rib bones	0·925
Panniculus muscle	0·906

Thus the connective tissue over fat on the loin had almost reached equilibrium with the atmosphere of the store whereas other parts of the surface had suffered much smaller reductions in a_w. These figures indicate that the rate of evaporation from different parts of a carcass may vary by a factor of the order of 10.

If parts of the surface are, or become, non-aqueous the equation $P_s = a_w P_s^*$ has no longer a clear physical significance though it might be used empirically, regarding a_w as an average value of a type which cannot be specified precisely. For many purposes it is convenient to specify the evaporation properties of a carcass by the "wetness", which is defined as the ratio of the rate of evaporation to that of a geometrically identical wet body under the same conditions. In the experiment with lamb carcasses referred to above, the wetness was measured directly by comparing the rate of evaporation of half carcasses with that of the opposite halves which had been coated with an agar gel of a_w greater than 0·999. A mean value of 0·57 was obtained for the wetness and there was no significant change in wetness during the storage period of 10 days.

Hicks (1937) studied the evaporation from hindquarters of beef at approximately −1·4°C and relative humidities of 90 to 95 per cent. with rates of air flow from 30 to 200 cm per min, i.e. under conditions similar to those used for shipments of chilled beef. His results showed substantial decreases in the rate of evaporation with increasing time of storage under constant conditions. For instance, the average wetness during the sixth week of storage at −1·4°C, 93 per cent. R.H., was approximately 43 per cent. of that during the first week of storage.

Weight Loss during Chilling

In the early stages of chilling the value of $(P_s - P_a)$ is determined mainly by the temperature difference between the surface and the air, but in the later stages the temperature differences are small so that the value of $(P_s - P_a)$ is determined mainly by the wetness of the surfaces and the relative humidity of the air. These two phases of the cooling process should be considered separately. They will be referred to as the cooling and holding phases.

Theoretical studies of the cooling of a wet body have shown that the direct effect of the rate of air flow on the total weight loss during the cooling phase is small. The direct effect of air speed on the rate of evaporation is almost exactly compensated by changes in $(P_s - P_a)$ due to the corresponding effect of air flow on the rate of reduction in surface temperature. It appears that the only controllable factor which would have a large effect on the water loss during the chilling phase of a wet body is the rate of reduction of the air temperature to the lowest safe value. In practical terms this means that the weight loss during chilling may be reduced by increasing the refrigerating capacity per ton of meat. Decreasing wetness of the surface may reduce the saving

in weight loss, which is possible by this means, below the amount which is theoretically possible for a wet body. The large reduction in weight loss by rapid freezing at a low temperature, without prior chilling, is due to this same cause.

Scott and Vickery (1939) showed that the rate of evaporation during chilling of beef in a forced circulation chiller was approximately proportional to $(P_s{}^*-P_a)^{1.2}$. The departure from the linear relation which would be expected for a wet surface is, no doubt, due to progressive reduction in the average wetness of the surface tissues. This is an empirical relation. Much more work would be needed before it would be possible to specify and predict the changes in wetness of the surface tissues precisely.

Weight Loss during Storage

It has already been pointed out that during the holding phase in chilling and, of course, during storage proper, the value of (P_s-P_a) is determined mainly by the wetness of the surfaces and the relative humidity of the air. The relative humidity of the air is determined by the properties of the meat, the properties of the cooler, the input of heat to the system, and the leakage of water vapour into the space.

A. J. Smith and others have outlined the principles governing the effects of these factors on the rate of weight loss from stored meat but more work is necessary to arrive at sound and reasonably simple means of predicting the rate of weight loss from a particular cargo in a particular store and especially the change in rate of weight loss due to changes in the design or operation of a store.

The rates of weight loss occurring in practice are very variable. In conventional frozen stores losses of the order of 0·3 per cent. per month seem to be typical with carcass beef but higher and lower rates are not unusual. Relatively high rates of weight loss are common with boneless beef. No doubt these are due largely to the high ratio of surface to volume in boneless beef and also to a relatively high average wetness of the exposed surfaces.

The rate of weight loss from chilled beef in ships' chambers is commonly of the order of $1\frac{1}{2}$ to 2 per cent. in 50 days.

Griffiths, Vickery, and Holmes (1932) obtained a great deal of information on the weight loss from New Zealand lamb during cooling, freezing, transport, and storage on land. They found large differences in weight loss from comparable material in different stores. They also found that holding carcasses up to 24 hours on the cooling floor before freezing led to a substantially greater loss between slaughter and the completion of freezing than in carcasses which were frozen immediately after slaughter and dressing. However, the carcasses which were held before freezing lost weight at a slower rate in storage, and after some months' storage under similar conditions the difference in total weight loss between carcasses cooled before freezing and those frozen immediately had become small. Similar effects were observed with pork (Howard, unpublished data, 1951). These observations provide further evidence that the wetness of a carcass depends on its previous history.

MICROBIOLOGICAL EFFECTS

The fundamental quantity governing the availability of water to microorganisms is the a_w. In the surface tissues of carcass meats there are considerable variations in a_w and in some tissues large gradients in a_w immediately beneath the surface. There are also gradients in the microbial populations with depth. Absence of precise knowledge regarding these gradients renders it extremely difficult to make exact statements regarding the microbiological consequences of surface desiccation. There is, however, ample evidence that surface drying is important in controlling microbial development and it is well known that chilled meats subjected to severe drying are usually spoiled by moulds rather than by bacteria.

During chilling of beef the surface desiccation resulting from the high rates of evaporation may lead to death of a large fraction of the important psychrophilic bacteria on some muscle and connective tissue surfaces. Most of the mortality occurs during the first 24 hours of chilling. After this time surface moisture contents generally tend to increase and bacteria tend to proliferate. Bacterial growth can, however, be controlled by maintaining high drying rates during the later stages of chilling. The

evidence for the importance of drying has been presented by Scott and Vickery (1939), and cannot be considered in detail here. The extent of microbial control is affected by the rate and extent of evaporation from the surface, the rate of cooling, and the rate of growth of the bacteria concerned. These are not independent. Two general conclusions may, however, be given. Firstly, microbial control is most readily achieved on the thickest and most slowly cooling portions of the side on which the greatest quantities of heat are dissipated per unit area of surface, and on which surface desiccation is greatest. The second conclusion is that the greater the rate of cooling of a surface the less is the amount of drying required to prevent bacterial growth.

The data of Scott (1936, 1937) show that during storage of chilled meats, meat spoilage bacteria will not grow on beef muscle in air at $-1°$ to 4°C at an a_w below 0·96. For three yeasts the lower limit for growth was from 0·90 to 0·92 a_w. No comparable data for common meat spoilage moulds appear to be available. In 10 per cent. CO_2 the limiting a_w's are slightly higher than in air and this gas is a much more efficient inhibitor of bacterial growth at an a_w of 0·97 than on muscle of normal water contents (Scott 1938). On discharge in England the surface water contents of the muscle of Australian chilled beef cargoes were indicative of a_w's between 0·97 and 0·99, although these would be underestimates if the electrolytes had moved from the surface. For other types of surface the a_w's may have been appreciably lower and more effective in controlling microbial development. Even on muscle surfaces, however, observed rates of microbial growth have sometimes been appreciably less than expected, and the possibility that other factors might interact with CO_2 and the a_w should not be overlooked.

LOSS OF BLOOM

Chilling and Chilled Storage

The effects of the rate and extent of loss of water on the bloom of meat during chilling and storage are very complex, and there are insufficient data to allow more than a few general trends to be given.

In exposed muscle, rates of evaporation up to a certain unknown value cause intensification of colour owing to concentration of the myoglobin and to the formation of a gel-like superficial coating of partly-dried tissue which has greater transparency than the muscle beneath. Higher rates of evaporation may lead to the formation of minute air cells amongst the desiccated muscle fibres. The scattering of light from the interfaces so formed decreases the depth from which the light is reflected and the muscle appears to have a lighter hue. In chilled carcasses, this intense loss of bloom is likely to occur only on thin, superficial muscles, such as panniculus carnosus.

Reduction of the moisture content of superficial connective tissue usually causes greater translucency and, *in situ*, a more pleasing appearance. Excessive desiccation, however, gives a wrinkled, parchment-like appearance.

During the storage of chilled beef for periods up to 50 days, the higher the rate of evaporation the better is the bloom for rates up to approximately 0·055 per cent. per day (Empey, Hicks, Holmes, and Vickery, unpublished data, 1939). For shorter storage periods there are few reliable data. Some experiments on lamb carcasses suggest that the optimum rate of evaporation may be about 0·2 per cent. per day or slightly lower (Vickery, unpublished data, 1954).

Scott and Vickery (1939) believe that conditions conducive to a relatively high rate of evaporation during cooling will aid substantially in the retention of good bloom during subsequent storage.

Freezing and Frozen Storage

Moran and Hale (1929) showed that freezing disrupts the network of collagen fibres in moist connective tissue, producing an increased opacity. Subsequent desiccation of the connective tissue greatly increases this opacity. In confirmation of these findings, Griffiths, Vickery, and Holmes (1932) showed that the higher the rate of loss of moisture during freezing of lamb carcasses, the more intense was the opacity of the superficial tissues and, therefore, the duller the appearance of the lambs. The opacity was much less intense if some drying of the superficial tissues occurred before freezing.

During frozen storage the loss of water occurs chiefly at the expense of the superficial layers, and the greater the extent of water loss the greater is the loss of bloom (Griffiths, Vickery, and Holmes 1932). The extent of this loss is, of course, considerably dependent on the rate of loss of water by the meat before storage. With the increasing loss of moisture, the connective tissue becomes more opaque and the exposed muscle acquires a paler colour following the replacement of ice crystals by air in and between the fibres. Loss of bloom during storage can be prevented by reducing the loss of moisture to negligible amounts by means such as the use of packaging material having low permeability to water vapour or by holding the meat in completely jacketed cold stores.

The precise physical conditions causing "freezer-burn" (intense, irreversible desiccation) are not known, but it is not necessarily associated with extensive loss of moisture. In edible offals freezer-burn often follows very low losses of moisture (Kaess, unpublished data, 1953).

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Fruit and Vegetable Storage Research

A CONFERENCE of over 30 investigators engaged in research on the problems of fruit and vegetable storage was held at the University of Sydney during the week commencing July 30, 1956.

Delegates were welcomed by Dr. J. R. Vickery, Chief of the Division of Food Preservation and Transport, C.S.I.R.O., and Professor R. L. Crocker, Professor of Botany, University of Sydney. Dr. Vickery stated that this was the second conference of its kind in Australia. The first was held in Sydney in 1946. Since then fruit and vegetable storage research in Australia had developed considerably, and it was now his pleasure to welcome to the conference delegates from all States in Australia and observers from overseas. Every State Department of Agriculture in Australia was represented, in addition to the University of Sydney, the Commonwealth Department of Primary Industry, and the Divisions of Plant Industry and Food Preservation and Transport, C.S.I.R.O.

For the first time the New Zealand D.S.I.R. had sent an officer, Mr. C. S. Padfield, to whom Dr. Vickery extended an especial welcome. Also among those present was Dr. Harlan K. Pratt, Associate-Professor of Post-Harvest Physiology at the University of California, who was in Australia as a Fulbright Scholar. Dr. Vickery added that the meeting was being held under the auspices of the Australian Agricultural Council, which had suggested that another conference be held in four years.

Dr. R. N. Robertson of C.S.I.R.O. was elected chairman of the conference, the programme of which is set out below:

July 30

Discussions on

- Orchard factors in relation to storage behaviour of fruit. (Leader: Mr. G. B. Tindale, Victorian Department of Agriculture.)

- The statistical design and analysis of fruit storage and related experiments. (Leader: Mr. G. G. Coote, Division of Mathematical Statistics, C.S.I.R.O.)
- Apple scald. (Leader: Dr. D. Martin, C.S.I.R.O. Tasmanian Regional Laboratory, Hobart.)
- Problems of citrus preservation. (Leader: Mr. W. B. McGlasson, South Australian Department of Agriculture.)

July 31

Discussions on

- Current problems in the transport and storage of tropical fruits. (Leader: Mr. C. D. Stevenson, Queensland Department of Agriculture and Stock.)
- What can metabolic studies contribute to storage problems? (Leader: Dr. F. E. Huelin, Division of Food Preservation and Transport, C.S.I.R.O.)

Lecture on

- Research in post-harvest physiology of fruits and vegetables in the University of California, by Associate-Professor Harlan K. Pratt.

The concluding session of the conference on July 31 was devoted to the consideration of recommendations for future research. These were discussed the following day by the Committee for Co-ordination of Fruit and Vegetable Storage Research, on which are representatives of C.S.I.R.O., the Commonwealth Department of Primary Industry, and State Departments of Agriculture. This Committee, which meets biennially to consider such matters, agreed among other things to plans for research on methods of controlling superficial scald in apples and mould in citrus. It also decided to set up a master photographic library of colour transparencies of fruit disorders at the headquarters of the C.S.I.R.O. Division of Food Preservation and Transport at Homebush.

On August 2, conference members visited orchards and packing-houses in the Gosford citrus-growing district 50 miles north of Sydney. They inspected work in progress at the Citrus Wastage Research Laboratory operated at Gosford by C.S.I.R.O. and the New South Wales Department of Agriculture, and were guests at an official opening of extensions to the laboratory. The extensions have been made to allow urgent research to be carried out on the sterilization of citrus fruit against possible fruit-fly infestation.

On August 3, delegates saw fruit and vegetable storage investigations being carried out at the Homebush laboratories of the Division of Food Preservation and Transport, where they were entertained at lunch. The concluding session in the afternoon was devoted to observations and discussions at the Division's Plant Physiology Unit, Botany School, University of Sydney.

LETTER TO THE EDITOR

VACUUM PROCESSING OF APPLES

Dear Sir,

I have just read with considerable interest the article "Canning Apple Products in Tasmania" in your June 1956 issue (*C.S.I.R.O. Food Pres. Quart.* **16**: 22). We have recently revived in Canada the vacuum method of processing apple tissue.

A method of retaining the natural colour and flavour of solid- and frozen-pack apples and apple pie filling has been needed by the processing industry. A salt-brine soak or a 30-minute blanch at 130°F have not proven entirely adequate. The vacuum method has been reinvestigated and commercial equipment designed to adapt the process to industry. The following points are claimed as advantages of the process now in use:

(1) The flavour of the original apple is very well retained.

(2) The shape of the piece is preserved and the apple tissue is firmed.

(3) The equipment for vacuumizing the apple tissue takes up less space than either soaking tanks or continuous hot blanch.

(4) The cycle for each vacuum chamber should not take more than 15 minutes. By using multiple chambers the process becomes continuous.

Limitations as to size of vacuum chamber have not been determined. However, perforated cylinders 24½ in. in diameter and 54 in. high hold between 550 and 600 lb of prepared apple per batch. Chambers should be small enough to be filled in not more than 10 min. Even with rapid filling it is thought best to convey the apples in preparation in 2 per cent. salt brine. The size of chamber is related to the capacity of each factory. For many plants vacuum chambers to accommodate perforated cylinders of 24½ in. by 54 in. could be used and extra capacity obtained by putting in more units.

The unit is composed of four stainless steel cylinders each equipped with mechanically operated valves for loading and unloading.

Solid Pack.—The process consists of drawing a vacuum of 27·5 in. in the vacuum chamber. With apples of optimum maturity for canning this vacuum should be held for 7 to 9 min and then released with steam over a 2-min period. Mature apples require as little as 4 min, but hard apples may require up to 11 min. These times are for apple segments not over ⅝ in. at the thickest point. If the process is correct the segment appears translucent without any white tissue. With all the usual apple products a blanch is required after the vacuum treatment. By continuing the steam treatment (in the vacuum chamber) after the vacuum is released the pieces can be heated to 160–170°F. (A large pop-off valve is necessary in case pressure is developed.) A mesh belt through a steam box will be required if the apples are to be heated to 190°F to inactivate the enzymes completely for freezing.

Pie Filling.—For pie filling at least 85 per cent. of the pieces should be free of any white tissue at the end of the vacuum process. If this percentage is not being obtained, lengthen the vacuum treatment.

Frozen Pack.—A superior quality of frozen apple can be made by following the procedure as already outlined and then continuing the blanch after the fruit is removed from the vacuum chamber until a minimum of 185°F has been attained in the sectors. The sectors are then chilled in a refrigerated syrup and finally packed and frozen. A distinct advantage of this process is that it eliminates the use of sulphur dioxide. Where large quantities of frozen-pack apples containing this chemical have been used in pies, bake ovens have been reported to have burned out in as little as three years.

F. E. Atkinson

Fruit and Vegetable Processing Laboratory, Experimental Station, Summerland, B.C., Canada.

(The authors of the original article, Messrs. R. A. Gallop and P. W. Board, have made the following comment on Mr. Atkinson's letter: "The vacuum method has not been tried in Australia and it is therefore not known whether it will result in a more acceptable product than is obtained by present methods".)

Concrete Floors for Food Factories

The attention of readers is drawn to a mimeograph "Report on Durable Concrete Floors for Factories" (No. R–7) by W. H. Taylor, C.S.I.R.O. Division of Building Research. The report makes particular reference to the chemical corrosion of concrete floors by certain materials, including foods. All important aspects of the construction of durable concrete floors are dealt with in detail. These include the selection of materials, preparations for laying, the laying itself, and curing.

Nine different surface treatments for protecting the concrete floors from chemical corrosion are described and a table is given showing which of these treatments, or which combination of treatments, should be used for protection against particular hazards. The corrosive agents referred to, most of which are encountered in food factories, include water (natural and acidic), common acids, chlorides, fruit and vegetable juices, sugars, milk, oils, and fats.

Copies of the report may be obtained on application to C.S.I.R.O. Division of Building Research, Graham Road, Highett, S.21, Vic.

NEWS from the Division of Food Preservation and Transport

FRUIT AND VEGETABLE PROCESSING RESEARCH

The cooperative researches on the processing of fruit and vegetables do not cover as many parts of Australia as the cold storage investigations described earlier.* For many years, however, a close link has been maintained through the Dried Fruits Processing Committee between those concerned with the dehydration and sun-drying of vine- and tree-fruits. This Committee comprises representatives of the Department of Agriculture in South Australia, the Victorian State Laboratories, the Commonwealth Department of Primary Industry, and C.S.I.R.O. (Commonwealth Irrigation Research Station at Merbein, near Mildura, Vic., and Division of Food Preservation and Transport). The cooperative researches arranged have led to many improvements in the processing and quality of dried fruits.

In New South Wales useful work has been done by a Committee for Co-ordination of Fruit and Vegetable Storage Processing Research which was set up in 1949 to arrange for cooperative investigations by the New South Wales Department of Agriculture, the Division of Food Preservation and Transport of C.S.I.R.O., and the University of Sydney. The coordination of activities has been mutually beneficial. The Department of Agriculture has run trials at Hawkesbury Agricultural College and its Experiment Farms on the field attributes of fruit and vegetables, and has grown crops for C.S.I.R.O. The Division of Food Preservation and Transport for its part has tested the processing quality of a number of fruits and vegetables, and has made the results available to the Department of Agriculture. It is likely that in the near future the Committee will include representatives from the food industry, which can play an important part in facilitating processing research.

* *C.S.I.R.O. Food Pres. Quart.* **16**: 58 (1956).

PERSONAL

Dr. J. R. VICKERY, Chief of the Division of Food Preservation and Transport, has accepted the invitation of the Food and Agriculture Organization of the United Nations and of the World Health Organization to join a committee of technical experts on food additives. The committee will meet at F.A.O. headquarters in Rome from December 3 to December 10, 1956, to consider the principles which should govern the use of food additives and methods for controlling their use. From Rome Dr. Vickery will proceed to England and the Continent, and on his return journey he may visit the Central Food Technological Research Institute at Mysore in southern India. Dr. Vickery left Australia on November 27 and will be overseas for about six weeks.

Dr. H. L. WEBSTER, Research Officer at the Division's Meat Research Laboratory, Brisbane, resigned at the end of August 1956 to accept a position as lecturer on the staff of the Biochemistry School, University of Sydney.

Mr. A. D. BROWN, Senior Research Officer at the Division's Meat Research Laboratory, resigned in November 1956 to accept an Imperial Chemical Industries Research Fellowship, tenable at Manchester University. Mr. Brown, who has been senior bacteriologist at the Meat Research Laboratory, has chosen as his field of research a fundamental study of bacteria which can grow at low temperatures.

CORRIGENDUM

VOLUME 16, NUMBER 2

Sensory Tests of Meat Quality

Page 29, second column: *The footnotes to the table should read:*

** Significant at 1 in 100 level.

*** Significant at 1 in 1000 level.

PUBLICATIONS BY STAFF

EFFECTS OF PRE-COOKING PROCEDURES ON INITIAL QUALITY AND QUALITY AFTER STORAGE OF DRIED MUTTON MINCE. *A. Howard, A. R. Prater, and G. G. Coote. C.S.I.R.O. Aust. Div. Food Pres. Transp. Tech. Pap. No. 1 (1956).*

An attempt was made to assess the relative importance for quality and storage of a wide variety of pre-cooking treatments for mutton to be dried as mince. Several methods were tried for cooking on and off the bone, and the temperatures, period of drying, and size of pieces were varied. It was concluded that the cooking of boneless pieces in live steam at atmospheric pressure for approximately 45 minutes was the most satisfactory procedure. This finding applied to meat from mature to old beasts dried in a two-stage through-draught dryer, when the cooking liquors were not returned to the mince.

SOME THEORETICAL AND PRACTICAL ASPECTS OF THE PLANNING AND CONDUCT OF TASTING TESTS. *E. M. Christie. Food & Nutr. Notes & Revs. 13: 21-30 (1956).*

This paper, presented originally at the 31st Meeting of the Australian and New Zealand Association for the Advancement of Science in 1955, discusses the organs and senses of taste and smell, then goes on to describe the rooms and methods for taste tests at the Food Preservation Laboratory at Homebush, including selection of tasters, scoring, and other practical details.

STUDIES IN THE METABOLISM OF PLANT CELLS. XI. THE DONNAN EQUILIBRATION AND THE IONIC RELATIONS OF PLANT MITOCHONDRIA. *S. I. Honda and R. N. Robertson. Aust. J. Biol. Sci. 9: 305–20 (1956).*

THE MORPHOLOGY OF RED BEET (BETA VULGARIS L.) MITOCHONDRIA. *J. L. Farrant, Coralie Potter, R. N. Robertson, and Marjorie J. Wilkins. Aust. J. Bot. 4: 117–24 (1956).*

Copies of the papers mentioned above may be obtained from the Librarian, Division of Food Preservation and Transport, Private Bag, P.O., Homebush, N.S.W. (Telephone: UM 8431, UM 6782.)

FOOD SCIENCE ABSTRACTS

EFFECTS OF FUNGICIDES ON THE SHELF LIFE OF FLORIDA VALENCIA ORANGES PACKAGED IN CONSUMER UNITS. *H. W. Hruschka, J. R. Winston, and J. M. Lutz. Pre-Pack-Age 8 (7): 13-15 (1955).*

The incidence of decay in oranges packaged in mesh bags, polyethylene bags, or crates, was markedly diminished by previous treatment of the fruit by a three-minute dip in either a solution containing two per cent. of sodium *o*-phenylphenate and one per cent. of hexamine, or a five per cent. solution of ethyl thionocarbamate, followed in both cases by a rapid rinse in water. Incidence of decay was higher when the oranges were dipped and packaged in Florida before transport to New York than when they were dipped in Florida, transported to New York in crates, and packaged. Taste tests with pairs of juice samples showed that the following factors had no deleterious effects on flavour: presence of decayed fruit in polyethylene bags, packaging in polyethylene bags, or dipping in either of the above fungicides.

The abstract in this section has been taken from Food Science Abstracts *with the kind permission of the Controller of Her Majesty's Stationery Office, London.*