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FREEZING PERFORMANCE AND QUALITY OF STRAWBERRIES GROWN IN PEAT AND MINERAL SOIL

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ABSTRACT

Comparative tests over 5 seasons (1972-76) on the freezing performance of strawberries grown under field conditions showed that fruit from peat soil gave consistently higher drip losses on thawing than fruit from mineral soil for all cultivars tested. The effect could not be repeated when plants were grown at another location in troughs filled with peat, mineral, or 1 : 1 peat : mineral soil.

The difference in freezing performance of field-grown strawberries may be due to the very rapid vegetative growth of the plants in peat resulting in a looser cell structure which could be more easily damaged during freezing. The climate prevailing on the peatlands may also be a contributing factor. Tests in 1975 and 1976 showed only small differences in the element content of the leaves or of the fruit of plants grown from the two soil types. Pectin contents of the fruits were also similar. Dry matter content was much lower in leaves of plants grown in peat than in those of plants from mineral soil.

Tests on the fruit for soluble solids, acidity and colour indicated that peat soil may influence these aspects of fruit composition in certain conditions, but that the effect is by no means consistent.

INTRODUCTION

The strawberry is one of the more difficult fruits to freeze (1) and texture changes after freezing and thawing are a major problem (2). Freezing strawberries, especially at a slow rate, damages the cell walls, and disarranges the cell contents (3, 4, 5, 6). The fruit loses juice, i.e., drip, on thawing and a correlation has been found between the soft texture of the thawed berry and the amount of drip (7).

Gormley published preliminary results (8) on the freezing performance and quality of strawberry cultivars grown in peat and mineral soils (Experiment 1). The soil types were at different sites, the peat being at Lullymore, Co. Kildare, and the mineral soil at Clonroche, Co. Wexford. Fruit grown in peat and then frozen gave a much higher drip loss on thawing than corresponding fruit from mineral soil. There was no difference in the soluble solids and acid content of fruit from the two sources but peat-grown fruit had a significantly higher pH.

Because of the differences in freezing performance of fruit from the two locations, or soil types, further comparative tests were carried out in 1972-1976. The quality of the fruit in terms of soluble solids and acid contents, shear value, skin and flesh colour, and drip loss was monitored.

EXPERIMENTAL

Experiment 1 (1971)

Results of this experiment have already been reported (8) but details of growing sites, growing and test procedures used have not.

The cultivars Cambridge Vigour, Templar and Elista were grown on a well-drained Acid Brown Earth of loam to clay loam texture at Clonroche, Co. Wexford, and on cut-over fen peat at Lullymore, Co. Kildare. The plants were grown according to standard practice. The fruit was tested for pH, soluble solids and acid content, puree colour and shear value. The methods used for physical and chemical tests were generally similar to those reported by MacLachlan and Gormley (9) for strawberry fruit.

Experiments 2 and 3 (1972-73)

The cultivars Cambridge Vigour, Gorella, Talisman and Elista were grown in 1972 and Cambridge Vigour, Gorella and Elista in 1973. Growing sites and procedures were the same as in Experiment 1. The physical and chemical tests (three replications at each site) carried out were also the same except that samples of the 1972 fruit were frozen by both slow freezing and Freon freezing techniques, and tests for puree colour, fruit pH, soluble solids content and acidity were only carried out on spot samples (i.e., no replications, one sample tested per cultivar). The 1973 fruit were blast frozen only and drip tests in both seasons were carried out after 2 months at -30°C .

Histological examination of the 1973 fruit was carried out by embedding in paraffin, sectioning, and examining under a compound light microscope at 450X.

Experiments 4 and 5 (1974-75)

It was decided to grow the plants at one location, i.e., Kinsealy, in order to reduce the possible effect of climate. The plants were grown in concrete troughs with drainage, containing a 150-mm depth of Lullymore peat, mineral soil or a 1:1 mixture of peat/mineral soil. The mineral soil was classified as a well-drained Grey-Brown Podzolic soil of clay loam texture with a high pH. There were 60 plants, cultivar Cambridge Vigour, for each treatment and there were two replications. Fertiliser application and weed control were in accordance with standard commercial practice. The plants were irrigated when necessary.

The 1974 fruit was frozen by liquid nitrogen, blast freezing and slow freezing techniques while that from 1975 was blast frozen only. Drip tests were carried out after 6 months storage at -30°C .

Physical and chemical tests on fruit were similar to those in Experiment 1 and they were carried out on two occasions during the 1974 cropping season and three times during the 1975 season. Leaf Ca, Mg and dry matter content were measured for plants from the different soil types in 1975. Leaf Ca, Mg and dry matter content were also measured in 1975 on strawberry plants (Cambridge Vigour) grown at Lullymore on peat and also from commercial plots of Cambridge Vigour grown on mineral soil at Kinsealy.

Drip tests were also carried out on a blast-frozen sample of Cambridge Vigour grown at Lullymore in 1975.

Experiment 6 (1976)

Six replicate samples of Cambridge Vigour strawberry fruit and leaves from commercial-scale plots on peat (Lullymore) and mineral (Kinsealy) soils were compared. The fruit, or leaves, for each replicate were picked from a separate row in the field. The leaves were tested for dry matter, Ca, Mg, N, P, K, B, Mo and Cu content and fruit for alcohol insoluble solids (AIS), Ca, Mg and pectin content. The pectin was fractionated by a modification of the method of Warren and Woodman (10) according to Kenny (11). The samples of fruit for the above tests were slow frozen and stored for about 2 weeks at -30°C before testing. Samples of fruit for drip tests were blast frozen.

A support factor was calculated for fruit from the six replicates according to the method of Jewell *et al* (12) by measuring the number of achenes/cm² on 10 berries from each replicate and dividing by the average berry diameter.

RESULTS

Experiments 2 and 3 (1972-73)

Drip loss: The results (Table 1) show that peat-grown strawberries gave a much higher drip loss on thawing than those from mineral soil. The results for the four individual cultivars in 1972 had a similar overall trend to the mean values with the difference being most pronounced for fruit of Gorella (35 vs 14%, $p < 0.05$) and least for that of Elista (28 vs 19%, $p < 0.05$). The grand mean drip values in 1972 were 38% for blast freezing and 19% for Freon freezing. In 1973 the results for the three cultivars tested were the same as in 1972 and Elista had a lower drip content ($p < 0.05$), when grown on mineral soil, than the other two cultivars.

TABLE 1: Drip loss^a (% v/w) for strawberries grown under field conditions in peat and mineral soil

Year	Freezing method	Drip (%)		F - test	SE
		Peat	Mineral		
1972	Freon - blast ^b	36	22	***	± 0.72
1973	Blast	43	31	**	± 1.30

^aAveraged over four cultivars in 1972 and three in 1973

^bMean figure of the two freezing methods

Chemical tests and fruit colour: The tests for puree colour and fruit composition in 1972 were carried out on unreplicated spot samples and the results were not analysed

statistically. However, when the data were averaged over the four cultivars there were small differences in fruit composition and colour with the values of 1.37 vs 1.23 meq/10 g for acidity, 6.8 vs 7.4% for soluble solids and Hunter L values of 29 vs 30 for puree colour, on peat and mineral soils respectively.

In 1973 fruit from peat soil was lower in soluble solids content and lighter in colour than that from mineral soil (Table 2). In the case of the individual cultivars Elista had the lowest ($p < 0.01$) soluble solids content (6.5%), Gorella had the lowest ($p < 0.01$) acidity (1.19 meq) while Cambridge Vigour had the lightest ($p < 0.01$) puree colour ($L = 37$).

TABLE 2: Chemical composition^a and puree colour for strawberries grown under field conditions in peat and mineral soil – 1973 data

Soil type	Soluble solids (%)	Acidity (meq/10 g puree)	Puree colour (Hunter L)
Peat	7.1	1.41	34
Mineral	9.0	1.45	30
F – test	***	NS	*
SE	± 0.11	± 0.02	± 0.63

^aAveraged over three cultivars

Experiments 4 and 5 (1974-75)

Drip loss: The results (Table 3) show that there was no significant difference in freezing performance, based on drip loss, for Cambridge Vigour strawberries grown in troughs containing peat, mineral or peat/mineral soil. The pattern of results was the same as in Table 3 when liquid nitrogen or slow freezing techniques were used and grand mean drip data (1974) for liquid nitrogen vs blast freezing were 27 and 40% and for liquid nitrogen and slow freezing, 27 and 60% respectively.

A sample of Cambridge Vigour strawberries grown in peat at Lullymore had a drip loss of 31% (blast frozen).

TABLE 3: Drip Loss (% v/w) for Cambridge Vigour strawberries grown in troughs containing peat, mineral and 1 : 1 peat : mineral soil

Year	Freezing method	Drip			F – test	SE
		Peat	Mineral	1 : 1 Peat : Mineral		
1974 ^a	Blast	36	43	43	NS	± 3.6
1975 ^b	Blast	27	27	26	NS	± 0.66

^aDrip time 5 hr

^bDrip time 6 hr

GORMLEY: FREEZING OF STRAWBERRIES

Chemical tests and fruit colour: There was no significant difference in soluble solids content and puree colour for fruit grown in the three soil types in 1974, with grand mean values of 7.1% and L = 34 respectively. Fruit from mineral soil had the lowest ($p < 0.05$) acidity, 1.18 meq, compared with a grand mean of 1.33 meq.

In 1975 the results were similar with no significant differences in pH of the puree, soluble solids, puree colour and shear press values for fruit from the three soil types. Grand mean values were pH 3.0, soluble solids 6.8%, Hunter L = 34 and shear value = 29 kg. Fruit grown in peat had the highest ($p < 0.05$) level of titrable acidity (1.37 meq) compared with a grand mean of 1.24 meq for the three soil treatments.

Leaf analysis: The results (Table 4) show that the trough-grown plants had higher levels of dry matter, Ca and Mg in the leaves than those grown in the field in either peat or mineral soil. Leaves from plants grown in peat in Lullymore had the lowest levels of these constituents.

TABLE 4: Dry matter, calcium and magnesium content of strawberry leaves of plants grown in different soil types and locations, 1975

Soil type	Location	Dry matter (%)	Ca ^a	Mg ^a
Peat (P)	Trough, Kinsealy	33.9	1.16	0.35
Mineral (M)	Trough, Kinsealy	36.3	0.96	0.35
1 : 1 (PM)	Trough, Kinsealy	34.9	0.96	0.35
Mineral	Field, Kinsealy	30.5	0.72	0.30
Peat	Field, Lullymore	27.2	0.54	0.22

^aExpressed as % of dry matter

Experiment 6 (1976)

The results (Table 5) show that leaves of strawberry plants grown in peat had a much lower dry matter content than those from mineral soil. Levels of the various mineral elements were almost similar for leaves from the two soil types and the range of values between the six replicates was generally small.

TABLE 5: Leaf analysis^a for strawberry plants grown under field conditions in peat and mineral soil, 1976

Soil type	Dry matter %	% of dry matter					ppm		
		Ca	P	K	Mg	N	B	Mo	Cu
Peat (Lullymore)	22.7	0.76	0.41	1.93	0.26	2.22	35	1.1	6.1
Range ^b	0.9	0.16	0.06	0.36	0.03	0.28	9	0.8	1.3
Mineral (Kinsealy)	35.1	0.83	0.24	1.36	0.32	2.40	35	0.4	6.3
Range ^b	2.3	0.12	0.01	0.19	0.03	0.40	8	0	1.8

^aMeans for six replications

^bIn Tables 5, 6 and 7, range is the difference between maximum and minimum values

The fruit differed to the greatest extent in drip loss (Table 6) and there were only fairly small differences in dry matter, alcohol insoluble solids, Ca and Mg contents between fruit from the two soil types. The pectin content of the fruit was also similar for the two soil types as was the degree of esterification (Table 7).

The support factor (achenes cm^{-2} divided by mean fruit diameter (cm)) for fruit from peat was 5.26 (values ranged from 4.60 to 6.16 over six replications) and for fruit from mineral soil 6.13 (values ranged from 5.11 to 7.41).

TABLE 6: Fruit analysis^a and drip test data for strawberry fruit grown under field conditions in peat and mineral soil, 1976

Soil type	Drip loss (% v/w)	Dry matter (%)	Alcohol insoluble solids (%)	Ca ^b	Mg ^b
Peat (Lullymore)	50	9.7	2.79	0.21	0.15
Range	4	0.4	0.53	0.09	0.02
Mineral (Kinsealy)	34	9.9	3.06	0.28	0.18
Range	6	1.3	0.58	0.03	0.00

^aMeans for six replications

^bExpressed as % of dry matter

TABLE 7: Pectin content^a of strawberry fruit grown under field conditions in peat and mineral soil, 1976

Soil type	% Pectin in AIS ^b	% Pectin in fruit ^b	Degree of esterification (%)
Peat (Lullymore)	21.55	0.59	76.4
Range	5.44	0.18	5.38
Mineral (Kinsealy)	21.81	0.67	77.3
Range	2.37	0.13	3.98

^aMeans for six replications

^bExpressed as anhydrouronic acid (%)

DISCUSSION

Freezing performance

The difference in freezing performance between strawberries grown under field conditions in peat and mineral soil was obtained in each season the experiment was carried out irrespective of the cultivar tested and the freezing method used.

Leaf analysis in 1976 did not show up any major plant nutritional differences which

might cause the difference in drip loss on thawing. The leaves, at time of fruiting in 1976, had adequate levels of nutrients for normal plant growth according to figures published by Bould (13) for strawberry plant leaves tested while the plant was fruiting. However, there was a large difference in the dry matter content of the leaves in 1976 between plants grown in peat and those grown in mineral soil and this could possibly give a plant with more juicy fruit. It could be argued, therefore, that the plants grown in peat had lower levels of nutrients than those from mineral soil, e.g., a lower content of the firming agent calcium — on a fresh weight basis, and that this could have resulted in a cell structure that would be more easily damaged during freezing.

Results of analysis on the fruit in 1976 did not fit in with these arguments. The dry matter content of peat-grown fruit was almost identical with that of the fruit grown in mineral soil, indicating that the former did not have a higher level of juice to 'drip out' during thawing. Calcium, Mg and alcohol insoluble solids contents were slightly higher in fruit from mineral soil in 1976, but the differences were such that they would not be expected to affect freezing performance. The pectin content of fruit from the two soil types was also practically similar and was within the range normally found in strawberries (14).

That the difference in freezing performance could not be reproduced in strawberries grown in troughs containing peat, mineral and 1:1 peat: mineral soil at Kinsealy is surprising. It had been hoped that if the effect on drip loss was due simply to the peat medium, then fruit from the peat/mineral soil should show a drip loss intermediate between that from peat and mineral soil. However, this was not the case. Failure to repeat the large drip losses found for fruit from Lullymore peat may have been due to a number of factors. The Kinsealy troughs were sheltered from the north by a hedge and were elevated 15 cm above the ground which would probably influence soil temperature; the climatic difference between Kinsealy and Lullymore could also have an effect.

It is difficult, therefore, to explain the poor freezing performance of the Lullymore peat-grown strawberries. It may be related to climatic conditions prevailing at Lullymore which are very suitable for rapid vegetative growth in spring, and summer when fruit is ripening. Factors aiding rapid vegetative growth include abundant moisture due to the depth of peat, high air temperature in May, June and July and the possibility of raised CO₂ levels due to the decomposition of peat. This could result in a 'looser' cell structure in the fruit. Histological examination under a light microscope did not show up any differences in cell structure between the peat and mineral strawberries, but perhaps more powerful resolution would be required to show up differences.

Jewell *et al* (12) have shown a relationship between fruit achene number per cm² and berry breakdown after making into jam. They used the term 'support factor' for the ratio of achenes cm⁻² divided by the average fruit diameter, and the higher the support factor, the less the fruit breakdown on making into jam. They found that the vascular strands attached to each achene maintained their structural integrity during jam making. Possibly the same principle could apply in the case of freezing and it is interesting to note that in 1976 fruit from mineral soil had a higher support factor than that from peat.

However, it should be noted that achene number can be related to other factors such as fruit size (15) and so the support factor theory must be applied with caution.

Soluble solids, acidity and fruit colour

The soluble solids content and puree colour of strawberries grown in Lullymore peat was lower and lighter, respectively in 1973, than that from fruit grown in mineral soil. This agrees with previous work on tomatoes where soluble solids content was lower on peat (16). The colour of carrots grown in peat was also lighter than those from mineral soil (17).

In 1972, spot samples were tested and a difference was found in soluble solids content only, whereas in 1971 the only difference between Lullymore peat-grown fruit and fruit grown in mineral soil was a lower pH for the latter (8). Fruit acidities were different for plants grown in troughs in peat, mineral and peat/mineral soils but there were no differences in soluble solids, puree pH, or colour. These combined data over a number of seasons suggest that peat soil may influence these aspects of fruit composition in certain seasons, and under certain conditions, but that the effect is by no means consistent.

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