Grower Summary

TF 213

Extend the marketing period of Gala apples. Phase I: Establishing analytical methods to assess flavour.

Final 2014

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Further information

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GROWER SUMMARY

Headlines

- Gala storage in 5% CO_2 and 1% Oxygen (5/1) with or without SmartFresh^{TM} was better for extending the storage quality of fruits over fruits stored in 1% O_2 with or without SmartFresh^{TM}.
- Orchards producing Gala with high dry matter content (16 % DM) maintained their texture and overall taste panel acceptability for longer during extended storage.

Background and expected deliverables

UK production of Gala is expected to increase by 40% over the next four years. To provide a market for this fruit there is a need to extend the marketing period of UK Gala into April/ May. The challenge facing growers storing Gala beyond late March/early April is to compete with new season imports from the Southern hemisphere which are perceived to have superior quality at this stage of the season.

For Gala a number of storage regimes are currently being used; a regime of <1% CO_2, 1% O_2 at 0.5°C will allow storage up to February. Extending storage into March or early April requires the use of 5% CO_2, 1% O_2 at 1.5°C to prevent the development of scald and loss of firmness during shelf-life. There have been several reports indicating that after long-term controlled atmosphere (CA) storage, Gala apples have less flavour, relating to a decrease in flavour volatiles. Low oxygen concentrations and high carbon dioxide concentrations both contribute to this effect. Work funded by APRC (Stow and Genge, 2000) looking at storage in a range of CO_2 (0, 2.5 and 5% CO_2) and O_2 (1, 1.5 and 2%) conditions, reported that flavour production in general declined after 110 days of storage, and that where CO_2 was present in the atmosphere, flavour volatile production was suppressed. The highest flavour production was reported at the highest oxygen concentration tested (2%).

Given the advent of alternative strategies to control scald and reduce softening, such as SmartFresh^{TM}, ethylene scrubbing and ultra-low oxygen storage such as used with dynamic controlled atmosphere (DCA) technologies, the need to incorporate 5% CO_2 in the storage atmosphere may be less important for longer term storage. It is vital for UK growers to define the best storage regimes for long-term storage of Gala where flavour production can be maintained for longer.

There have been many studies to identify volatiles in terms of their contribution to apple flavour. Methods for volatile capture by Solid Phase Micro extraction (SPME), or Thermal

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Desorption techniques followed by analysis using Gas Chromatograph with Mass spectroscopy (GC-MS), are currently under further investigation at NRI.

A number of studies have charted the fall in volatile production during CA and air storage, and, as mentioned above, it is well documented that CA storage suppresses production of flavour production with time. However, some studies (Stow and Genge, 2000; Plotto *et al.,* 1999) have found a poor correlation between ester flavour volatile decline and taste panel assessments of good eating quality, which suggests other attributes such as sweetness and acidity and texture (crispness) are also essential for the overall sensory perception of fruit quality. This underlines the importance of including the full range of characteristics in any assessment of eating quality of flavour

This project seeks to define a practical protocol for assessing Gala flavour in terms of volatiles and flesh composition that can be used to optimise pre and post-harvest practices to maintain flavour, as well as identifying key orchards with fruit suitable for long-term storage. Moreover, a preliminary study is being undertaken on the effects of picking date, storage regime and SmartFresh™ application on flavour retention of long-term stored fruit.

In addition to HDC funds, co-funding from this project has been kindly provided by Norman Collett, World Wide Fruit, A.C. Goatham and Son, Chingford and Mansfields. Further funding by AgroFresh allowed an investigation of the role of SmartFresh™ on eating quality of fruit stored under alternative CA regimes.

Summary of the project and main conclusions

Gala clones from 6 orchards (A-F) on two picking dates were used. The harvest quality is summarised in Tables 1 and 2.

Table 1 Harvest quality of Gala apples picked from six orchards on two picking dates. Each data point is the mean of measurements on two samples of 10 fruit.

Orchard	Pick 1			Pick 2		
	Firmness (N)	% Brix	CTIFL Starch score	Firmness (N)	% Brix	CTIFL Starch score
A	91.84	10.6	2.8	n.d.	11.4	3.6
B	93.10	10.4	1.6	92.00	11.6	4.6
C	89.30	10.4	1.6	90.76	11.6	4.7
D	103.02	12.0	1.4	98.42	11.8	3.9
E	98.35	10.8	1.4	97.08	12.1	4.0
F	84.67	11.4	3.4	n.d.	11.5	4.1

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Table 2 Dry matter (%) content, respiration rate (ml CO_2/kg/h), internal ethylene concentration (ppb) of Gala sourced from 6 orchards over two picking dates

Orchard	Pick 1			Pick 2		
	% Dry Matter	Resp rate	I.E.C. (ppb)	% Dry Matter	Resp rate	I.E.C (ppb)
A	13.7	1.21	129.3	15.2	1.17	777.1
B	14.0	1.16	82.3	14.8	1.48	103.1
C	16.8	1.31	78.6	15.5	1.59	576.8
D	16.5	1.22	372.2	15.9	1.14	824.4
E	14.4	1.32	345.0	14.7	1.53	792.9
F	13.6	1.20	58.6	13.5	1.54	807.4

Apples from orchards with a higher dry matter content at harvest tended to have higher soluble solids content at harvest, which resulted in fruit with a higher % Brix (15.5-16.0%) during the storage season.

Fruit with a higher DM content produced fruit that had higher fruit firmness as measured by penetrometer and by sensory evaluation.

The combination of higher fruit firmness and high % Brix, had a large contribution towards raising the overall acceptability of Pick 1 fruit tasted in April, but the relationship weakened in fruit tasted in June and with later picked fruit.

The fruit was stored under a range of CA regimes (summarised in Tables 3 and 4) and assessed in April and in June.

The influence of CA regimes depended on the time of the year fruit was tasted.

Table 3 summarises the overall acceptability of fruit assessed in April after six months of storage. The assessments were carried out by experienced Gala growers/marketers.

In April, the two orchards where fruits were high in % Brix and dry matter content (C and D), scored particularly highly following storage in 5%CO_2, 1% O_2 (5/1) at 1.5°C and picked at 80% starch with no SF-treatment. Storage in 3% CO2 and 2% O2 led to the highest overall acceptability score but when compared to overall acceptability scores in some orchard consignments however, when averaged across all six orchards, there was no statistical difference in the 5%CO_2, 1% O_2 regime with the other regimes tested.

Comparison of storage treatments confirm earlier observations that storing fruit in the absence of CO_2 leads to poorer fruit texture compared to fruit stored in 5% CO2.

Firmness of fruit was higher when kept in 5/1 CA stored at 0.5°C (HDC 4) compared to fruit stored in 1.0% O_2 <1% CO_2 (HDC 7) In April the effect of SF on firmness was not observed in Pick 1 fruit (80% Starch) but improved firmness retention in later picked fruit (60% Starch).

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Table 3 Overall acceptability of Gala apples in April following storage under a range of storage treatments followed by 3 days at 15°C and 2 days at ambient. Fruit were picked from 6 orchards on two picking dates. Each data point is the mean of assessments by 7 tasters.

PICK 1	Storage atmos	Temp	Harvest maturity (% starch)	SF?	Orch A	Orch B	Orch C	Orch D	Orch E	Orch F	Mean
AG 1	3%CO_2, 2%O_2	0.5°C	80%	+SF	5.75	5.75	6.00	6.50	6.38	6.63	6.17
AG 2	1.5%CO_2, 1.5%O_2	0.5°C	80%	+SF	6.38	5.38	6.50	5.88	5.88	5.63	5.94
AG 3	<1%CO_2, 1.2 %O_2	0.5°C	80%	+SF	5.71	5.75	6.00	6.38	5.75	5.88	5.91
AG 4	3%CO_2, 2%O_2 with conditioning	0.5°C	80%	+SF	6.83	5.86	5.00	6.86	5.43	5.50	5.91
HDC 1	5%CO_2, 1%O_2	1.5°C	80%	+SF	5.57	5.13	6.25	6.25	6.00	5.00	5.70
HDC 2	5%CO_2, 1%O_2	1.5°C	80%	-SF	5.43	5.50	7.25	7.25	4.63	4.86	5.82
HDC 3	5%CO_2, 1%O_2	0.5°C	80%	+SF	6.00	5.63	5.63	5.44	6.00	6.31	5.83
HDC 4	5%CO_2, 1%O_2	0.5°C	80%	-SF	6.38	5.86	6.63	5.13	6.75	5.00	5.96
HDC 5	<1%CO_2, 1.0 %O_2	0.5°C	80%	+SF	5.00	4.13	6.14	5.75	6.06	5.25	5.39
HDC 7	<1%CO_2, 1.0 %O_2	0.5°C	80%	-SF	4.69	6.13	5.00	6.25	4.98	4.38	5.24
mean					**5.77**	**5.51**	**6.04**	**6.17**	**5.78**	**5.44**	

PICK 2					Orch A	Orch B	Orch C	Orch D	Orch E	Orch F	Mean
AG 1	3%CO_2, 2%O_2	0.5°C	60%	+SF	6	6.75	5.25	7	6.25	4.71	5.99
AG 2	1.5%CO_2, 1.5%O_2	0.5°C	60%	+SF	6	5.43	5.88	5.48	6.13	4.38	5.55
AG3	<1%CO_2, 1.2 %O_2	0.5°C	60%	+SF	6.25	5.13	4.43	6.75	5.88	5.68	5.68
AG4	3%CO_2, 2%O_2 with conditioning	0.5°C	60%	+SF	5.07	5.29	6.21	6.43	6.14	6.9	6.01
HDC 6	<1%CO_2, 1.0 %O_2	0.5°C	60%	+SF	6.04	6.38	5.75	4.88	6.25	5.75	5.84
HDC 8	<1%CO_2, 1.0 %O_2	0.5°C	60%	-SF	5.14	5	3.75	4.75	5.44	5.75	4.97
mean					**5.75**	**5.66**	**5.21**	**5.88**	**6.01**	**5.53**	

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Table 4 Overall acceptability of Gala apples in June following storage under a range of storage treatments followed by 3 days at 15°C and 2 days at ambient. Fruit were picked from 6 orchards on two picking dates. Each data point is the mean of assessments by 7 tasters. An ANOVA was carried out for HDC and AG treatments separately.

	Storage atmosphere	Temp	Harvest maturity (% starch)	SF?	Orch A	Orch B	Orch C	Orch D	Orch E	Orch F	mean
AG 1	3%CO_2, 2%O_2	0.5°C	80%	+SF	5.50	5.25	5.63	6.50	6.00	5.81	5.78
AG 2	1.5%CO_2, 1.5%O_2	0.5°C	80%	+SF	6.13	4.61	5.57	5.43	6.29	5.71	5.62
AG 3	<1%CO_2, 1.2 %O_2	0.5°C	80%	+SF	5.29	6.00	6.43	5.64	6.25	4.88	5.75
AG 4	3%CO_2, 2%O_2 with conditioning	0.5°C	80%	+SF	5.57	5.36	6.29	5.00	5.78	4.86	5.47
HDC 1	5%CO_2, 1%O_2	1.5°C	80%	+SF	5.56	5.79	5.71	5.38	6.00	6.25	5.78
HDC 2	5%CO_2, 1%O_2	1.5°C	80%	-SF	5.71	5.38	6.43	4.29	4.88	5.63	5.38
HDC 3	5%CO_2, 1%O_2	0.5°C	80%	+SF	5.83	5.75	5.94	6.22	5.71	6.81	6.04
HDC 4	5%CO_2, 1%O_2	0.5°C	80%	-SF	5.63	4.63	5.50	5.79	5.38	4.63	5.26
HDC 5	<1%CO_2, 1.0 %O_2	0.5°C	80%	+SF	6.00	5.63	5.69	5.71	5.06	6.00	5.68
HDC 7	<1%CO_2, 1.0 %O_2	0.5°C	80%	-SF	4.17	4.44	4.00	4.29	5.63	4.88	4.56
mean					**5.54**	**5.28**	**5.72**	**5.42**	**5.70**	**5.54**	

					Orch A	Orch B	Orch C	Orch D	Orch E	Orch F	**mean**
AG 1	3%CO_2, 2%O_2	0.5°C	60%	+SF	6.25	5.50	5.00	6.00	6.50	5.63	**5.81**
AG 2	1.5%CO_2, 1.5%O_2	0.5°C	60%	+SF	6.25	5.75	5.57	6.00	5.29	5.38	**5.71**
AG 3	<1%CO_2, 1.2 %O_2	0.5°C	60%	+SF	4.86	4.29	4.36	6.00	5.14	4.63	**4.88**
AG 4	3%CO_2, 2%O_2 with conditioning	0.5°C	60%	+SF	5.83	6.06	4.25	6.13	5.00	4.60	**5.31**
HDC 6	<1%CO_2, 1.0 %O_2	0.5°C	60%	+SF	5.86	6.50	5.29	6.31	5.71	4.44	**5.69**
HDC 8	<1%CO_2, 1.0 %O_2	0.5°C	60%	-SF	3.86	3.33	4.57	4.57	3.75	4.75	**4.14**
mean					**5.48**	**5.24**	**4.84**	**5.83**	**5.23**	**4.90**	

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In June the overall acceptability scores of fruit had dropped slightly from the April assessment. Moreover, differences in overall acceptability between orchards were lower than in the April assessment. Averaged across all treatments, orchard C and E scored slightly better overall acceptability than the other orchards.

The highest scoring regime was 5/1 picked at 80% starch + SmartFresh^{TM}. However, in comparison with other 5/1 treatments, no significant effects between treatments were observed.

When averaged across all orchards the effect of modifying CO_2 or O_2 (AG-treatments) on overall acceptability was similar to storing fruit in 5/1. However, there was a strong orchard interaction with CA regimes and in orchards that had higher dry matter content 3% CO_2, 2% O_2 and 1.5% CO_2, 1.5% O_2 led to fruit with good overall acceptability. Interestingly storing Pick 1 fruit (80% starch) in 1% O_2 with SF provided fruit of equal acceptability,

No effect of storage temperature was seen on fruit firmness when Gala was stored in 5/1 (8.7-9.0 kg). Application of SF led to a small increase in firmness retention (9.2-9.3 kg) kg).In later Pick 2 fruit (60% starch) SF significantly improved firmness retention (8.8 kg) compared to untreated Gala (6.1 kg) stored in 1% O_2, <1% CO_2.

Fruit firmness of Gala stored until June was strongly influenced by the dry matter content of fruit. Orchards C, D, and F retained better fruit firmness during long-term storage. Picking fruit at 80% starch helped to retain fruit firmness.

Conclusions

- There was found to be a strong influence of orchard on the eating quality of long-term stored Gala.
- High dry matter content in Gala led to fruit with increased % Brix content and better firmness retention during storage.
- Fruit with higher % Brix and firmness were generally considered to have better overall acceptability.
- Untreated Gala at 85-80% starch background provided fruit with a better eating quality than later picked fruit in long-term storage.
- Later picked fruit (60 % starch) from some orchards treated with SmartFresh^{TM} were able to retain acceptable firmness and eating quality in April and June.
- Storing Gala in 5% CO_2, 1% O_2 either at 0.5 or 1.5°C, retained similar eating quality in April and June.

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- Gala stored in 1% Oxygen with SmartFresh^{TM} were in general of similar eating quality to 5/1 stored fruit.
- Alternative storage regime of 3% CO_2 and 1% O_2 and 1.5% CO_2 and 1.5% O_2 treated with SmartFresh^{TM} provided fruit of good eating quality in April and June.

Financial benefits

The results presented in this report were obtained from a single season, and therefore need to be validated before financial benefits can be estimated.

Action points for growers

The results presented in this report were obtained from a single season, and therefore need to be validated before action points can be provided.

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