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Project number:	TF 109 [Previously APRC SP 109]
Report:	Final report, July 1999
Project leader:	Professor H MacFie, Institute of Food Research

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Changes in the sensory properties and consumer preferences for dessert apples

July 1999

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Contents

1 – Executive summary

This study was a continuation of a larger project funded by the European Community and the Apples and Pear Research Council. The project, entitled 'Understanding apple buying and preference patterns throughout the season' comprised of three trials. The present study was a two-month extension of the first trial; 'Changes in the sensory properties and consumer preferences for dessert apples'.

The original project gave a detailed study of the sensory properties and consumer preferences of dessert apples each month from August to January. The present study carried testing on into February and March.

Sensory data indicated some very clear trends throughout the season, particularly for the texture attributes. There were some very large sensory changes in the Cox, whereas the Royal Gala appeared relatively constant in that regard. The preference data over the eight months showed evidence of segmentation with some consumers preferring a sweet apple and others preferring an acidic apple. There appeared not to be a systematic shift in preference; differences over the months are more likely due to differences in the range of varieties available.

2 - Project background

This study was a continuation of a larger project funded by the European Community and the Apples and Pear Research Council. The project, entitled 'Understanding apple buying and preference patterns throughout the season' comprised of three trials. The present study was a two-month extension of the first trial; 'Changes in the sensory properties and consumer preferences for dessert apples'.

The original project gave a detailed study of the sensory properties and consumer preferences of dessert apples each month from August to January. The present study carried testing on into February and March.

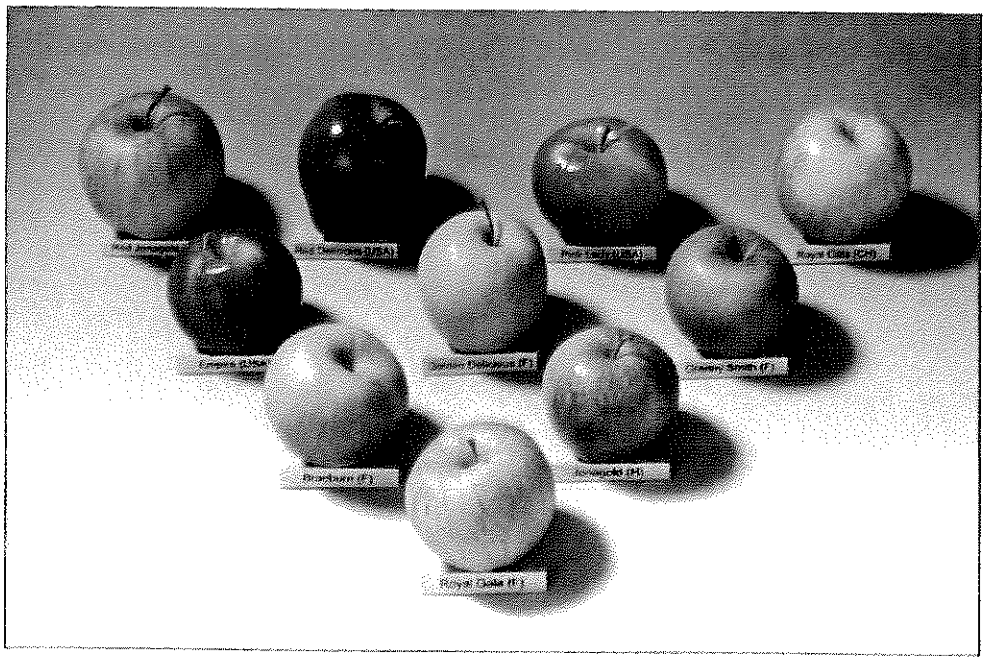
The objective of the trial was to:

- Measure changes for important sensory attributes throughout the season and identify gaps in the market.

To meet the objective a trained sensory panel profiled the apples each month. At the same time a consumer preference trial was conducted. A technique called preference mapping was used to combine the sensory and consumer data.

Figure 1

Study Seven – February



Red Jonagold
England

Red Delicious
USA

Pink Lady
USA

Royal Gala
Chile

Empire
USA

Golden Delicious
France

Granny Smith
France

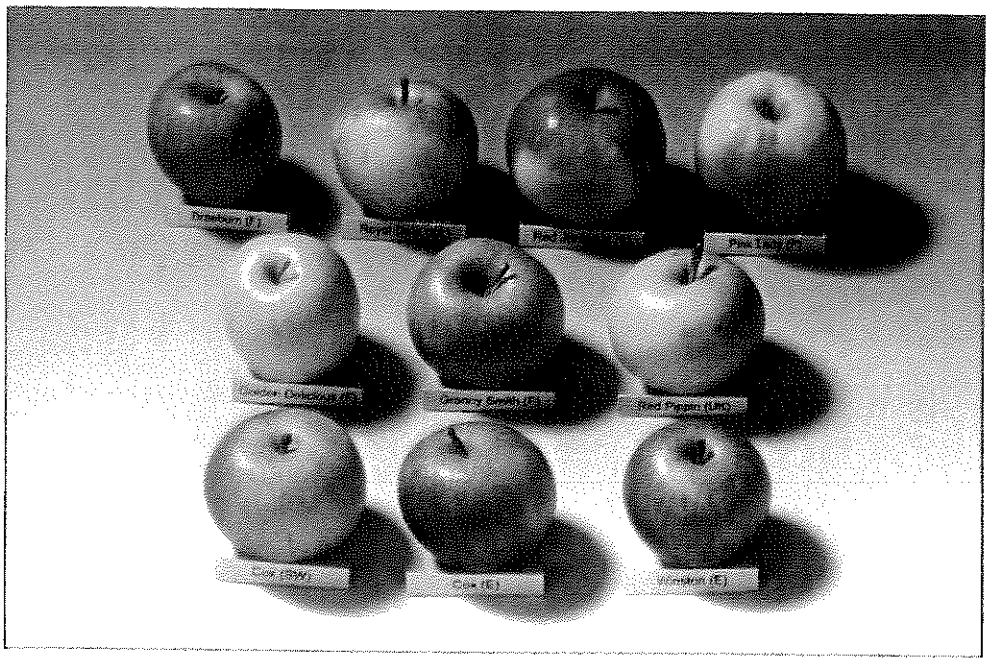
Braeburn
France

Jonagold
Holland

Royal Gala
France

Figure 2

Study Eight – March



Braeburn
France

Royal Gala
South Africa

Red Jonagold
England

Pink Lady
France

Golden Delicious
France

Granny Smith
France

Red Pippin
England

Cox
Switzerland

Cox
England

Winston
England

3 - Changes in the sensory properties of dessert apples

3.1 - Introduction

The methodology used for the extra two months was identical to that used previously. For the sake of completeness it will be outlined again here.

The use of sensory descriptive profiling for characterising the sensory properties of food products is now well established. With well-trained panellists who have been especially selected for their sensory acuity, highly reproducible results that characterise very small differences in perception can be accurately measured.

The methodology proceeds by first establishing a vocabulary of words, or descriptors or sensory attributes as they are variously called, on a training set of samples that are selected to show as wide a variation as possible. The descriptors are all selected to describe an objective sensory perception, not a liking attribute. As far as possible the end labels for the line scales used to score the intensity of the sensory attribute are either "Nil" or "Extreme" but this is not true in all cases. The panellists agree the definitions for the words and practice sensory profiling until they feel content with the definitions.

In the case of this study, all sensory assessments were carried out by the Sensory Panel run at Sensory Dimensions, Reading. This panel has performed a large number of sensory trials on dessert apples previously for the Institute of Food Research for a range of 12 varieties of apples originating from the Southern Hemisphere (Daillant Spinnler et. al., 1996[1]) available in June, and 12 varieties of Northern Hemisphere apples available in November.

3.2 - Materials and methods

3.2.1 - Samples

The apples used for February and March 1999 are shown, with their country of origin, in Figures 1 and 2 respectively. A selection of apples available on the market at the time of each study were provided by Sainsbury's. They were stored at 3^0C until 12 hours before testing, when they were removed from storage and allowed to reach ambient temperature ready for tasting. Prior to tasting any labels were removed and the apples were washed in cold water and dried. Each apple was assigned a three-digit numeric code. Unless otherwise stated in the report, 'Cox' refers to Queen Cox.

3.2.2 - Sensory testing

Sensory testing was carried out by Sensory Dimensions, Reading University Innovation Centre, Reading and took place in the same week as the consumer testing. A trained

[1] *Daillant-Spinnler, B., MacFie, H., Beyts, P. and Hedderley, D. 1996 Relationships between perceived sensory properties and major preference directions of 12 varieties of apples from the southern hemisphere. Food Quality and Preference 7, 113-126.*

sensory panel of between 10-12 panellists tasted the apples and scored them for appearance, flavour and texture attributes (see Appendix 1 for an example list of attributes along with their descriptions).

For each study panellists attended a discussion session to taste the apples and agree on the attributes to use. In the discussion session they tasted a quarter of each apple. This was followed by three repeated tastings of the apples in three separate sessions. Panellists received half an apple for the tasting and the order that the apples were presented was balanced to minimise positional and carry over effects. The external appearance of the apple was scored first, followed by the external odour, first bite texture, texture during chewing, flavour during chewing, afterswallow, internal appearance and finally internal odour. In between each apple panellists took a sip of water and ate a piece of cracker to cleanse their palates.

3.2.3 - Data analysis

Two-way Analysis of variance with interaction was applied to each attribute separately. This enabled the significance of the samples and any interaction between panellists and samples to be tested. These results were used to select the key sensory attributes.

3.3 - Results of sensory testing

3.3.1 – Selection of key sensory attributes

A key attribute was defined as one which was scored consistently by the majority of the assessors and appears to vary significantly between the samples in the trial. In this case it may vary between varieties or through the season. The key attributes selected are listed in Table 1 and are organised in a logical order for future reference.

Table 1. Key sensory attributes selected.

External appearance	**External odour**	**First bite texture**	**Texture (during chewing)**
Yellow background Green background Red Streaks Shiny White/Yellow Specks Feels hard Size	Sweet Fresh	Skin Toughness Juiciness Hardness	Crispness Juiciness Skin Separation Density of Flesh Toughness Skin Bits
Flavour (during chewing)	**Afterswallow**	**Internal appearance**	**Internal odour**
Green Apple Red Apple Sweet Acid/Sour	Peel (in Mouth) Astringent	White Yellow Green Lines Juicy Fluffy	Grassy

3.3.2 – Changes during the season

For each of the key sensory attributes shown in Table 1, two graphs have been produced; one, presented on the left side, tracks the progress of varieties that were

sampled repeatedly throughout the season; the other, presented on the right side, shows the scores of varieties that were sampled only once or twice, organised by increasing score within a month. results from the previous six months have also been included, so that changes over the season can easily be seen. These are shown in Figures 3 to 33. Much information can be obtained by simple inspection of these figures; however the main conclusions will be reported separately for each of the main varieties.

Cox

- The yellow background in the Cox increased sharply and then declined from October. Red streaks increased from November to January and then decreased. There was a constant decrease in the look and feel of hardness, and the size.
- Apart from the October sample there was a slight downward trend in fresh odour.
- First bite skin toughness decreased sharply from September to October but not afterwards. There was a very persistent decline in first bite juiciness throughout season.
- Crisp texture, density of flesh and toughness decreased sharply, to rise again in March, but juiciness and skin separation decreased persistently.
- A persistent decrease in perceived green apple flavour was matched by a steady increase in red apple flavour. There was a very steep decline in perceived acidity/sourness.
- A sharp decrease in grassy internal odour after September was observed.
- The astringent note on afterswallow was very high in September.
- The amount of peel left in the mouth varied from month to month, but showed an overall downward trend throughout the season.
- The internal appearance became much more yellow, and much less white after September. There was a persistent decline in the number of green lines and in juiciness appearance, with the latter reaching a very low score in March. Fluffiness of flesh increased throughout the season.

Braeburn

- There was no consistent change in colour, but Braeburn did look and feel less hard as the season progresses. Most noticeable was a consistent decrease in shiny appearance.
- Perceived fresh odour declined.
- With the exception of the GB sample in November, there was a persistent decline in first bite skin toughness and, to a lesser extent first bite hardness.
- All texture parameters declined slightly, except for skin separation which declined sharply between November and February.
- There was a persistent decline in sweet flavour throughout the season, and some evidence of a rise in green apple flavour and acid/sour from November to January.
- The grassy internal odour reduced sharply in February and March.
- The astringent afterswallow note increased to a peak with the GB sample in November and then declined steadily.
- The flesh appeared more white and less yellow as the season progressed.

Royal Gala

- The yellow background decreased to January and then increased; the incidence of red streaks behaved oppositely. There was a decline in white and yellow specks after January.
- Fresh and sweet odour perception declined throughout the season.
- There was a slight drop in first bite juiciness after November.

- This variety showed relatively little change in perceived texture in the mouth throughout the season.
- The GB sample in November appeared to be more yellow than the other samples.

Golden Delicious

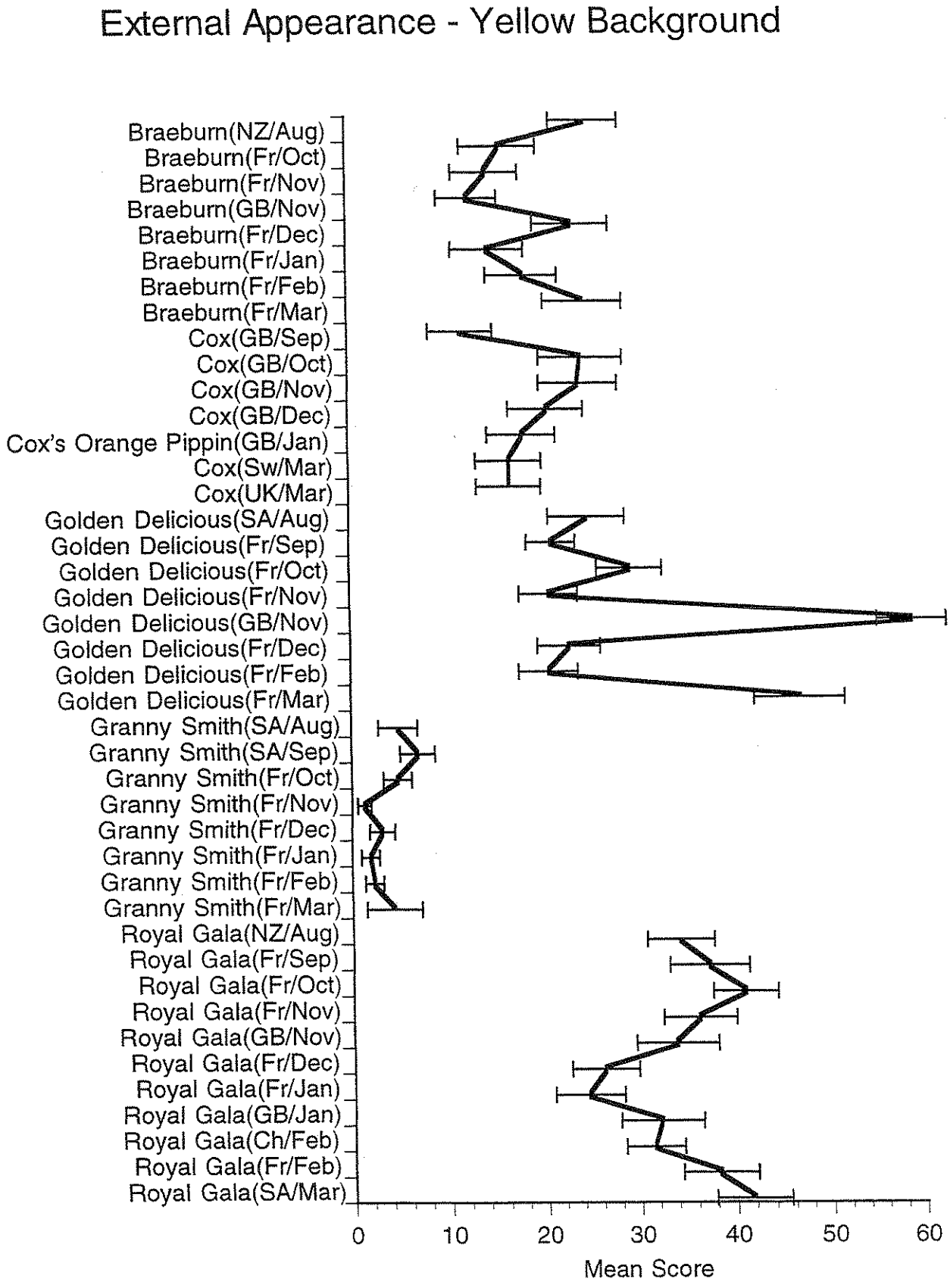
- The sample from GB was much more yellow and less green than the French samples. It was also larger. There was a consistent decline in the look and feel of hardness throughout the season. Apart from the October sample there was a downward trend in fresh odour.
- With the exception of the December sample, there was a reduction in first bite hardness and skin toughness after September, and a slight downward trend in first bite juiciness.
- There was a sharp reduction in crisp texture and toughness after September.
- The amount of peel left in the mouth declined slightly throughout the season.
- Juiciness appearance declined slightly through the season. Fluffiness of flesh increased to a high level in December and then dropped away sharply.

Granny Smith

- There was an upward trend in appearance of white and yellow specks, apart from January. There was a slight downward trend in shiny appearance and the feel, but not look of hardness. The apples appeared smaller as the season progresses.
- There was a noticeable downward trend in fresh odour, first bite skin toughness, and juiciness.
- There was a steady decline in all texture attributes throughout the season.
- The high, relative to other varieties, afterswallow note increased until November and then decreased in March. The amount of peel left in the mouth decreased steadily from December.
- There was a slight decrease in apparent juiciness of the flesh through the season.

Overall the data indicates some very clear trends throughout the season, particularly for the texture attributes. There were some very large changes in the Cox, whereas the Royal Gala appeared relatively constant in that regard.

Figure 3


External Appearance - Yellow Background
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

External Appearance - Yellow Background

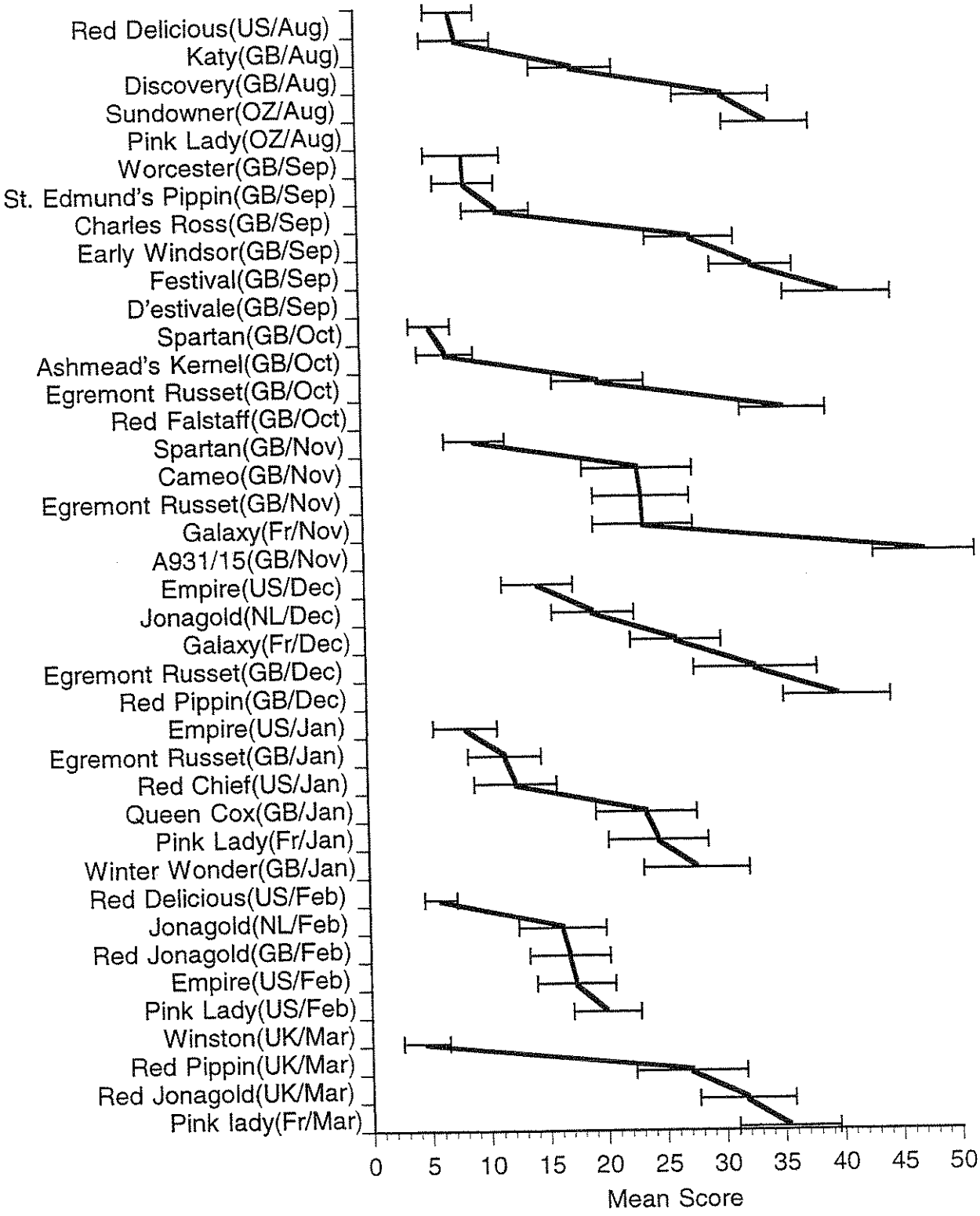
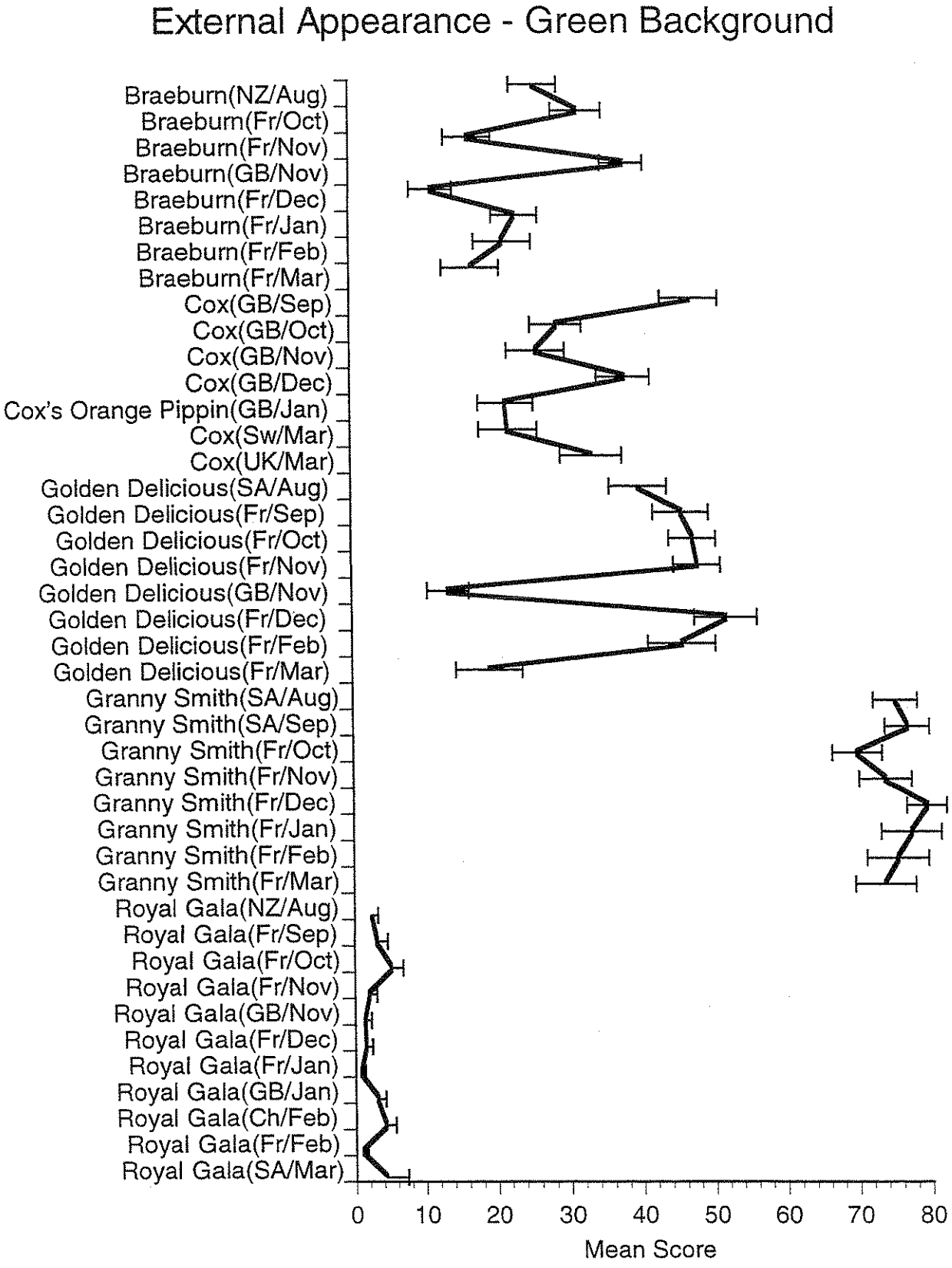


Figure 4


External Appearance - Green Background
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Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
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Royal Gala(Fr/Sep)
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Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
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10
20
30
40
50
60
70
80
Mean Score

External Appearance - Green Background

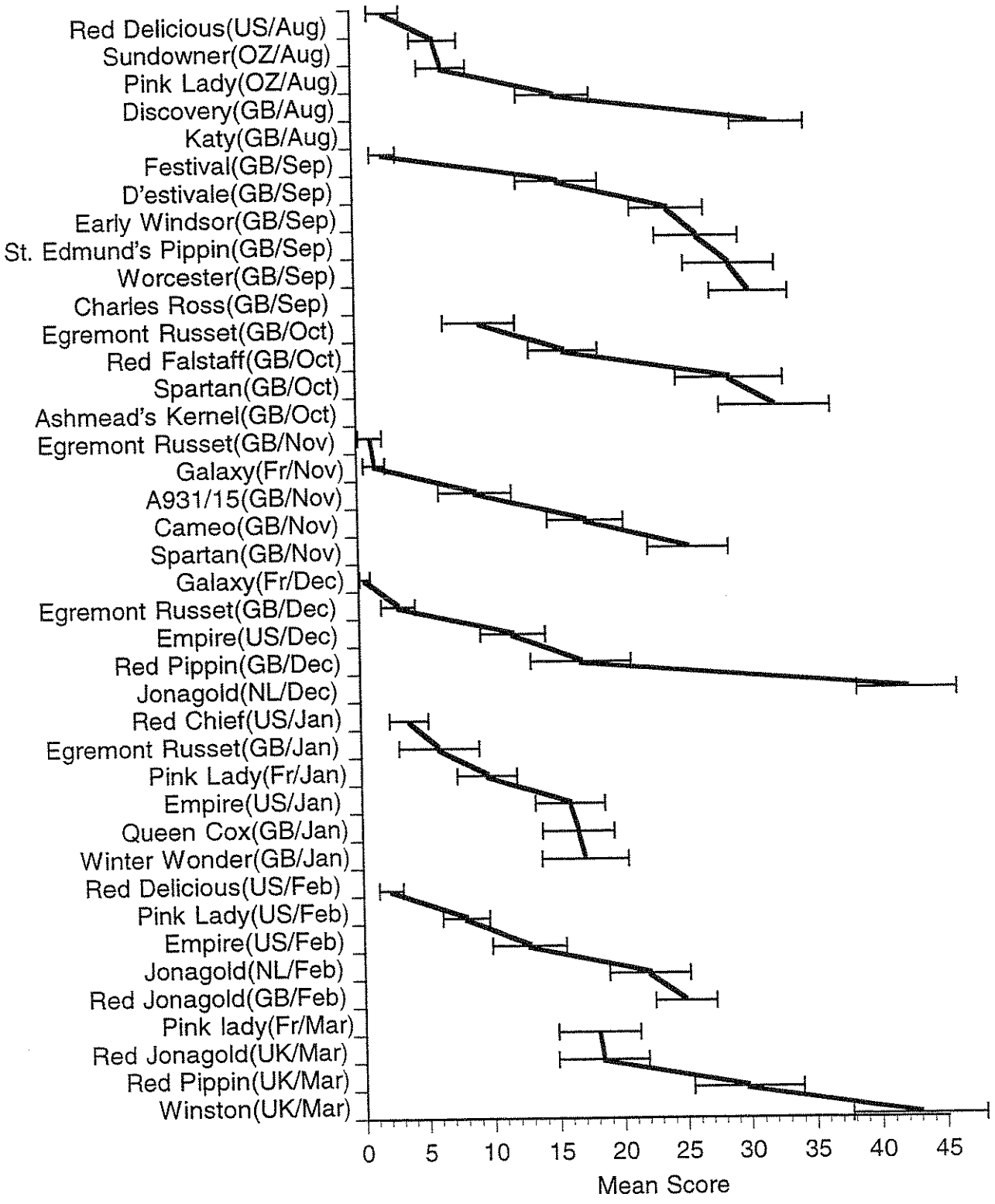
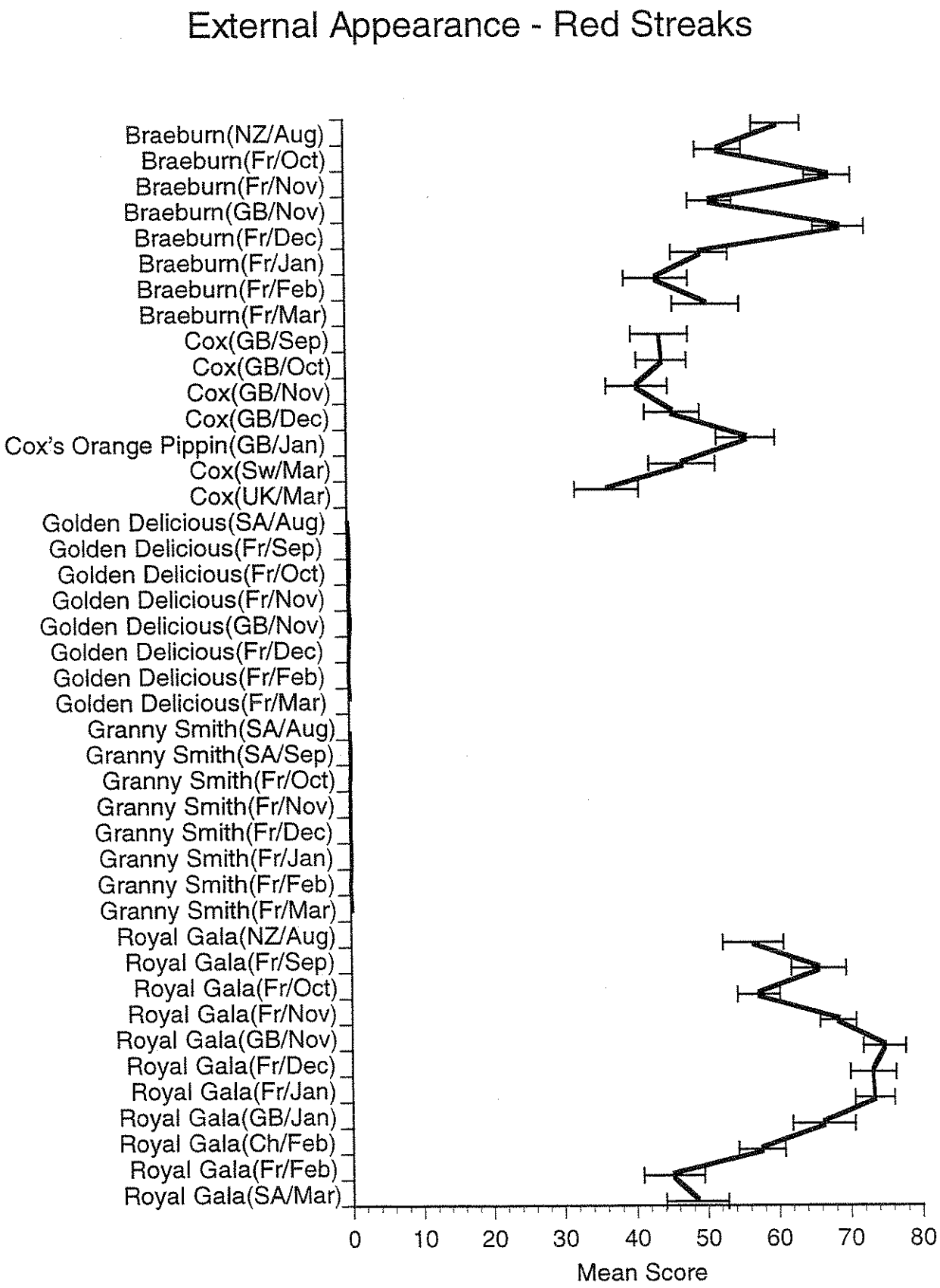


Figure 5


External Appearance - Red Streaks
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
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Cox(UK/Mar)
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Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
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Golden Delicious(Fr/Mar)
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Granny Smith(SA/Sep)
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Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
Mean Score

External Appearance - Red Streaks

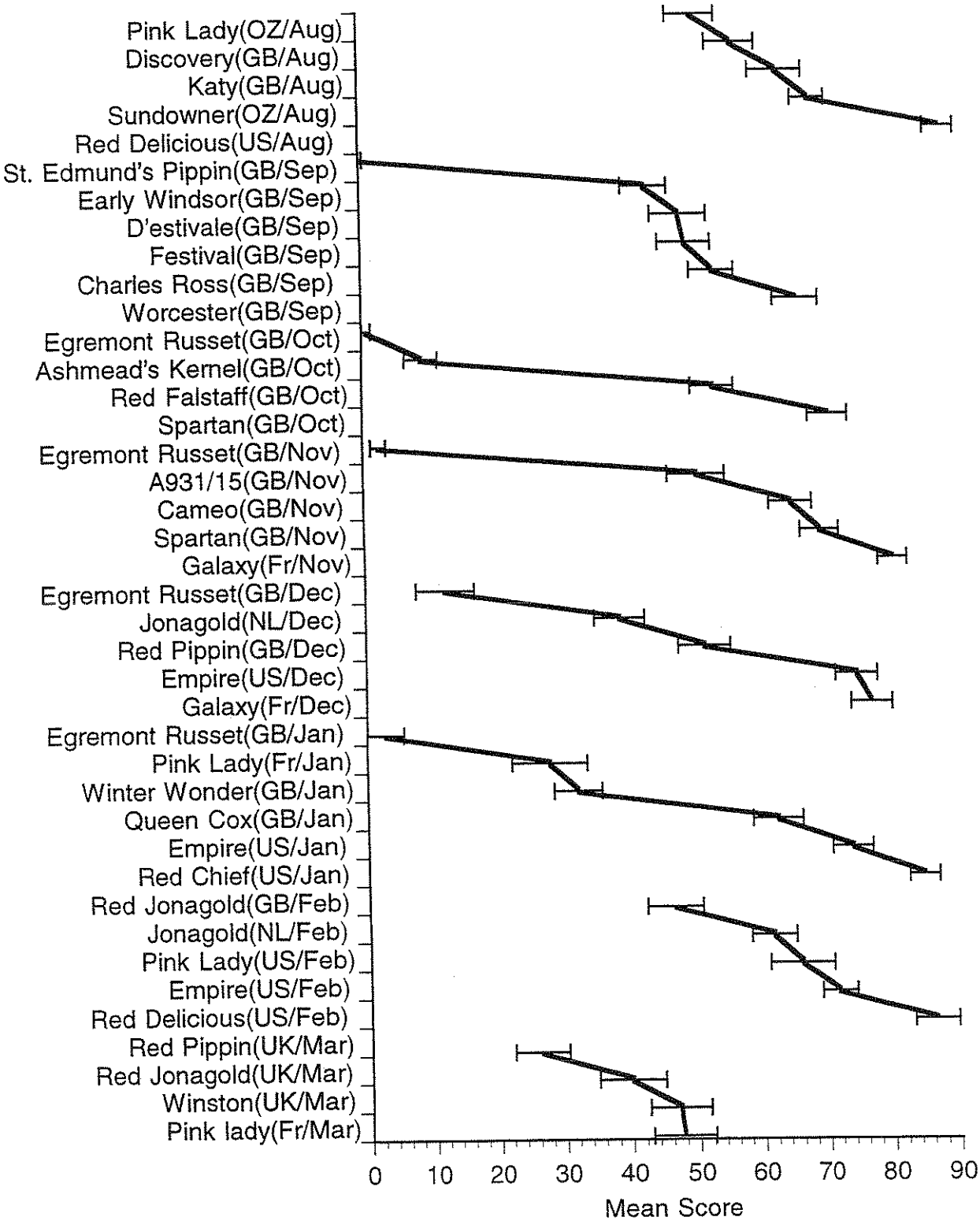
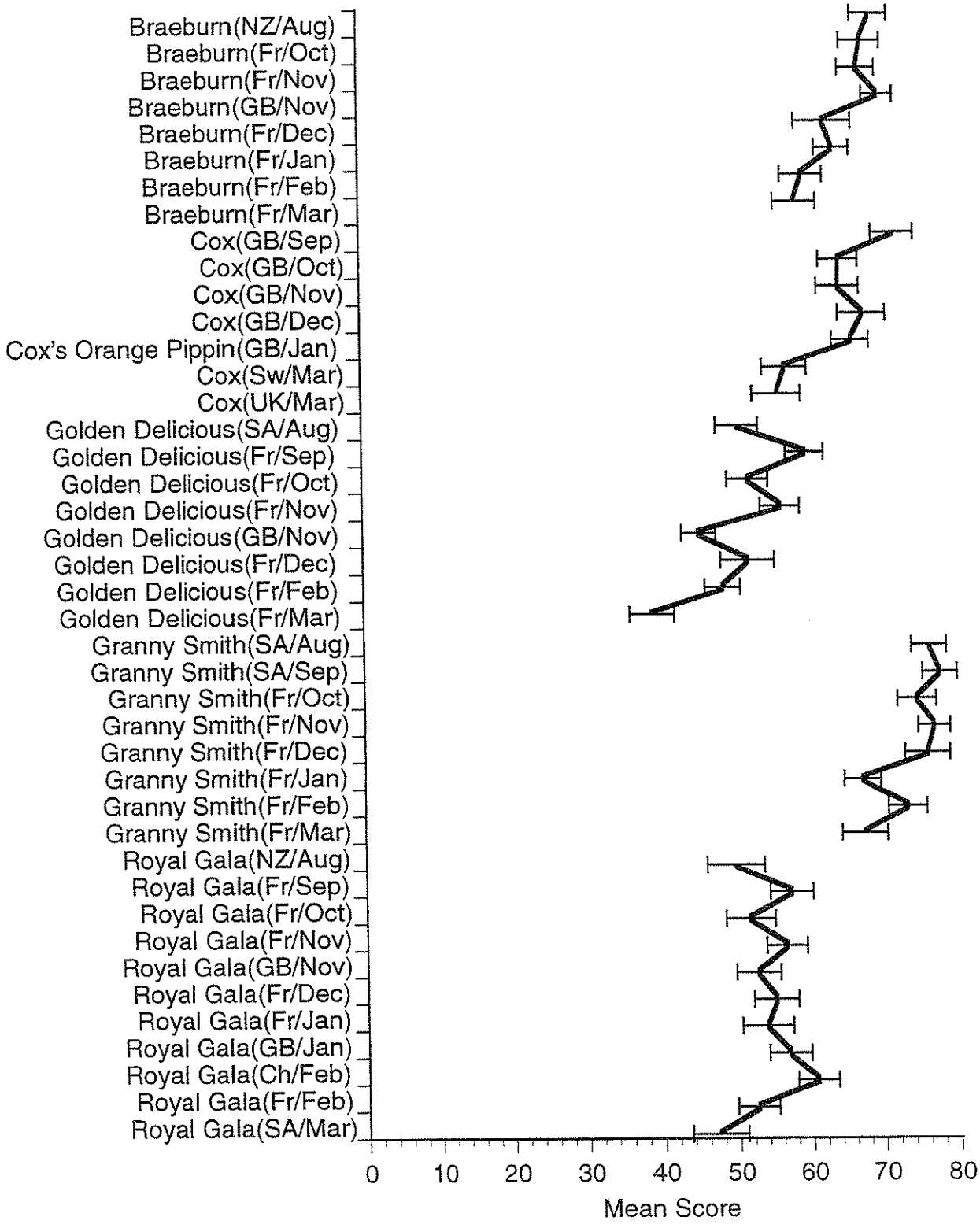


Figure 6

External Appearance - Looks Hard



External Appearance - Looks Hard

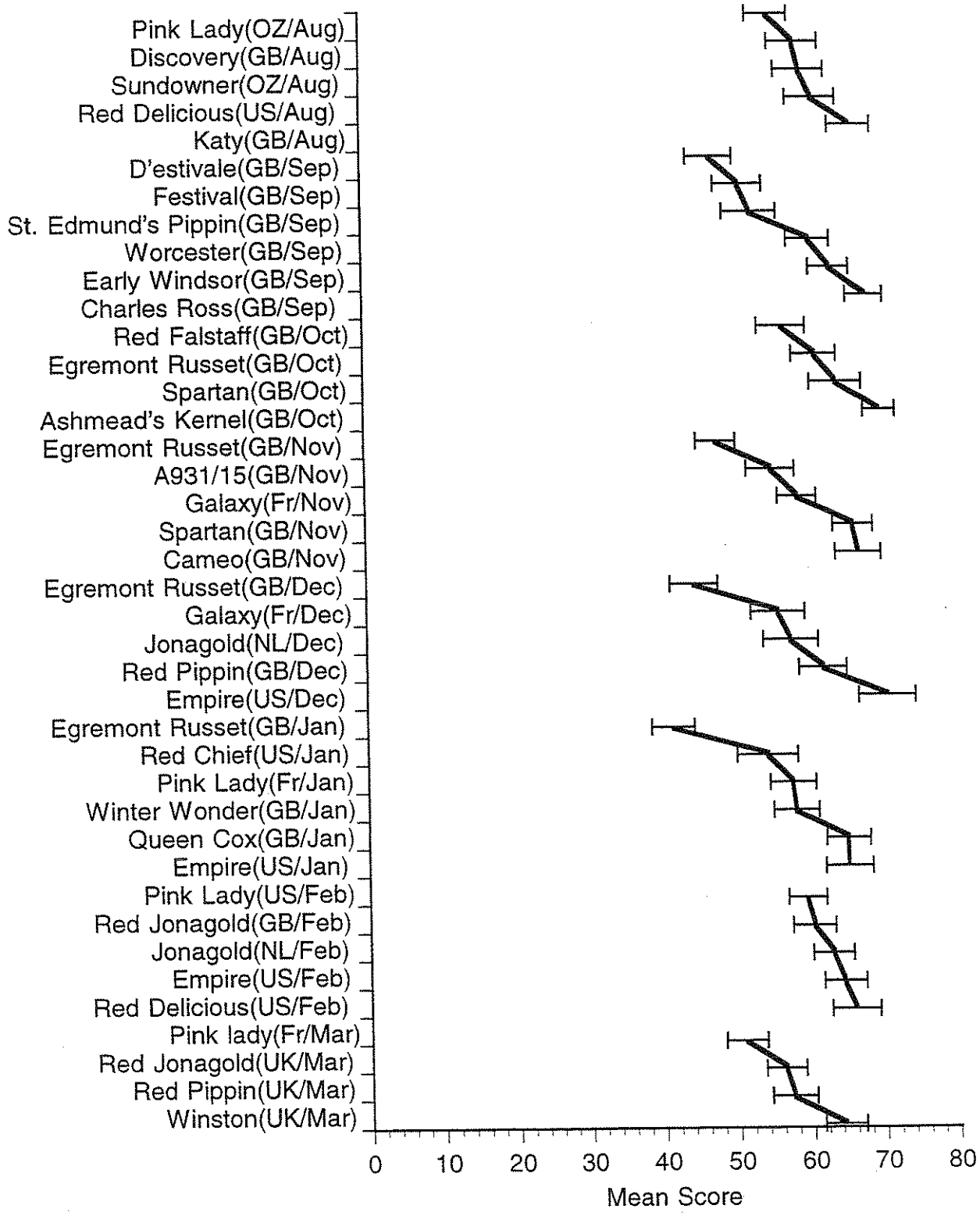
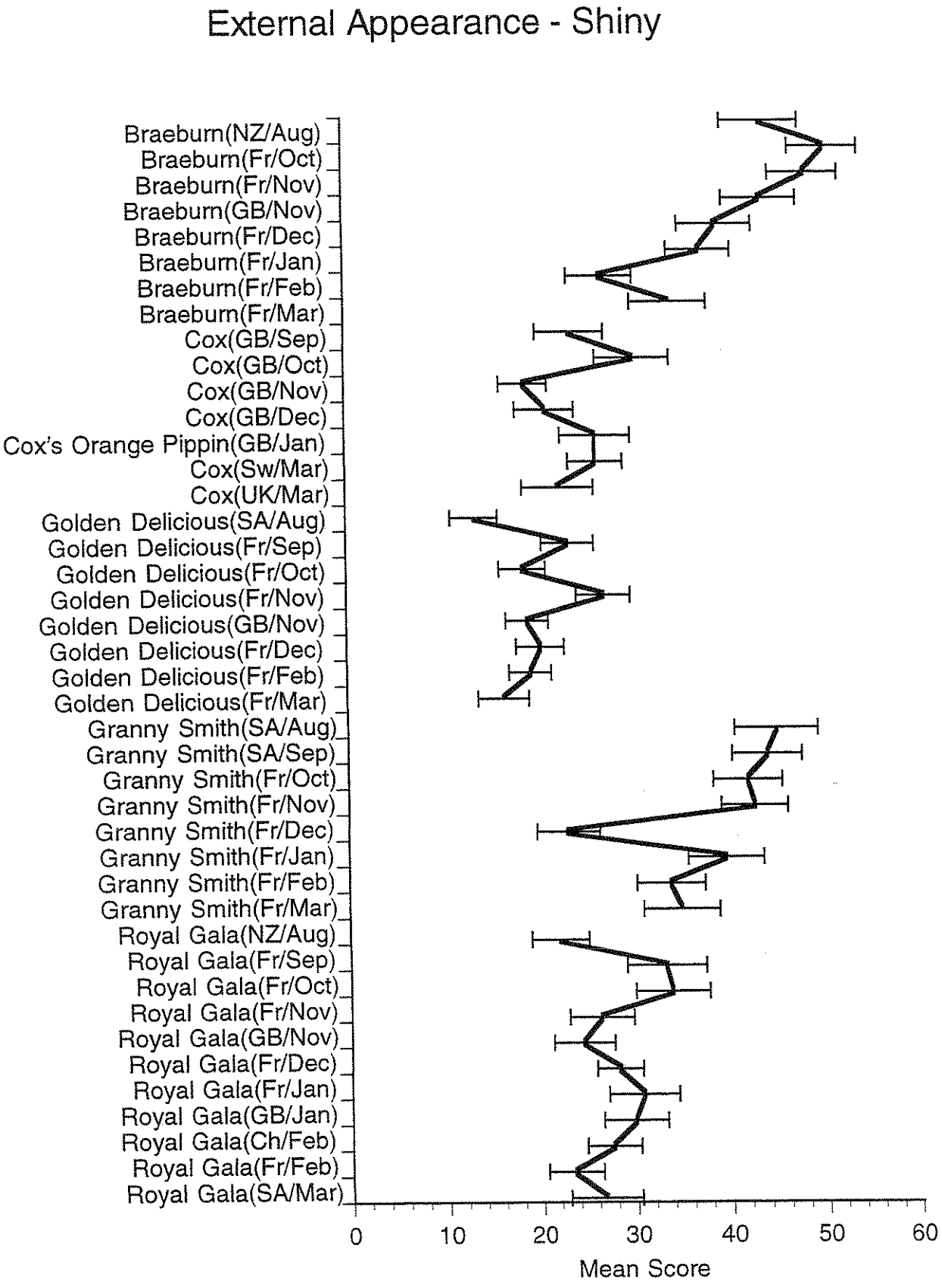


Figure 7


External Appearance - Shiny
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
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Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
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50
60
Mean Score

External Appearance - Shiny

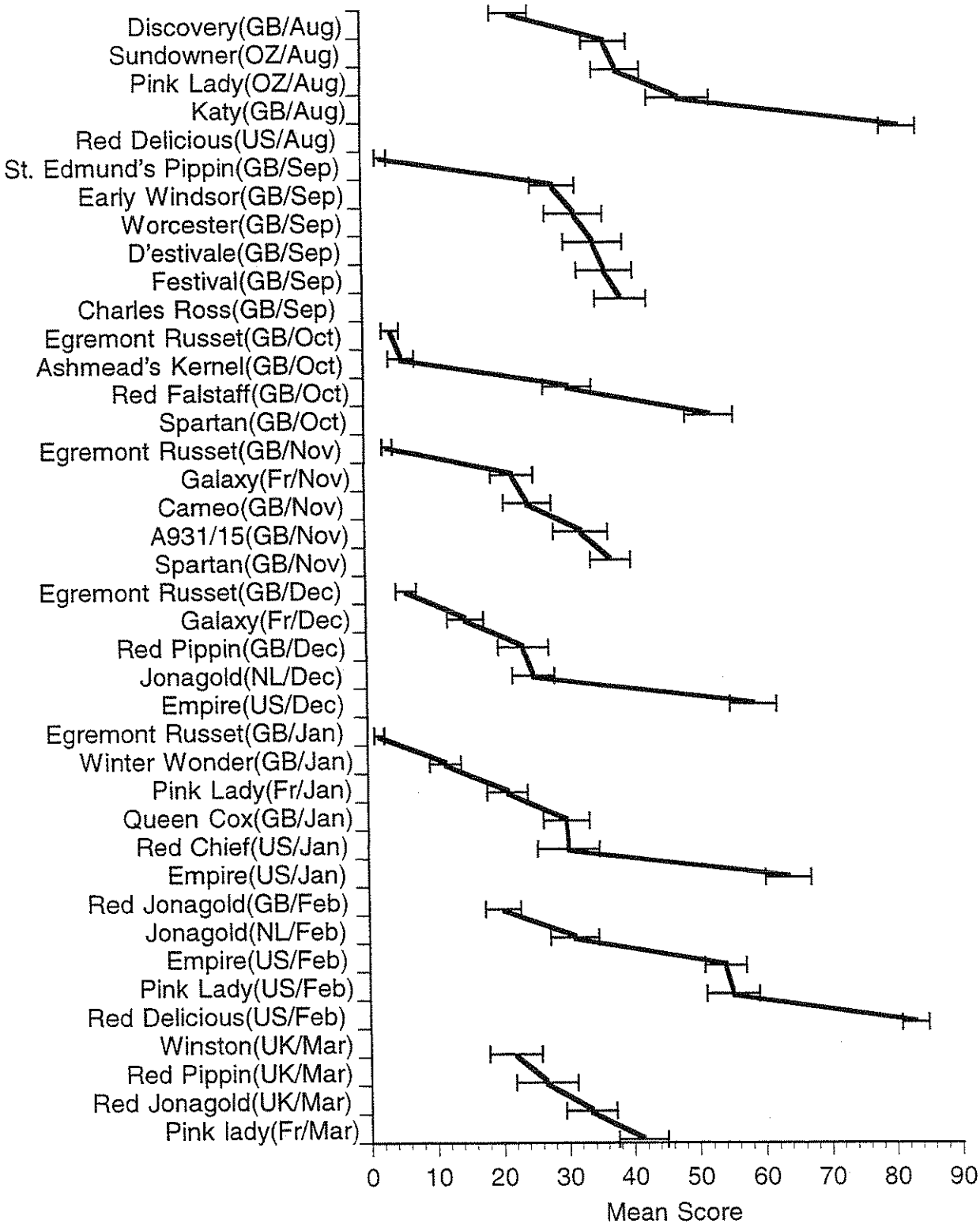
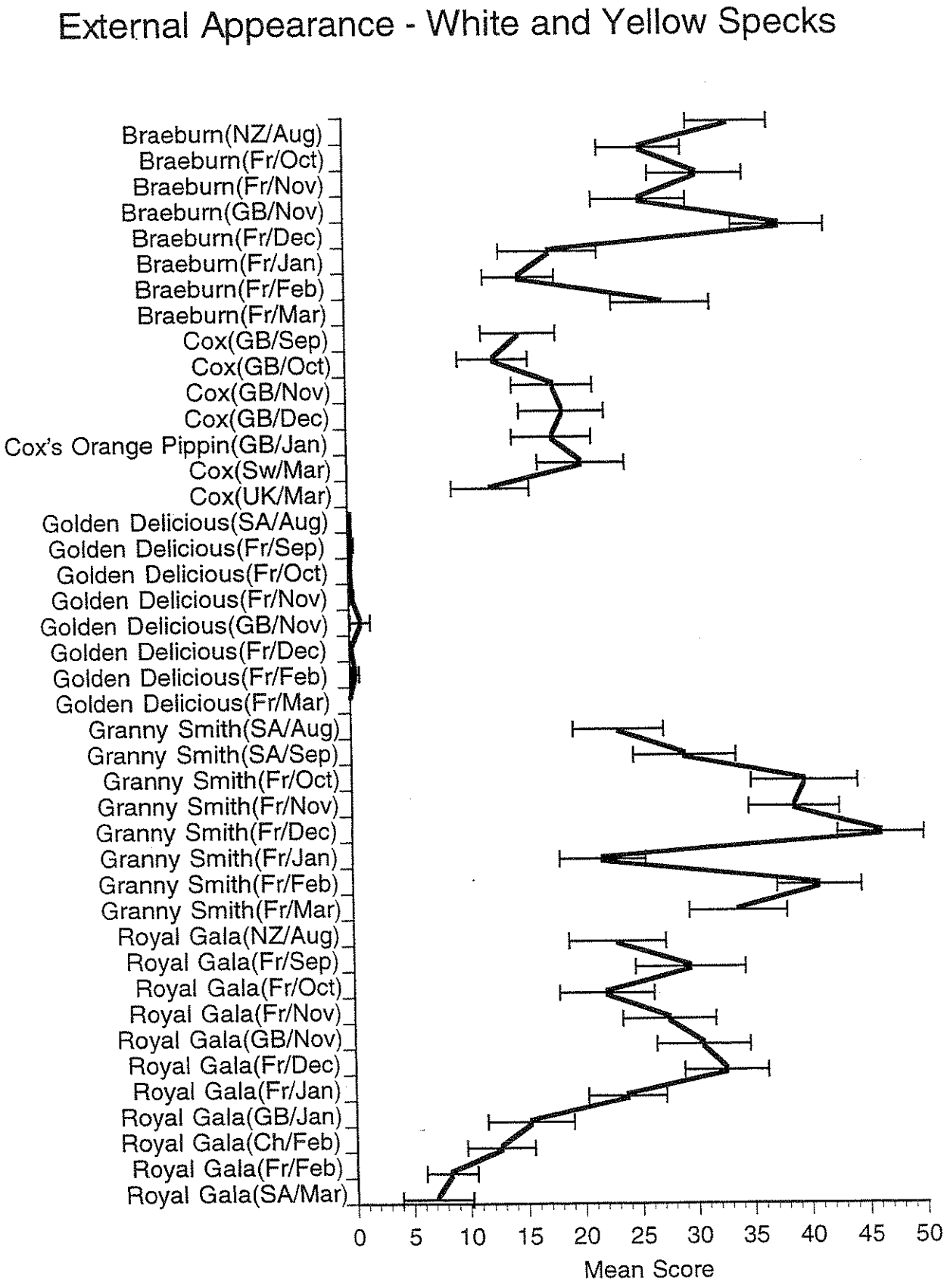


Figure 8


External Appearance - White and Yellow Specks
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
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Braeburn(Fr/Feb)
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Cox(GB/Sep)
Cox(GB/Oct)
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Royal Gala(Fr/Feb)
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25
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35
40
45
50
Mean Score

External Appearance - White and Yellow Specks

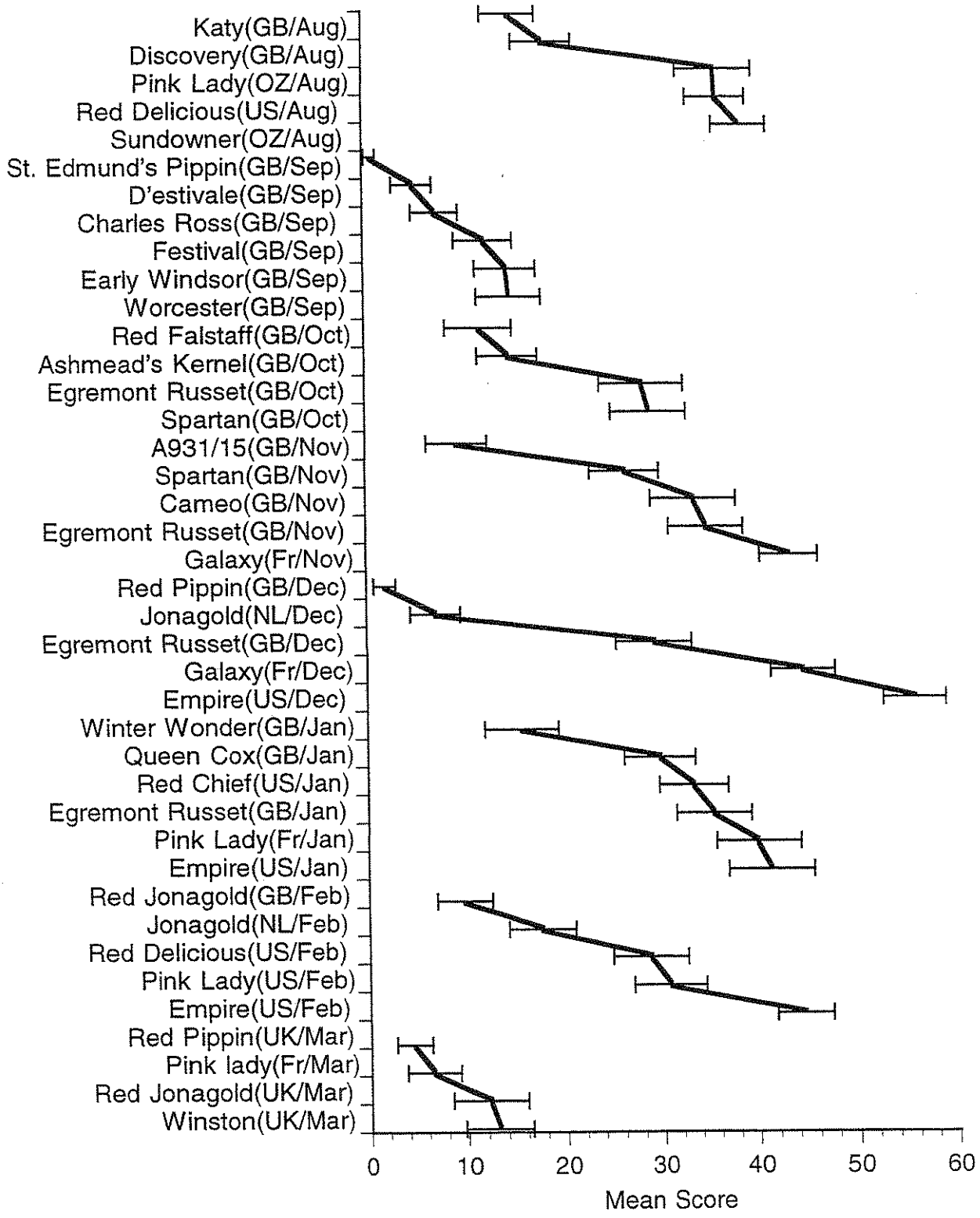
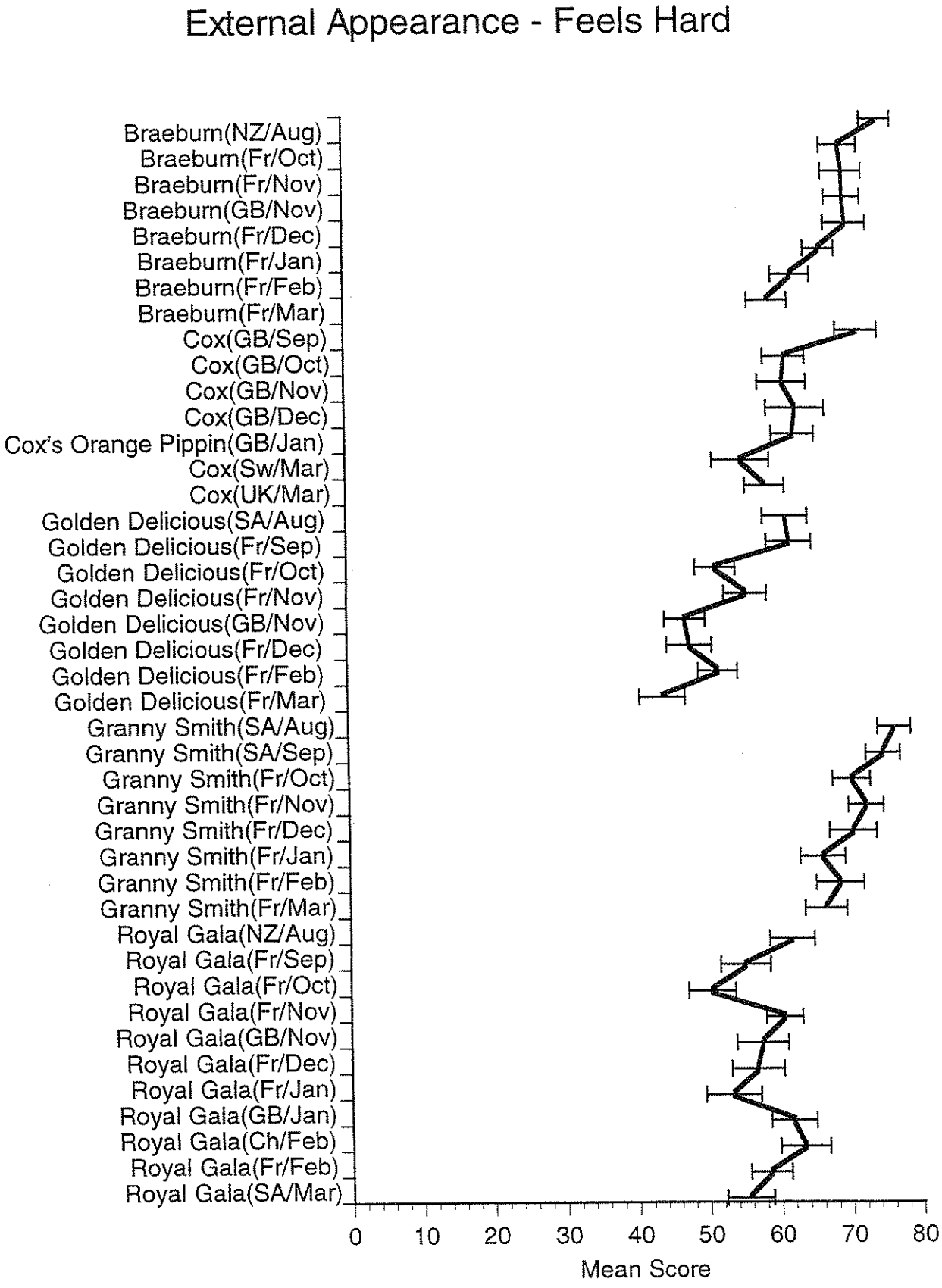


Figure 9


External Appearance - Feels Hard
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
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Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
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Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
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Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
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Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
Mean Score

External Appearance - Feels Hard

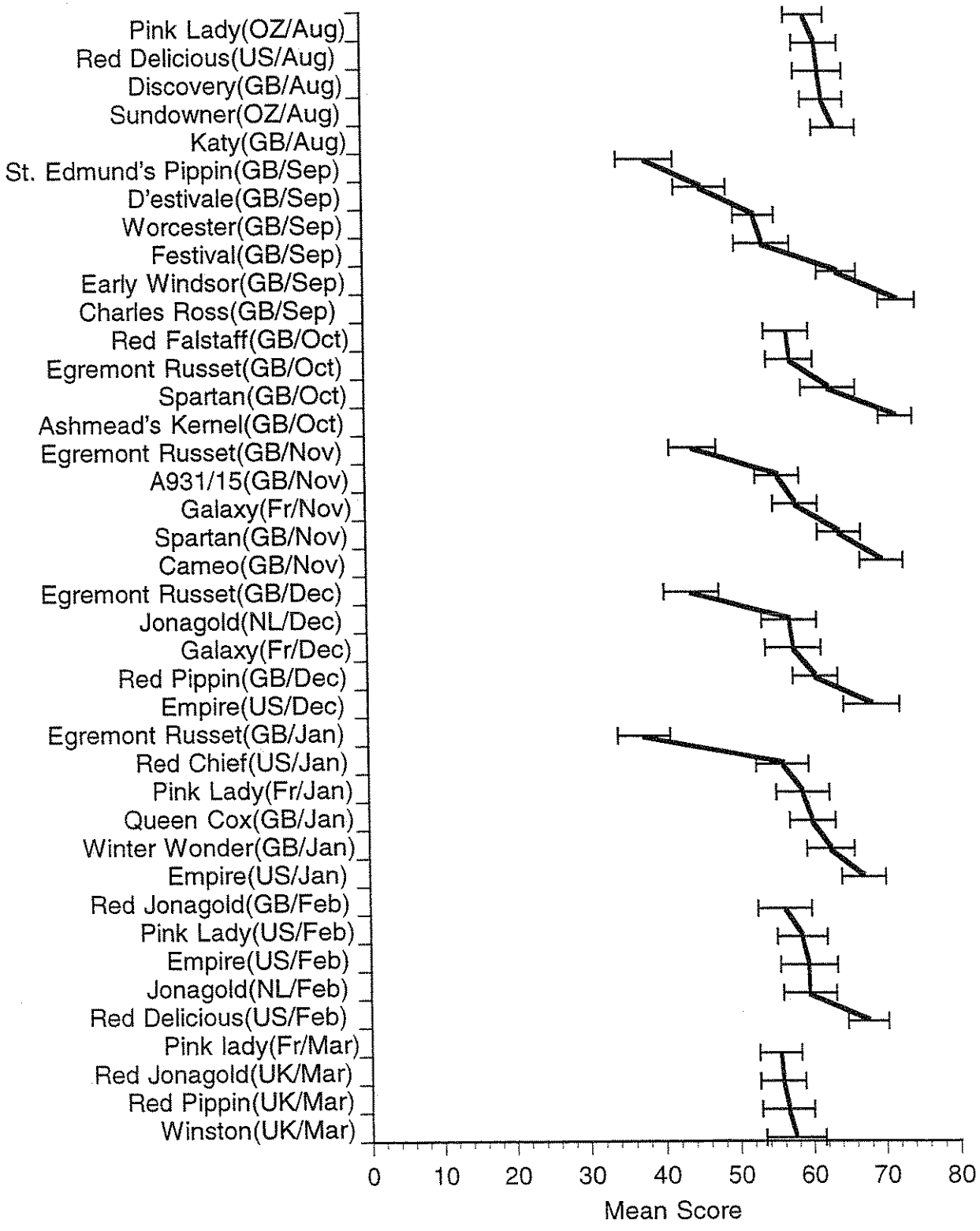
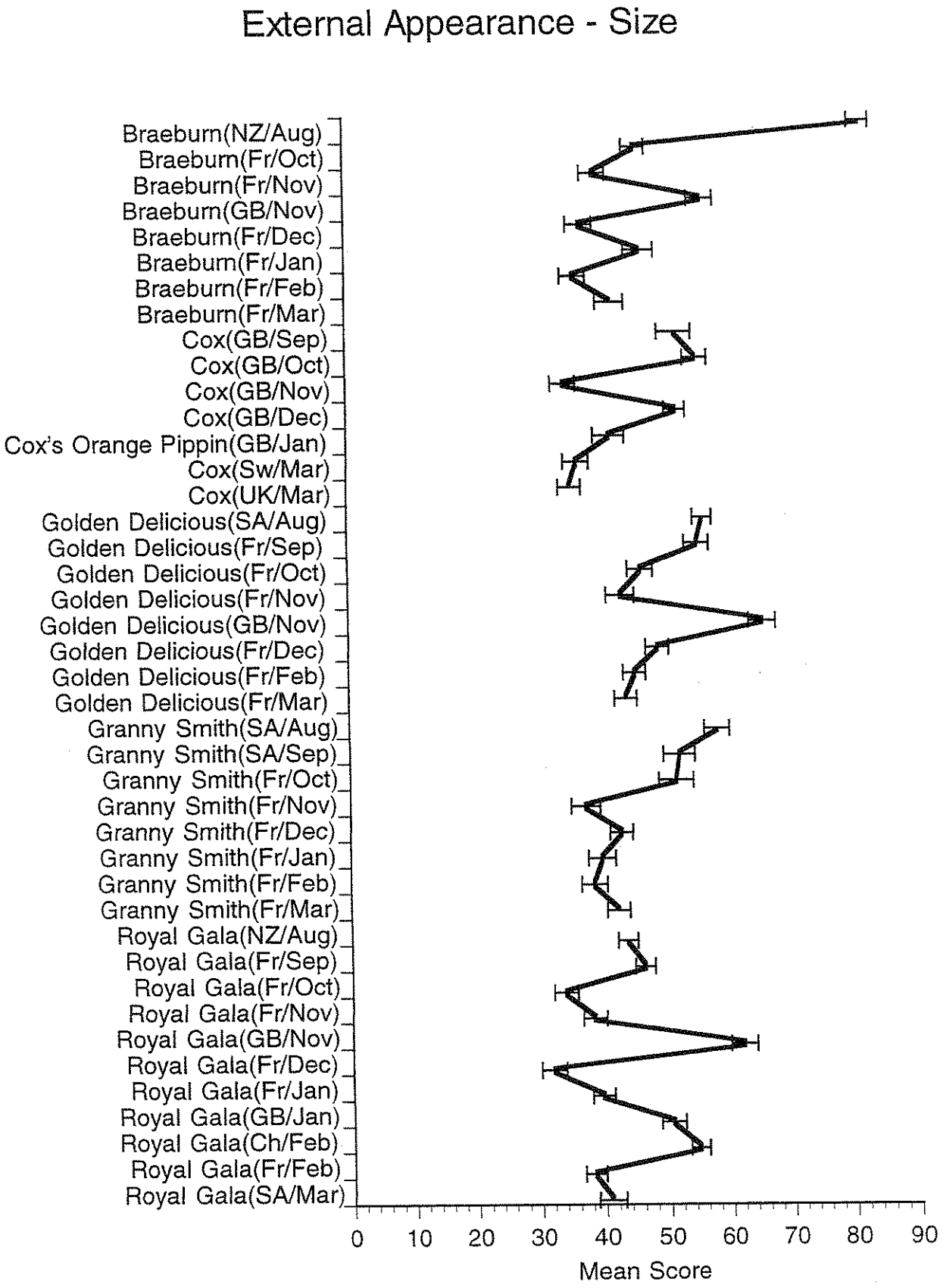


Figure 10


External Appearance - Size
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
90
Mean Score

External Appearance - Size

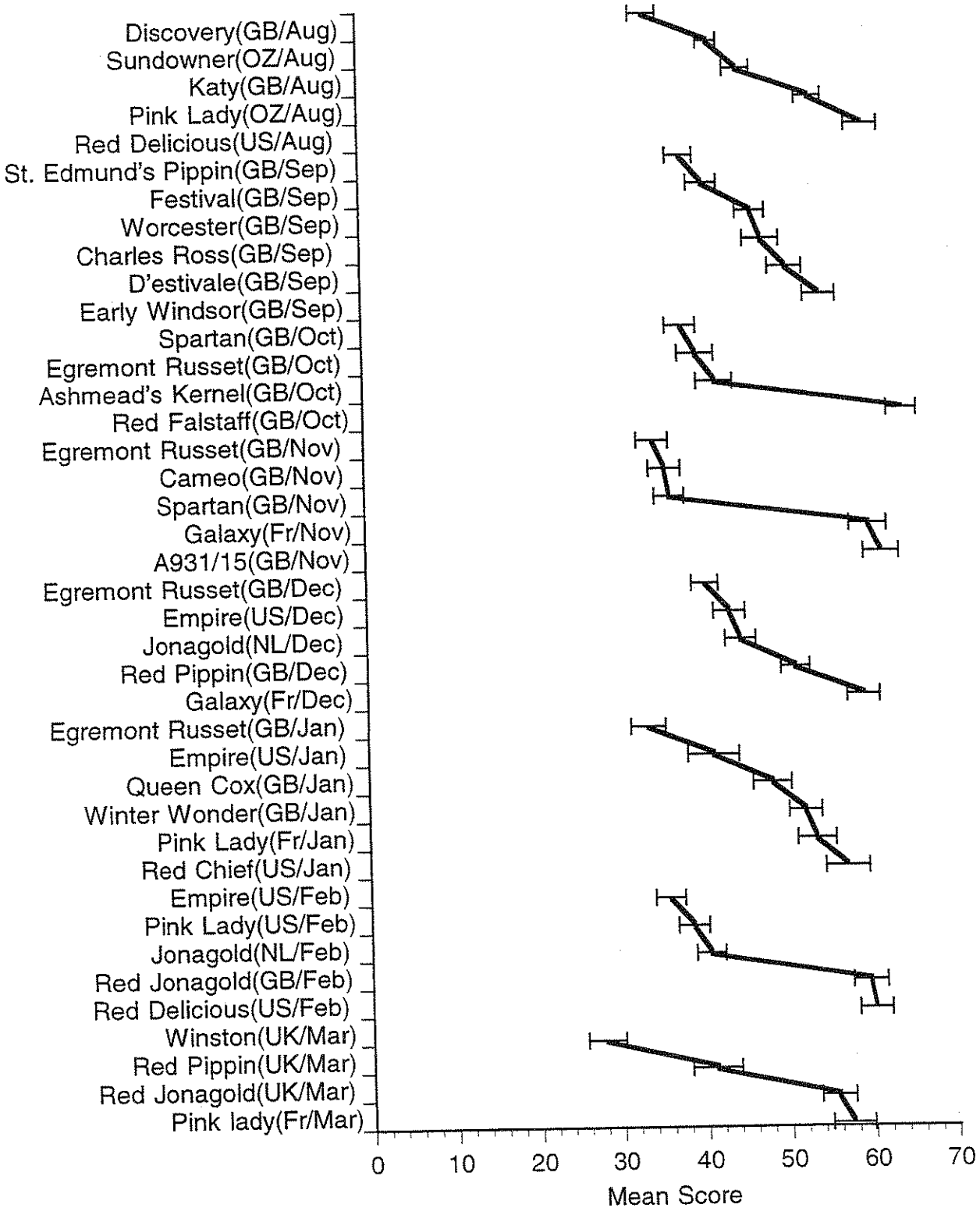
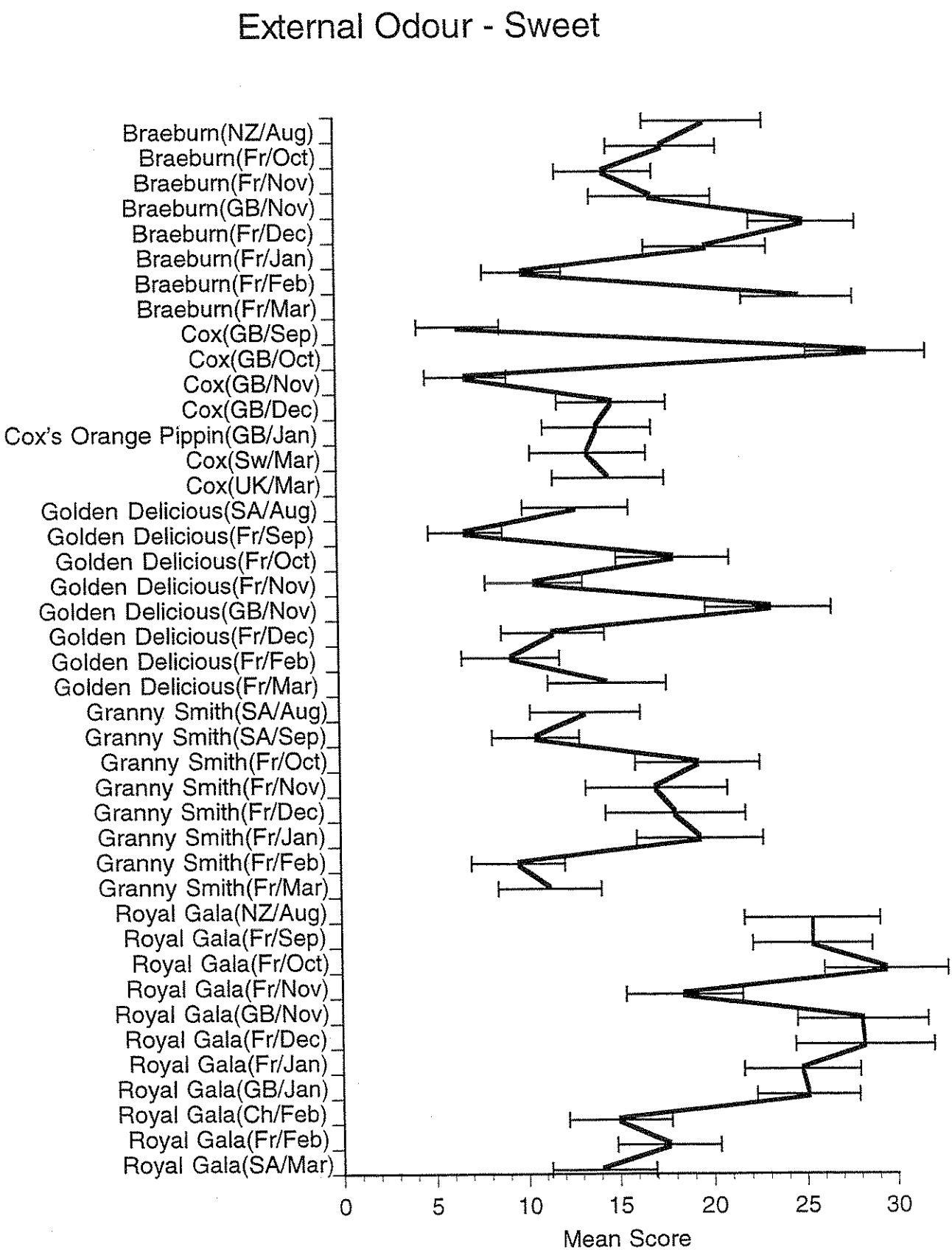


Figure 11


External Odour - Sweet
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
Mean Score

External Odour - Sweet

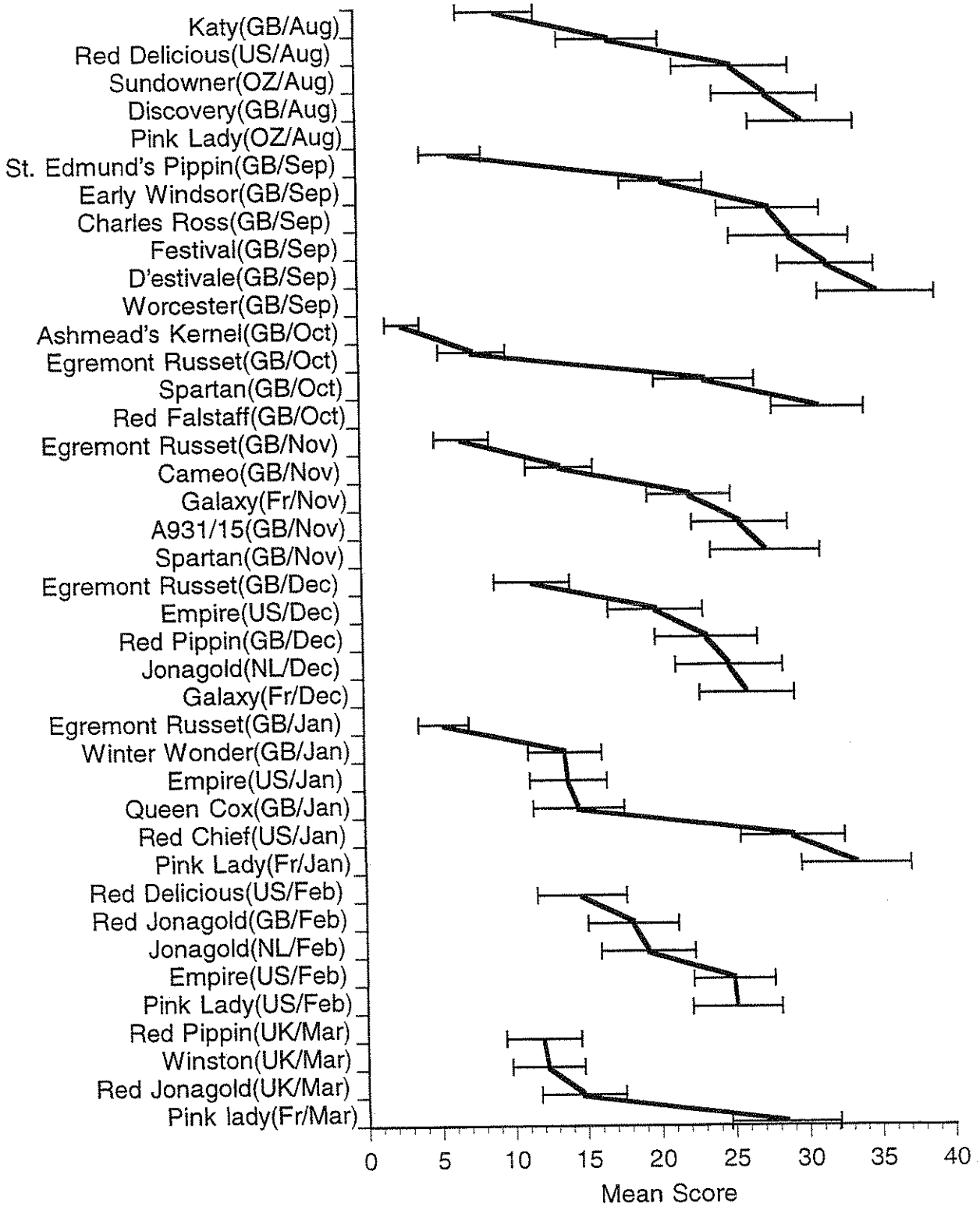
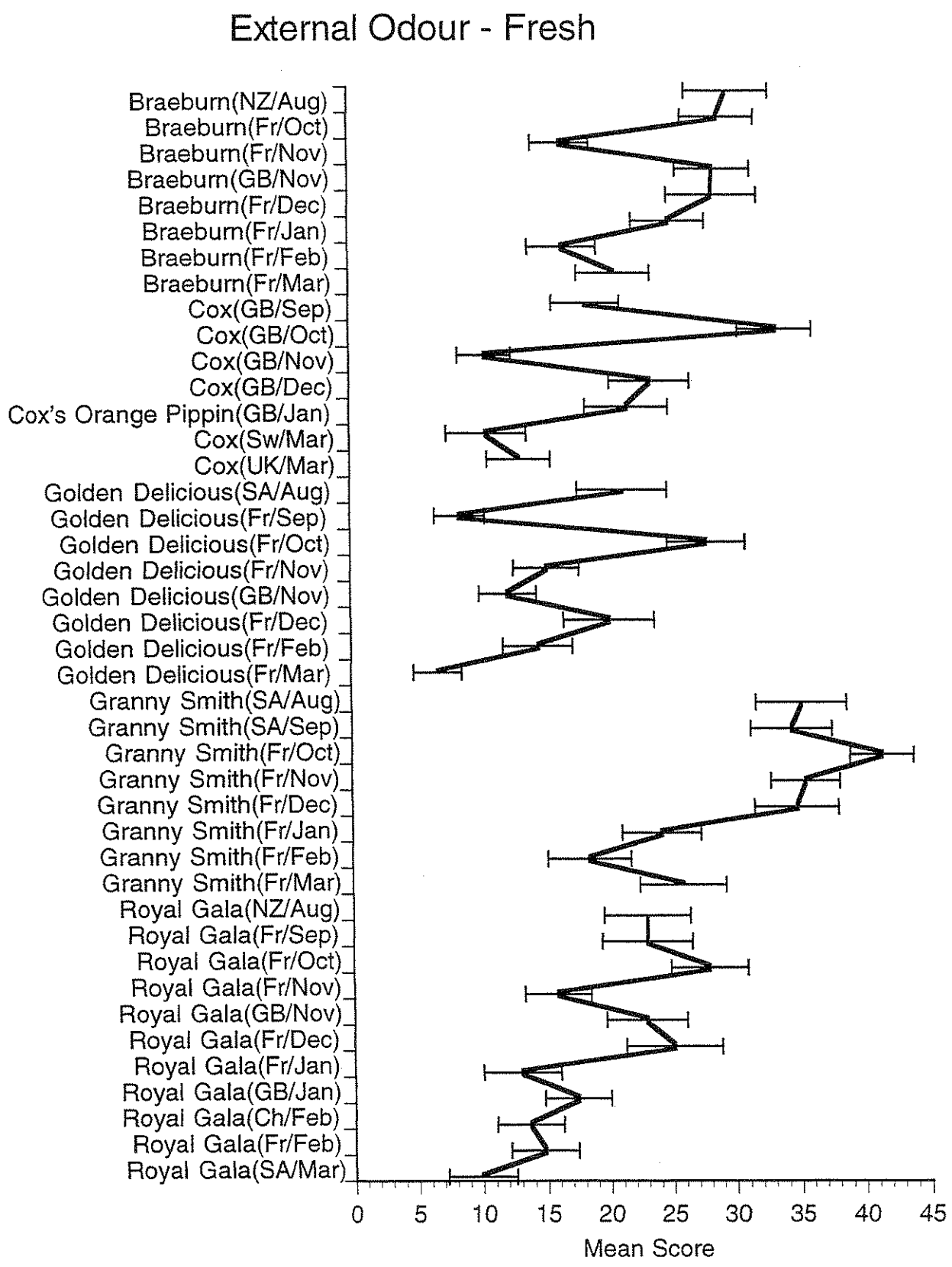


Figure 12


External Odour - Fresh
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
35
40
45
Mean Score

External Odour - Fresh

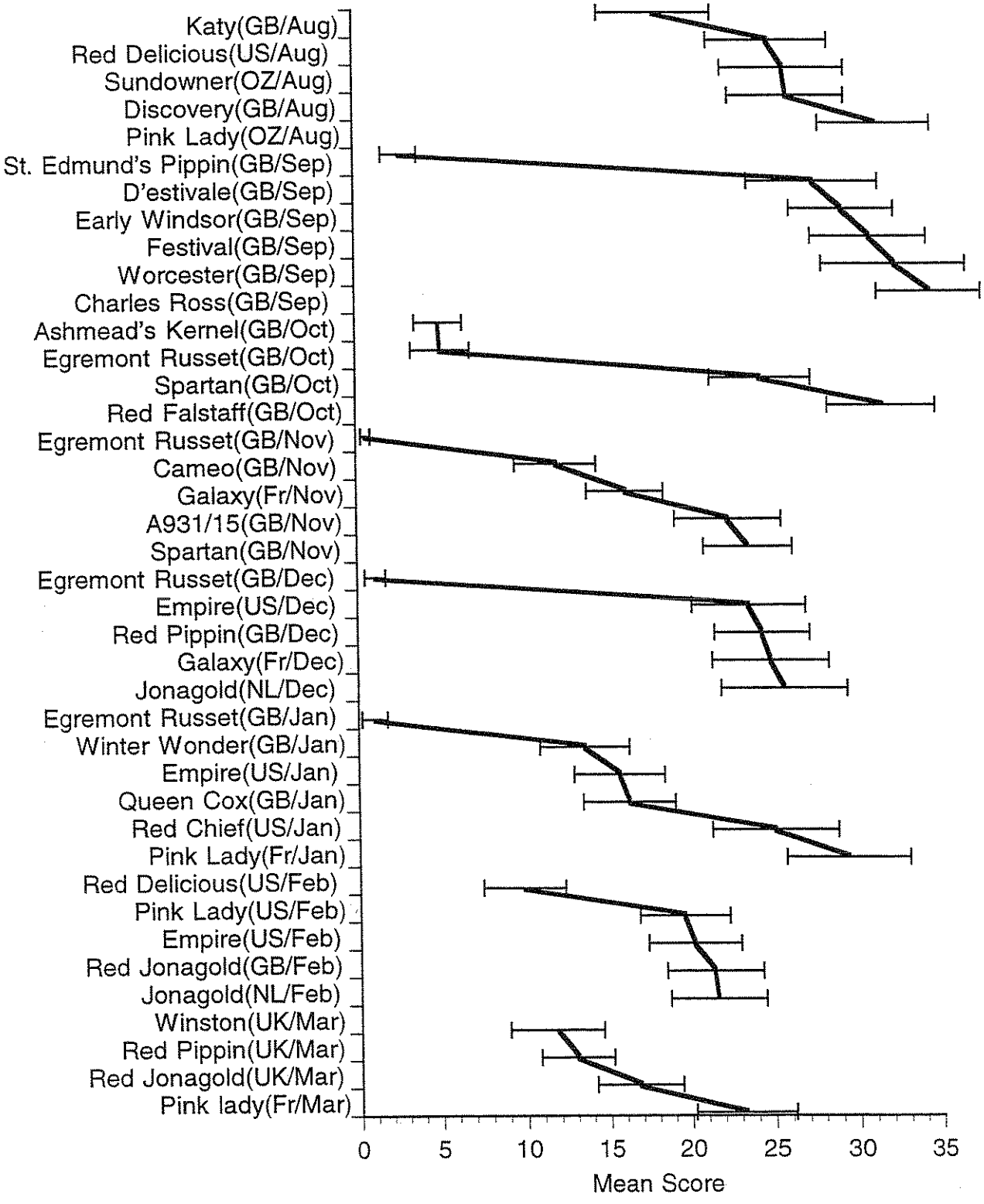
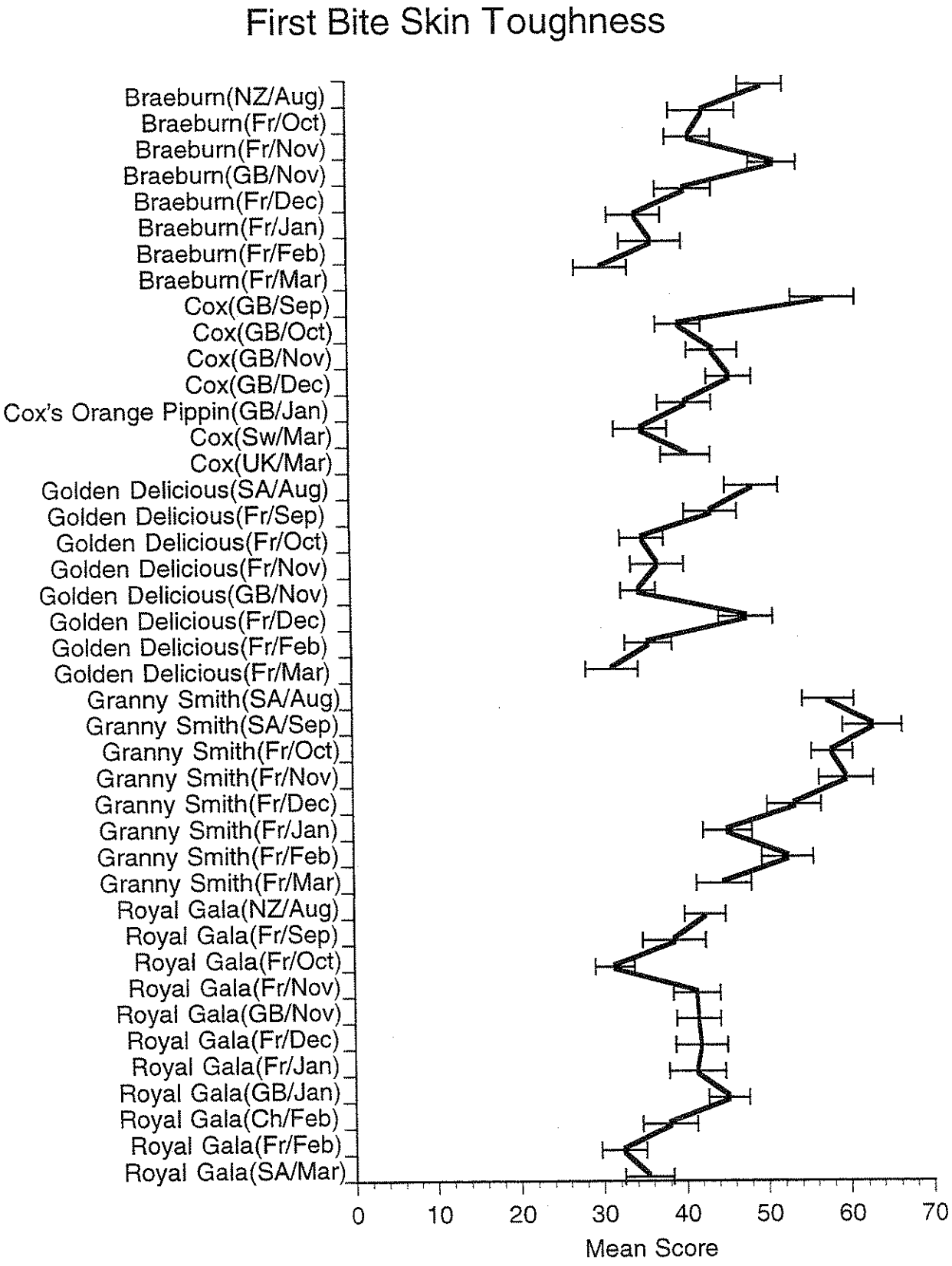


Figure 13


First Bite Skin Toughness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
Mean Score

First Bite - Skin Toughness

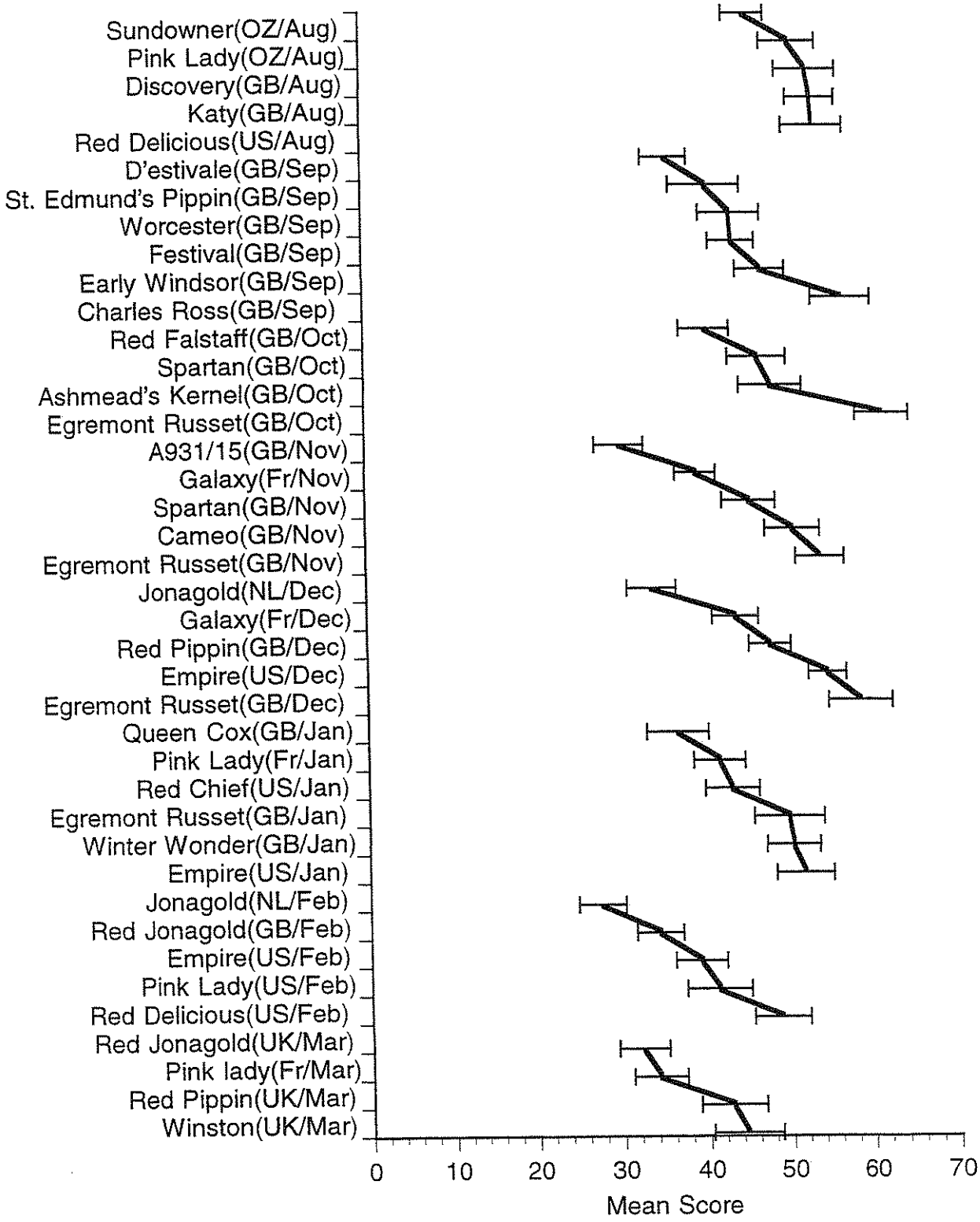
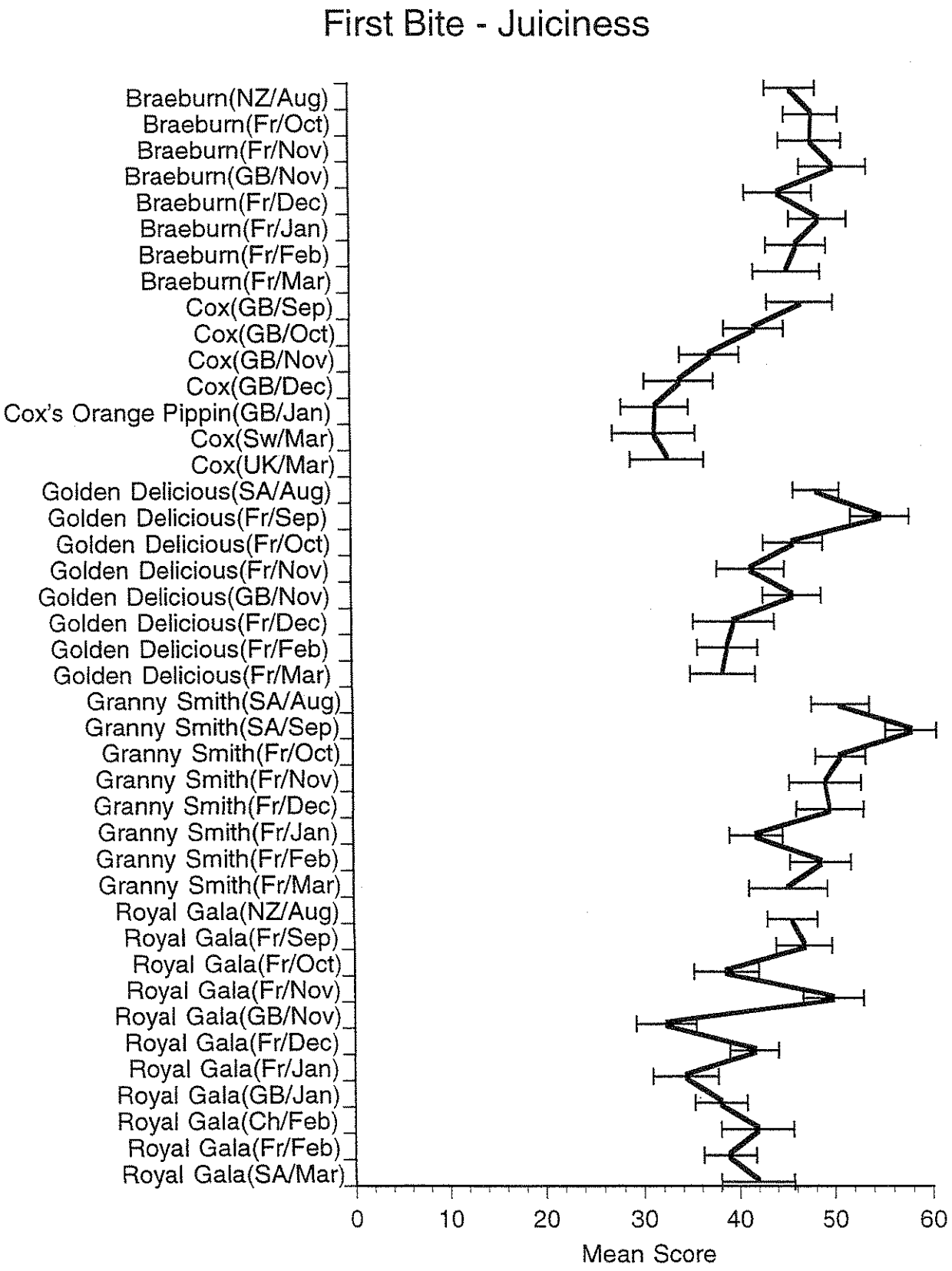


Figure 14


First Bite - Juiciness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

First Bite - Juiciness

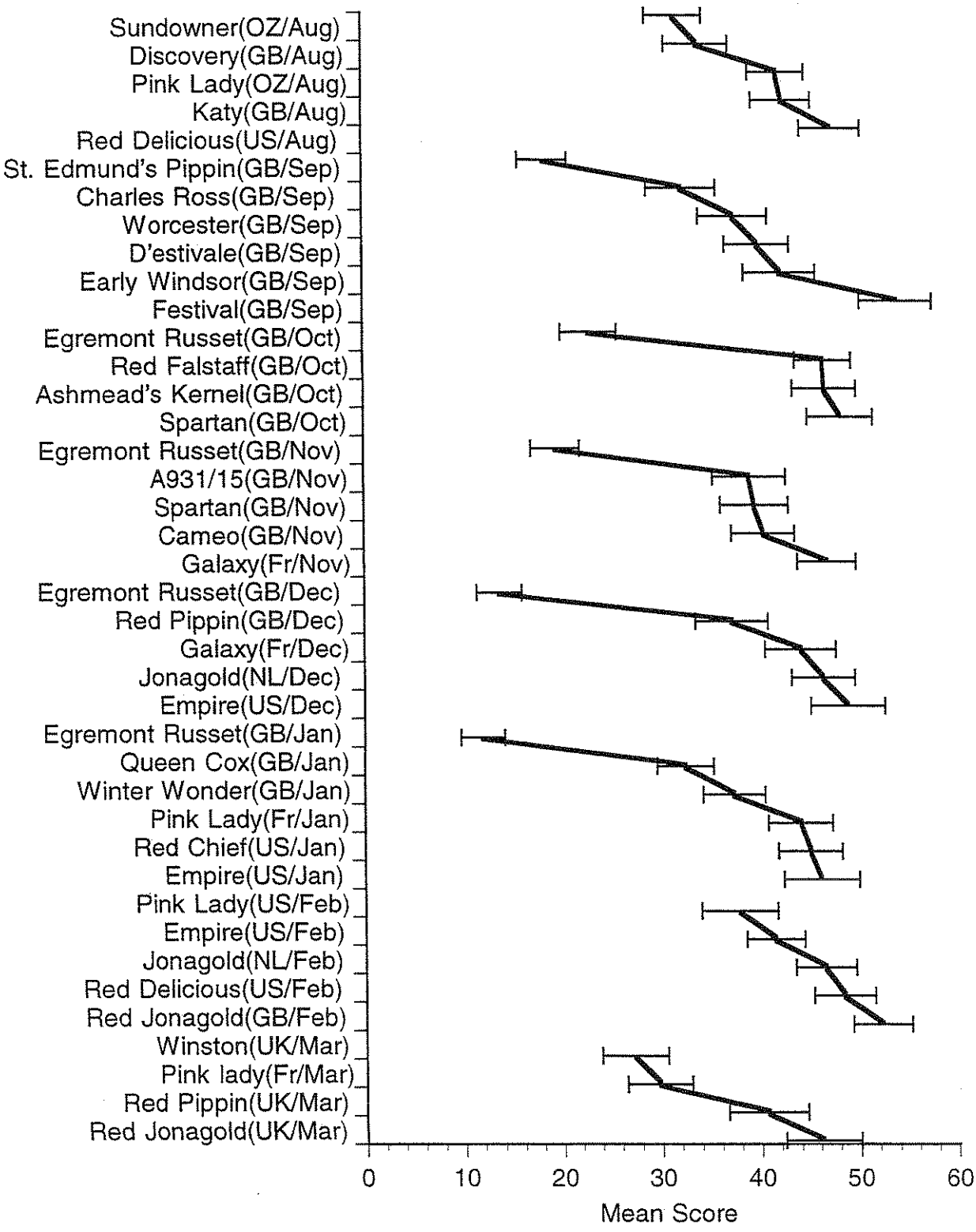
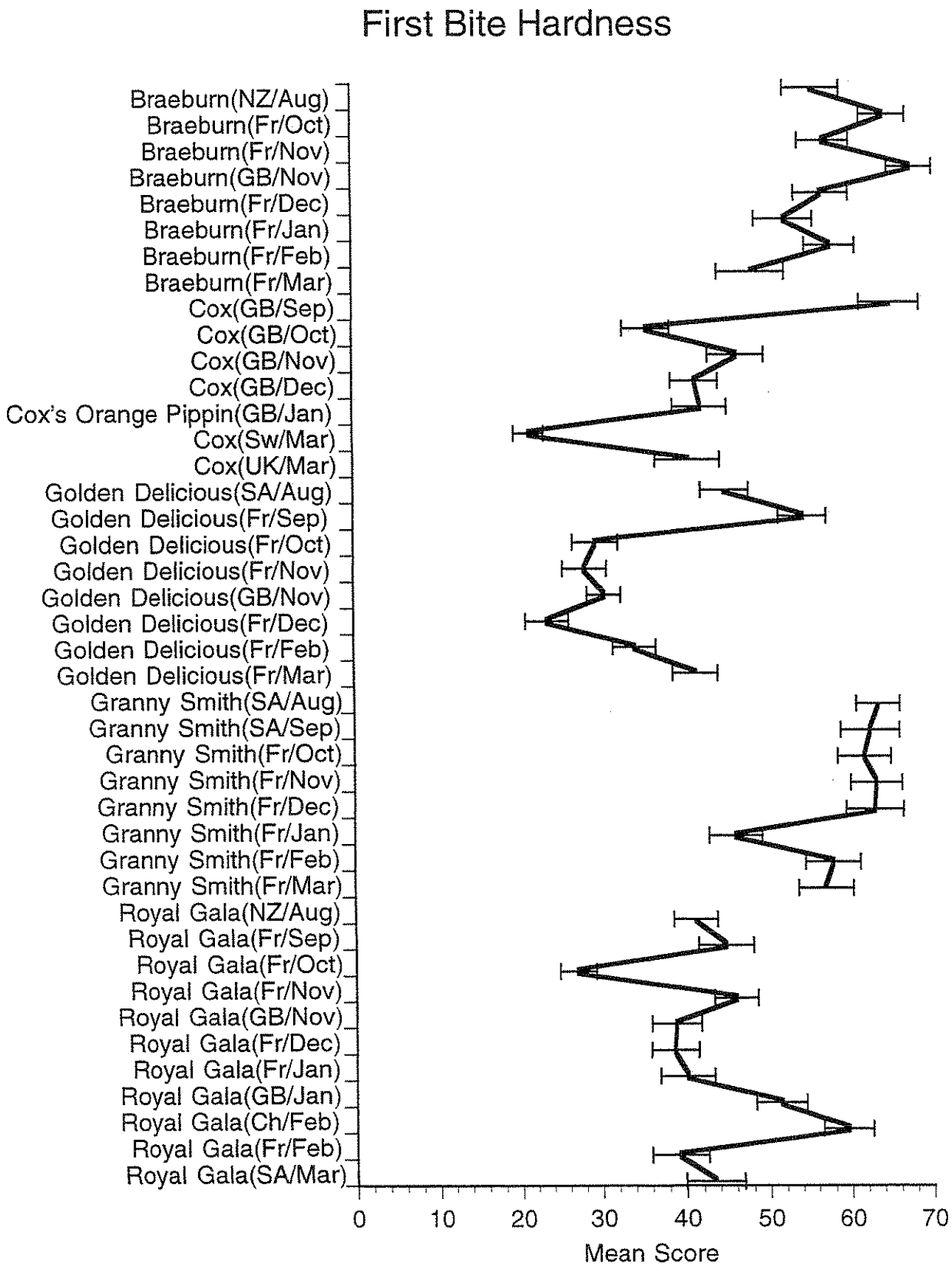


Figure 15


First Bite Hardness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
Mean Score

First Bite - Hardness

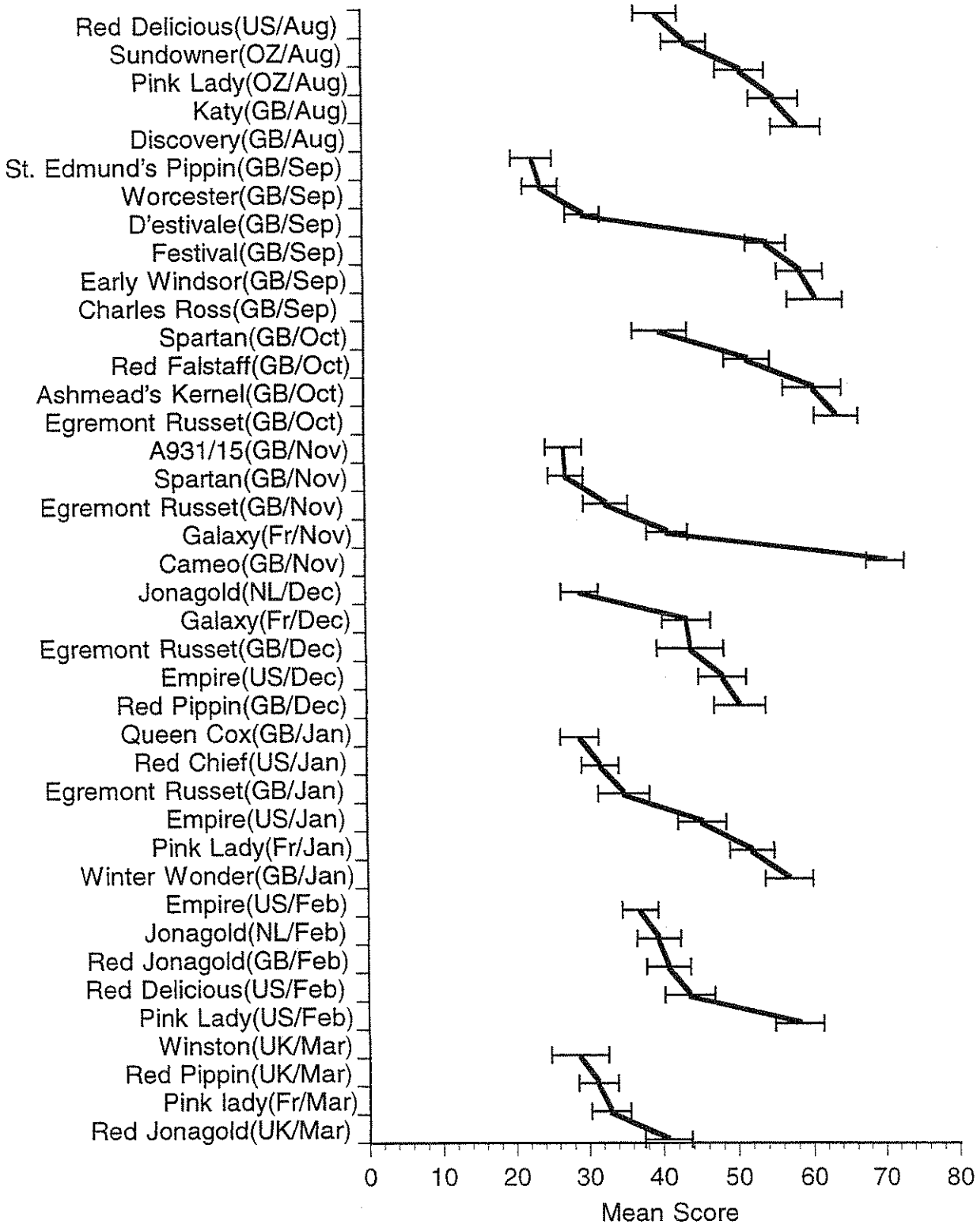
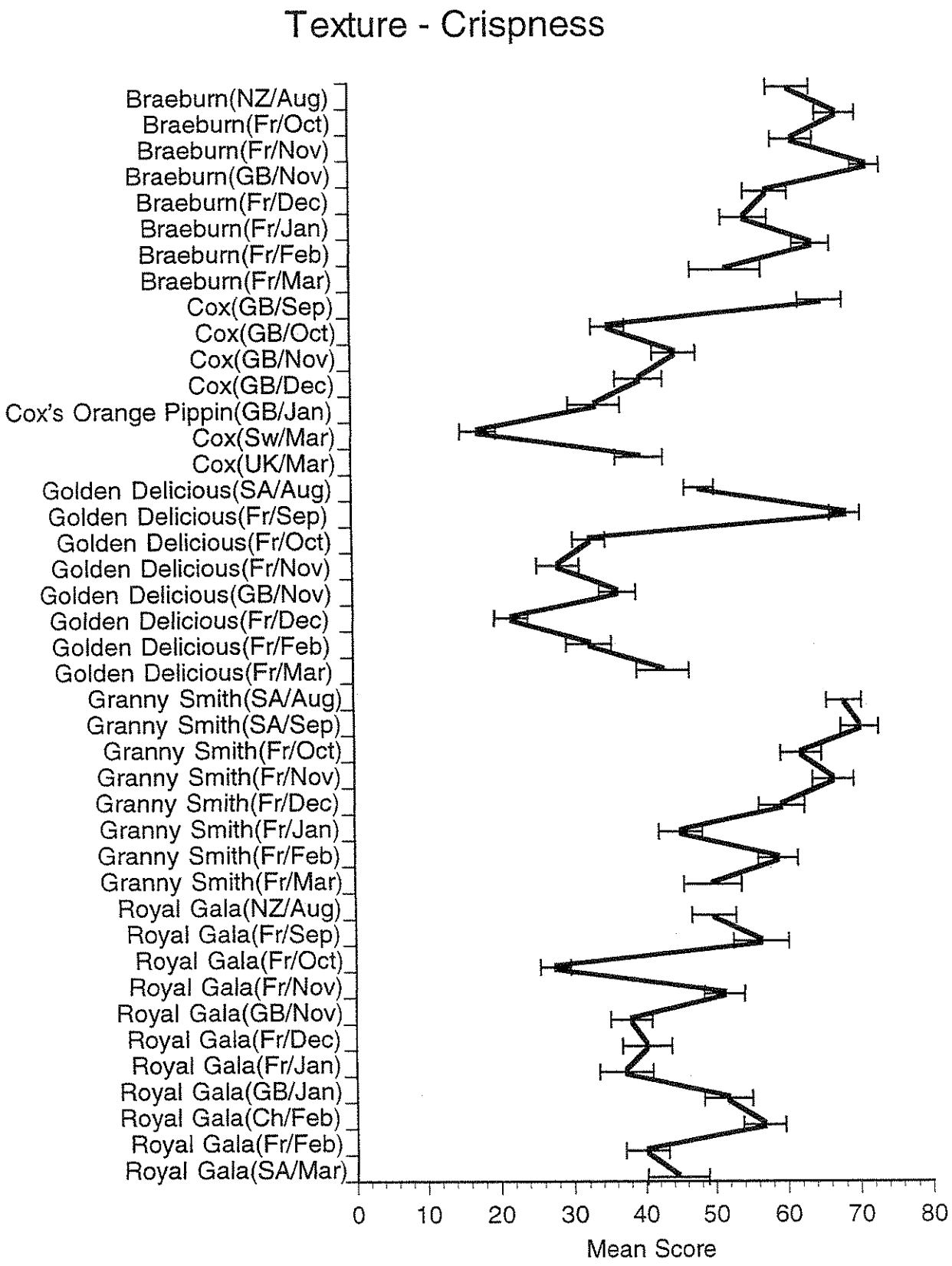


Figure 16


Texture - Crispness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
Mean Score

Texture - Crispness

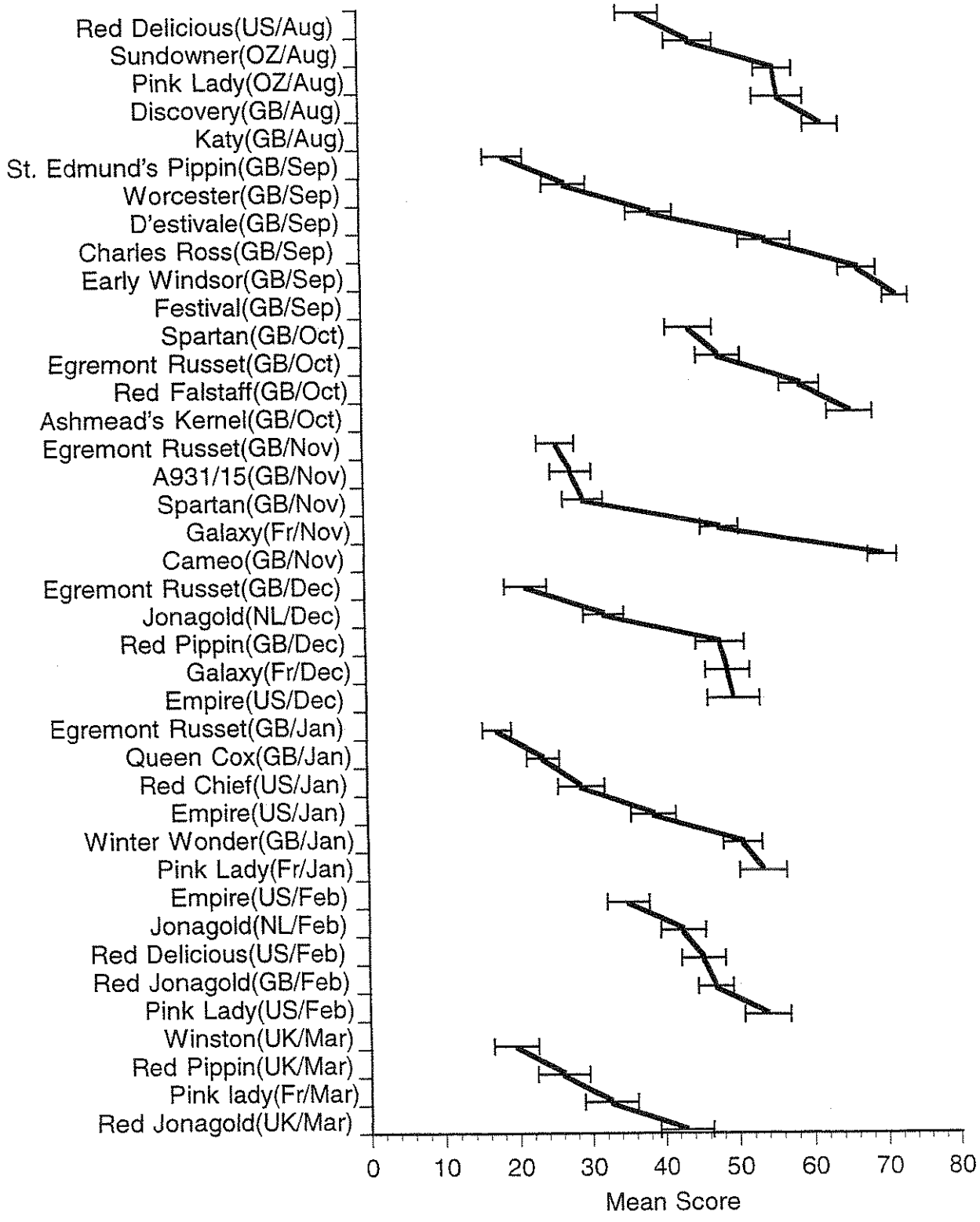
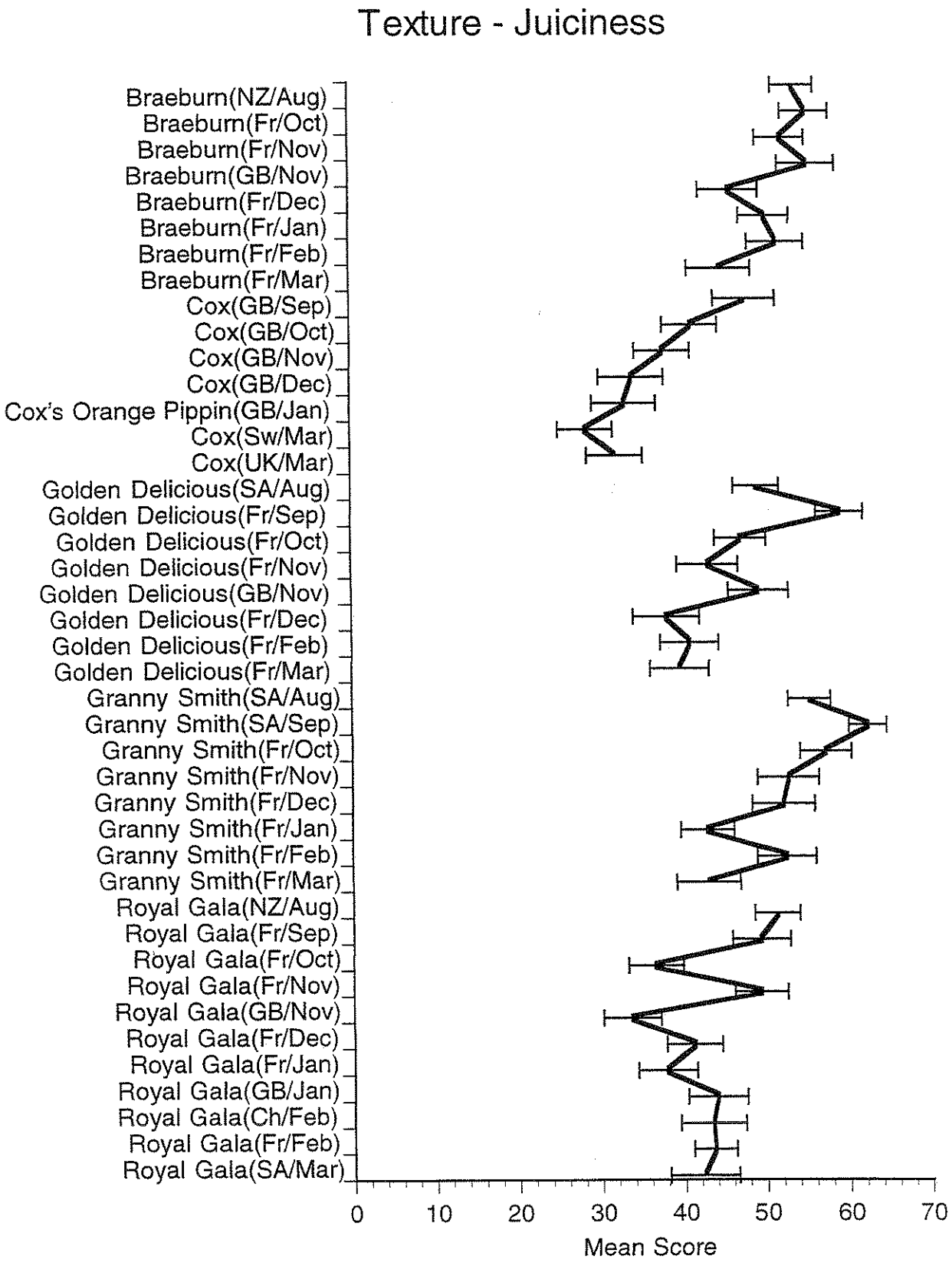


Figure 17


Texture - Juiciness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
Mean Score

Texture - Juiciness

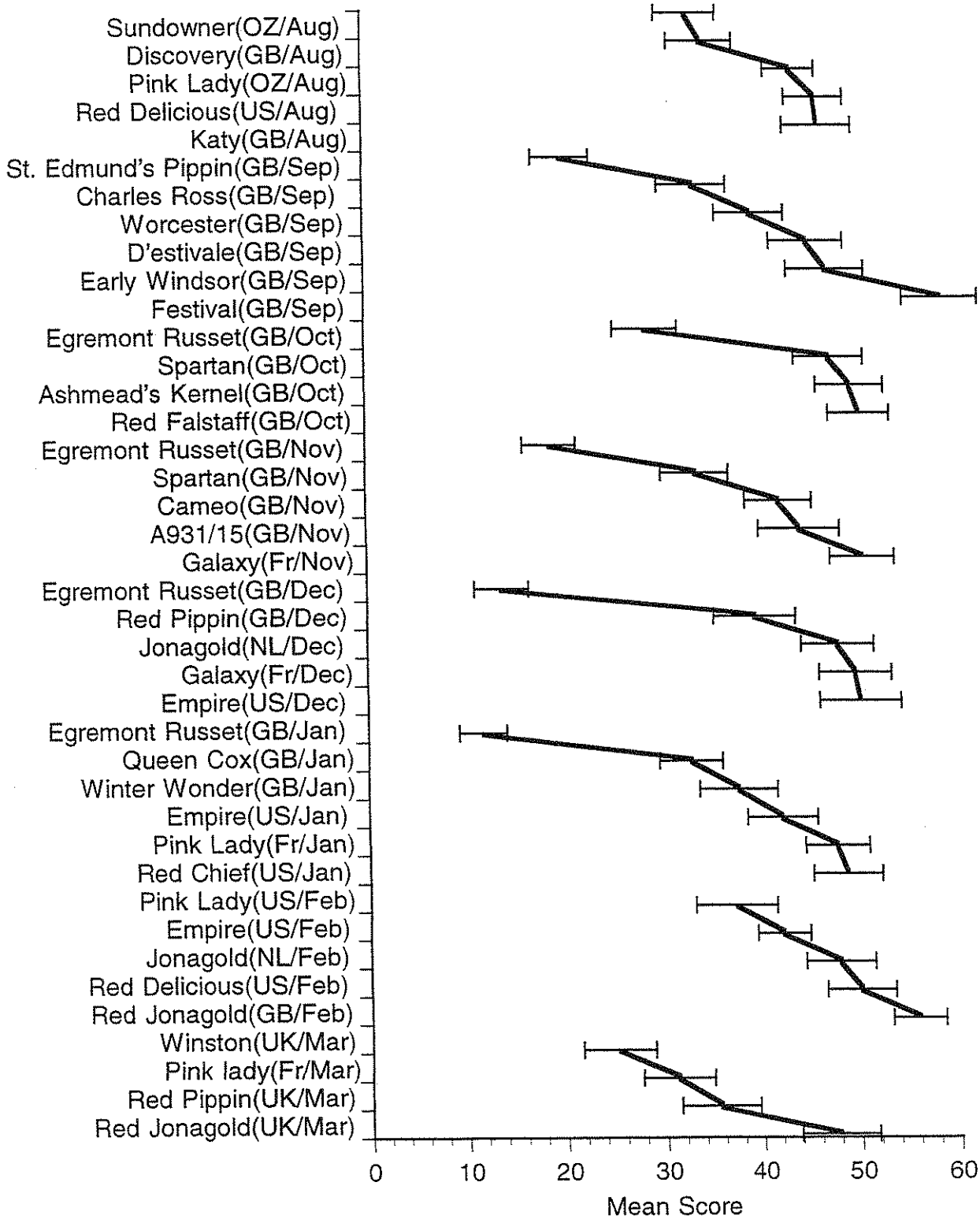
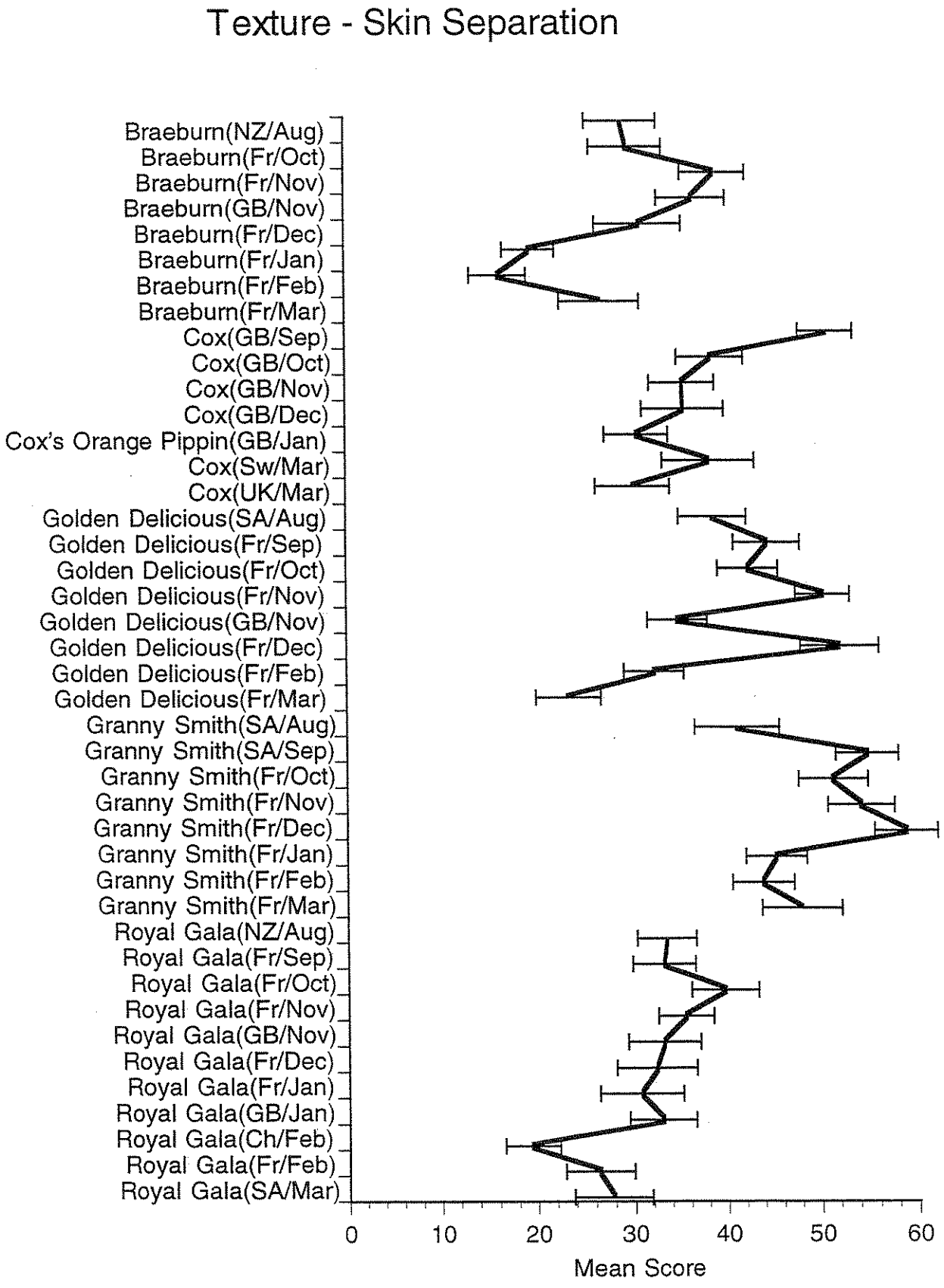


Figure 18


Texture - Skin Separation
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Texture - Skin Separation

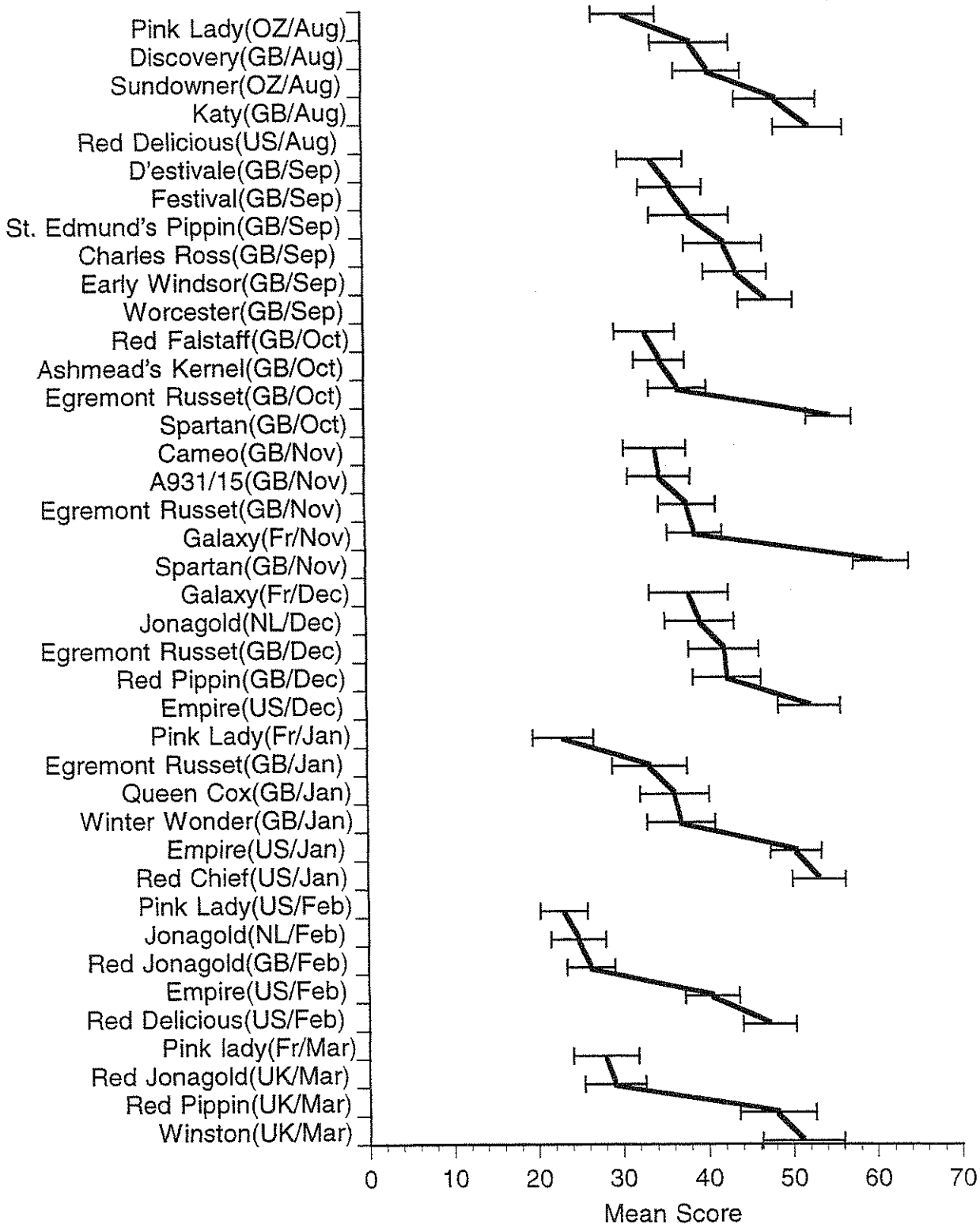
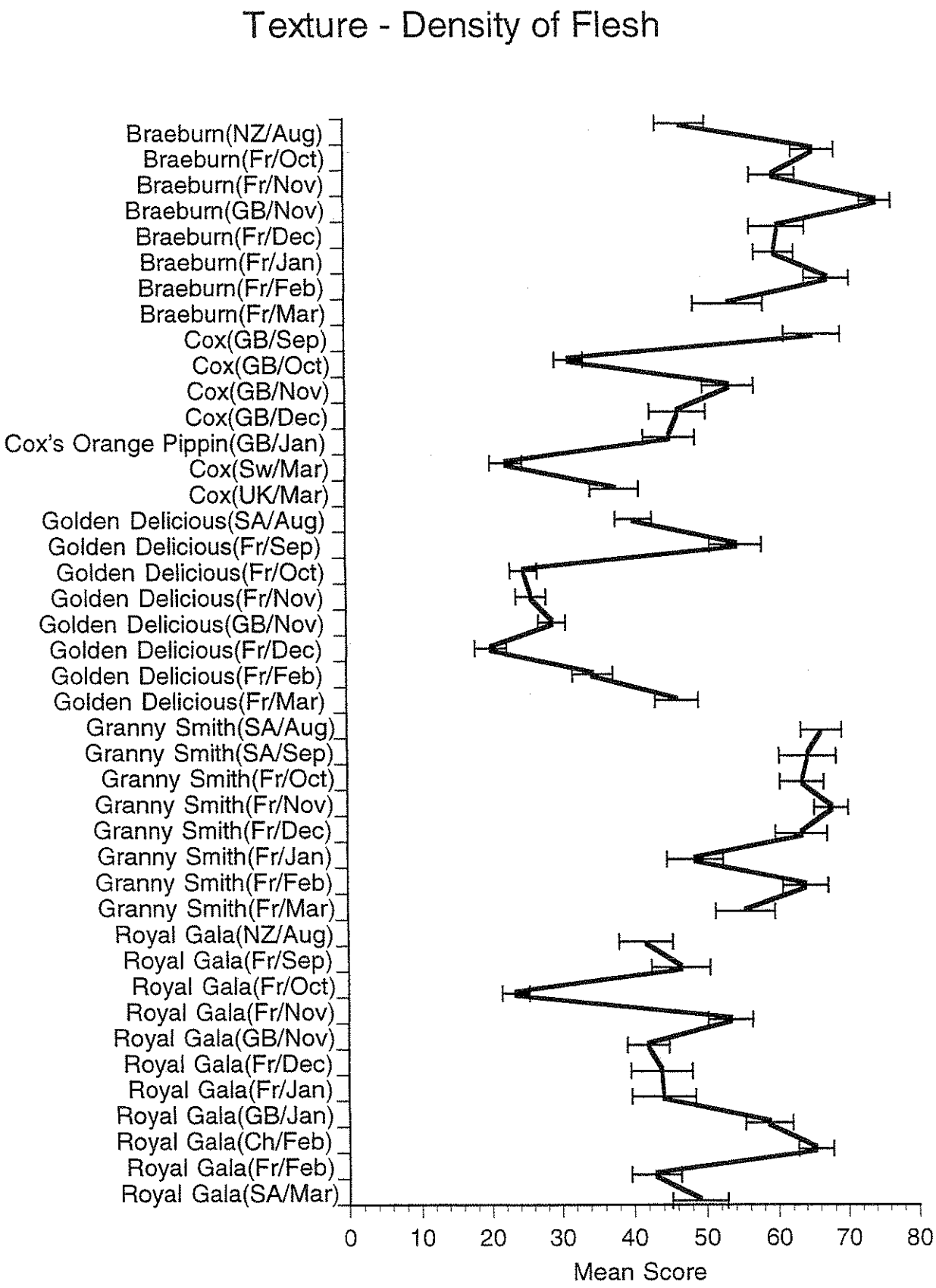


Figure 19


Texture - Density of Flesh
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
Mean Score

Texture - Density of Flesh

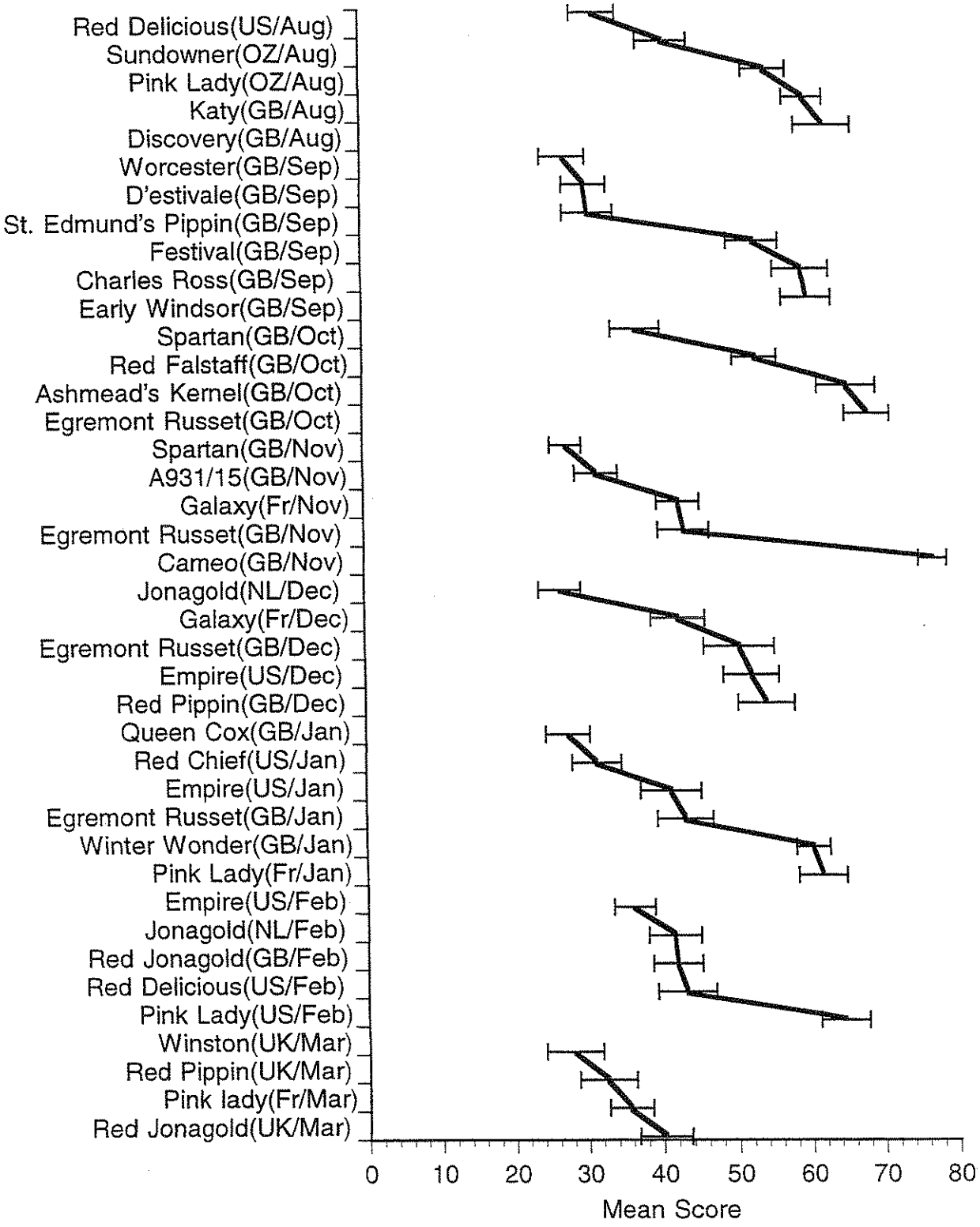
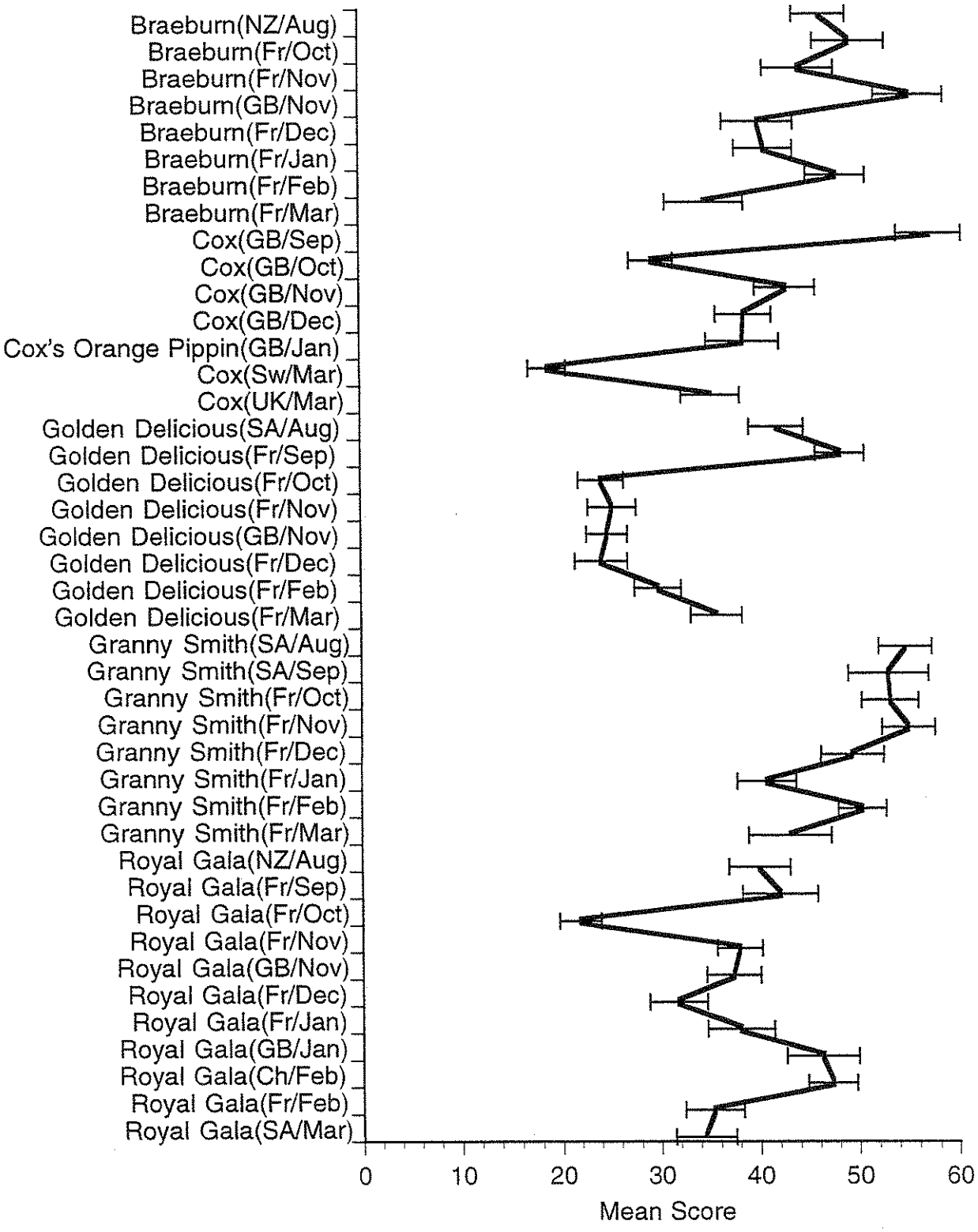


Figure 20


Texture - Toughness
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Texture - Toughness

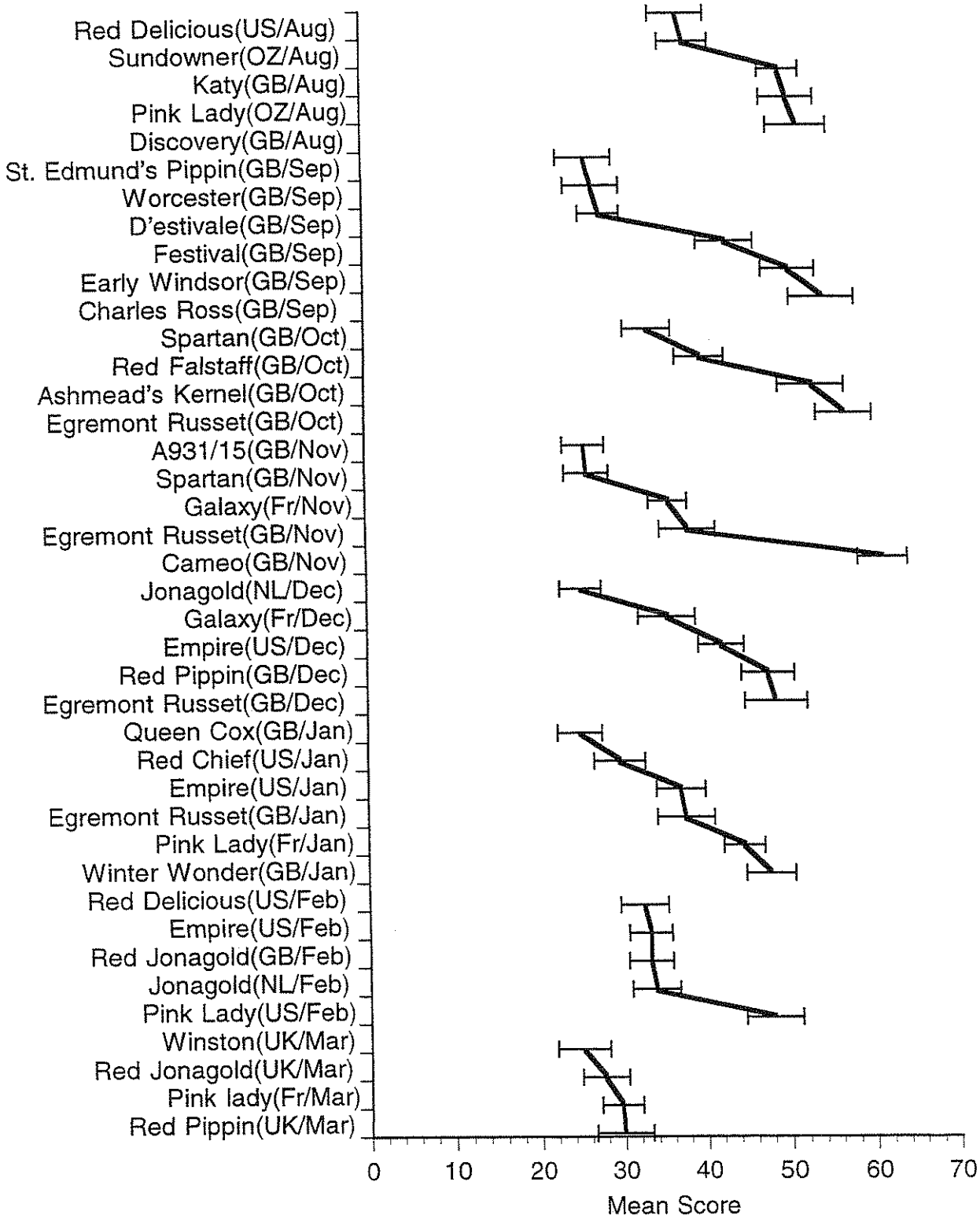
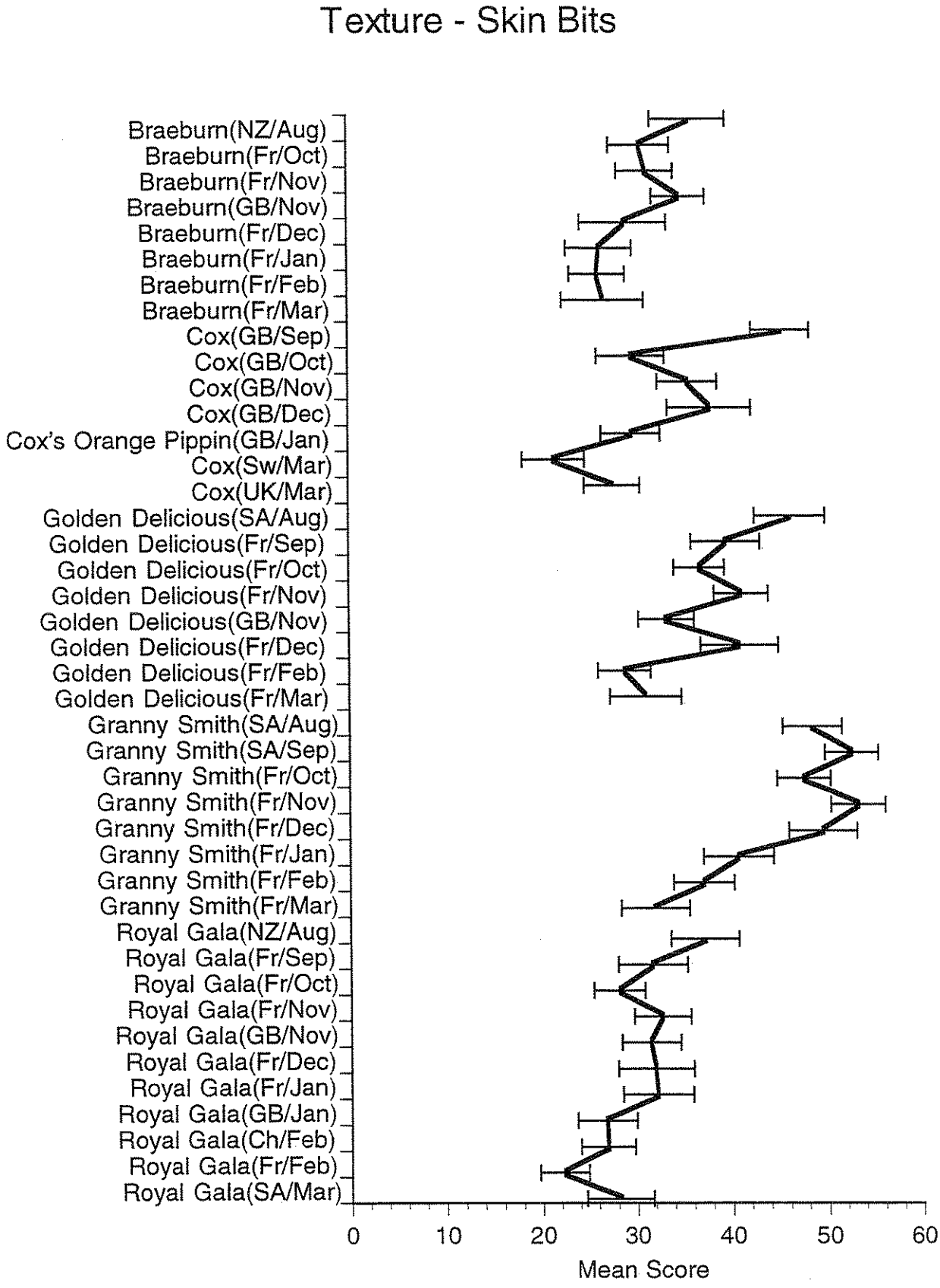


Figure 21


Texture - Skin Bits
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Texture - Skin Bits

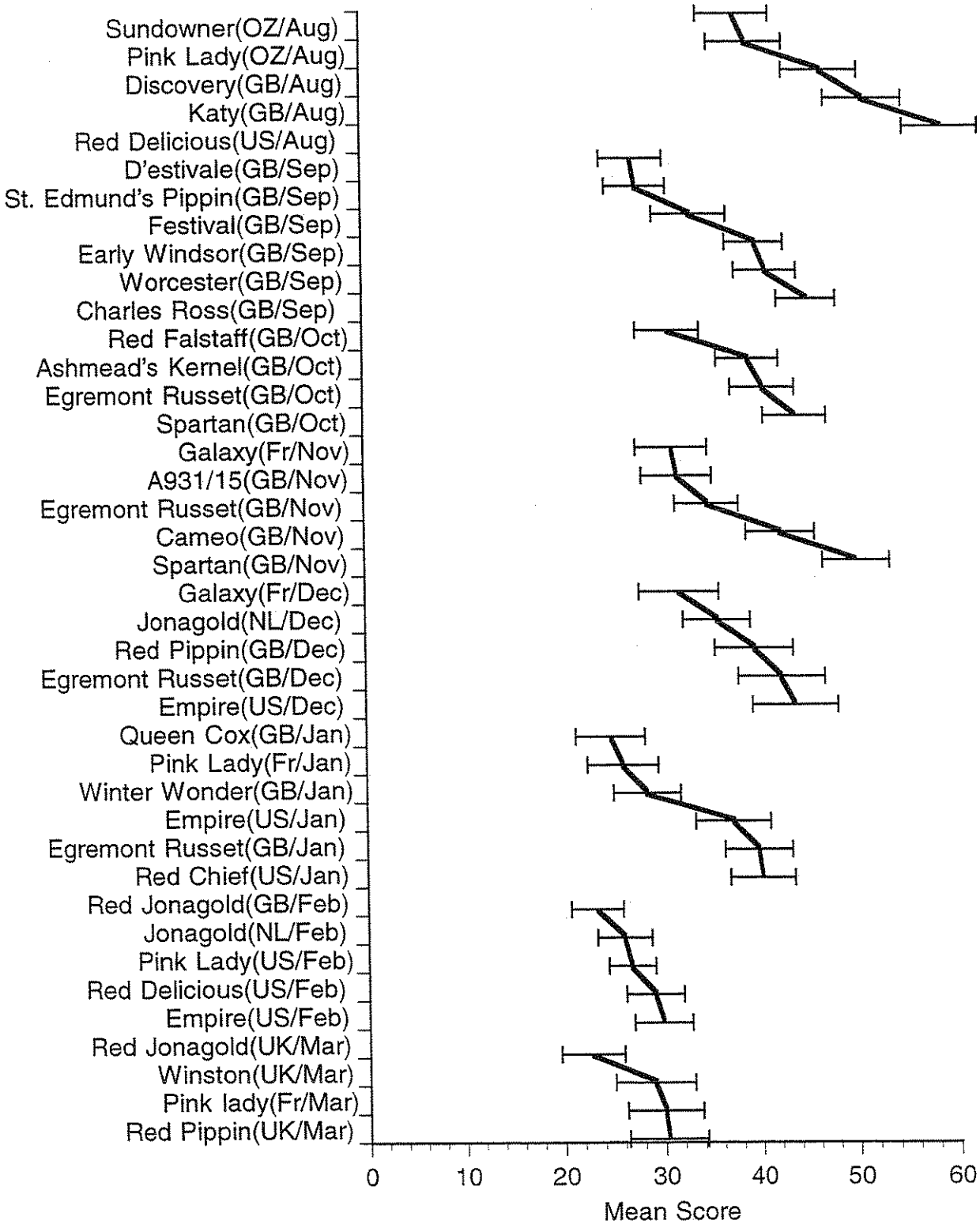
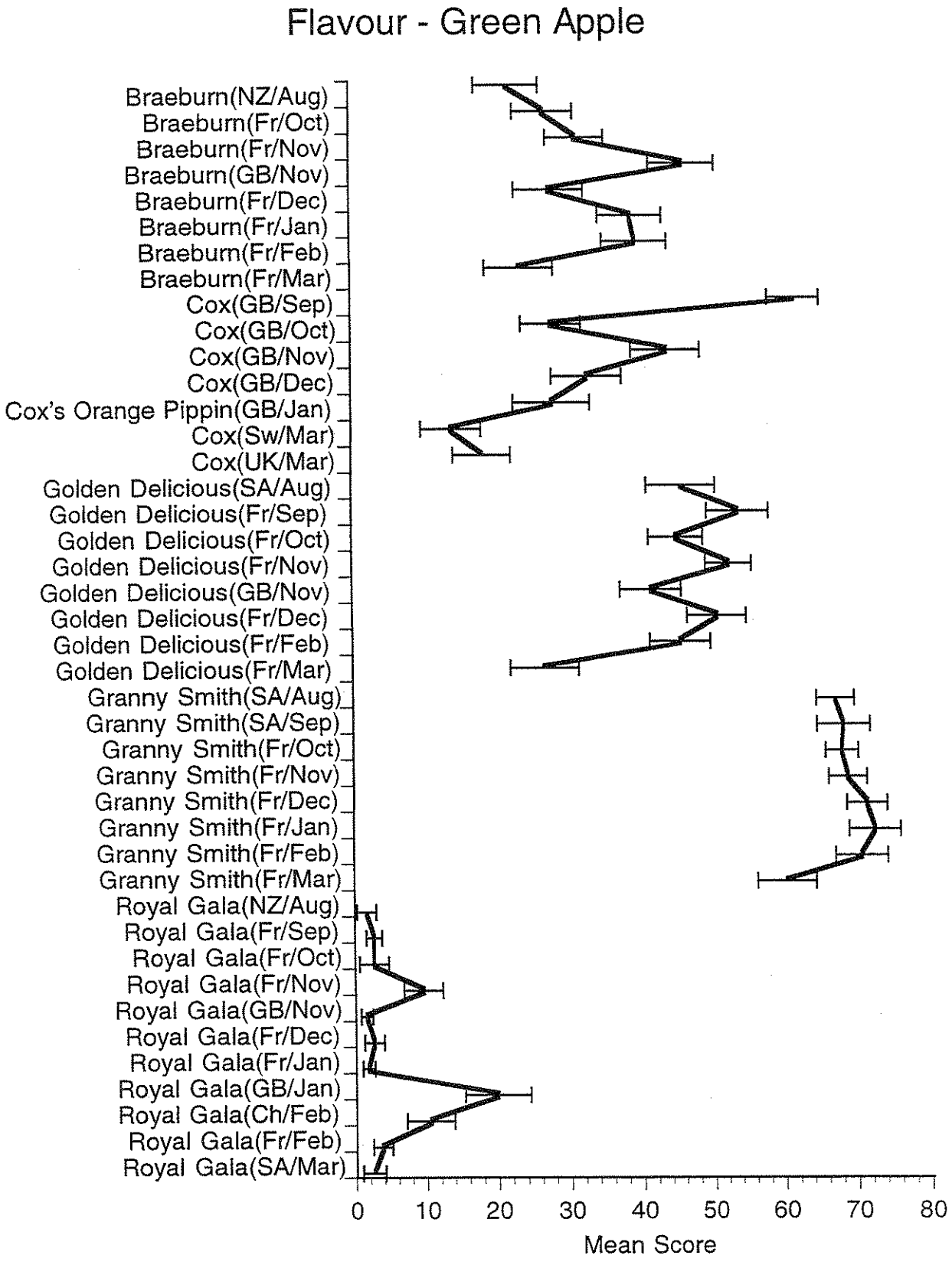


Figure 22


Flavour - Green Apple
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
80
Mean Score

Flavour - Green Apple

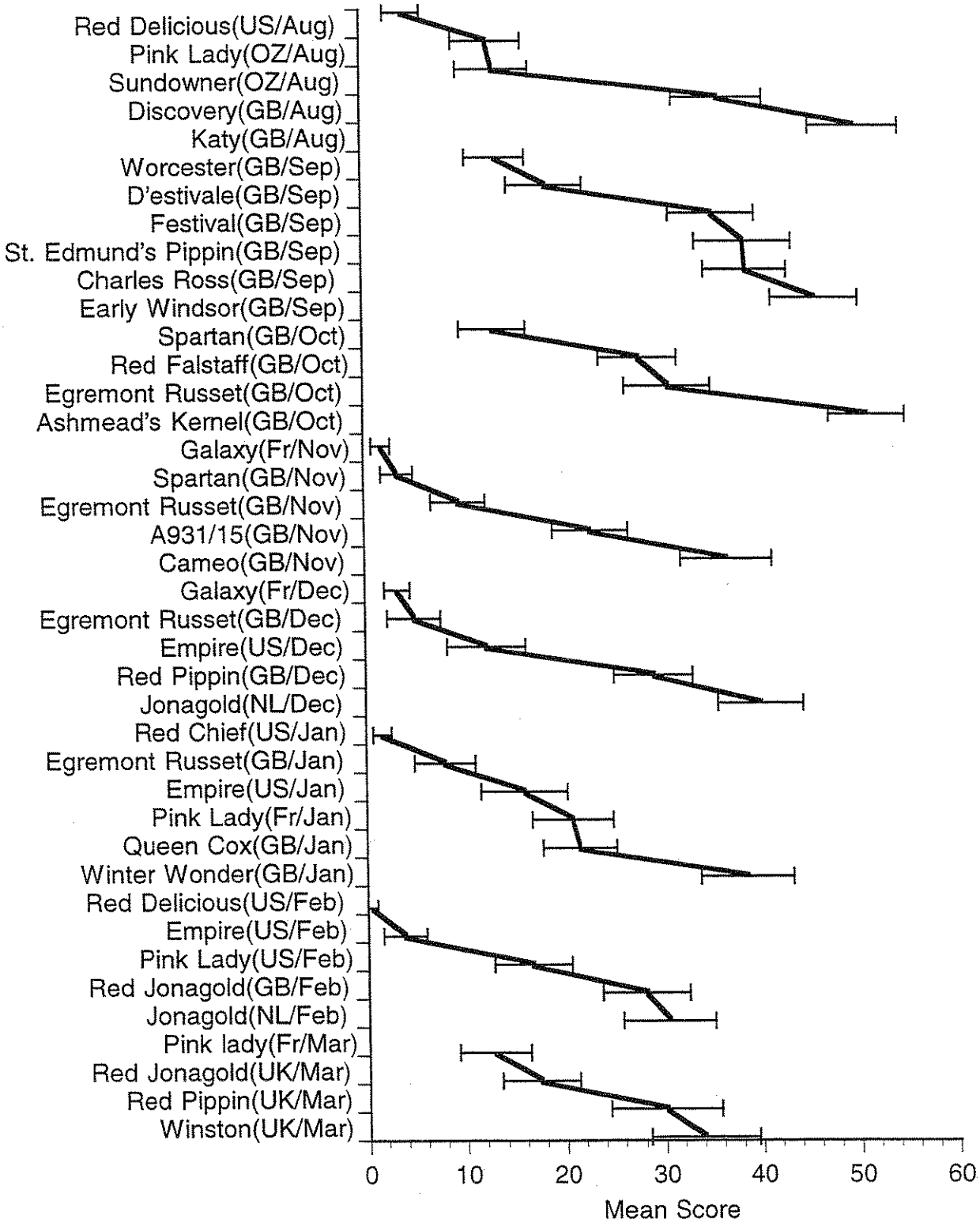
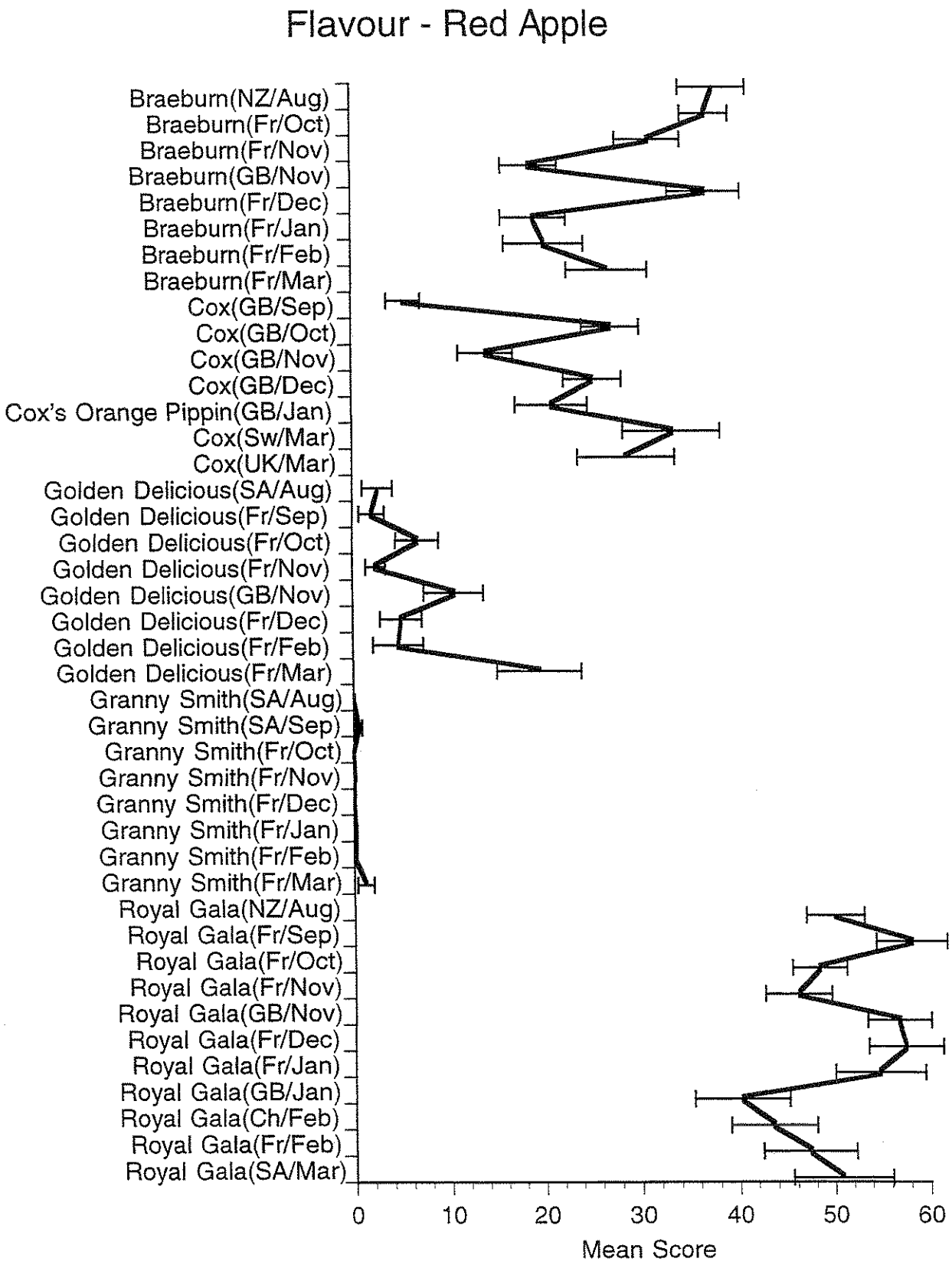


Figure 23


Flavour - Red Apple
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Flavour - Red Apple

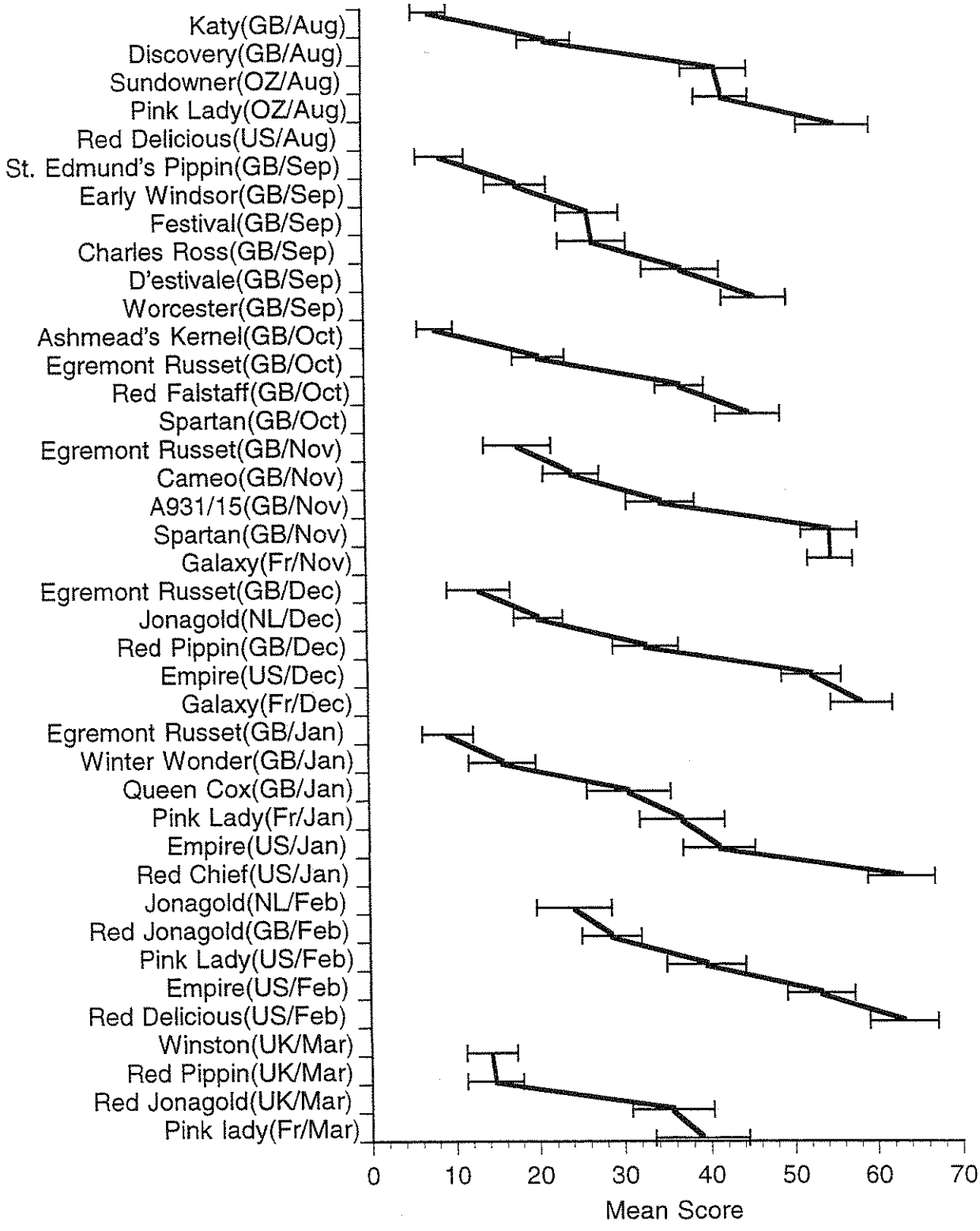
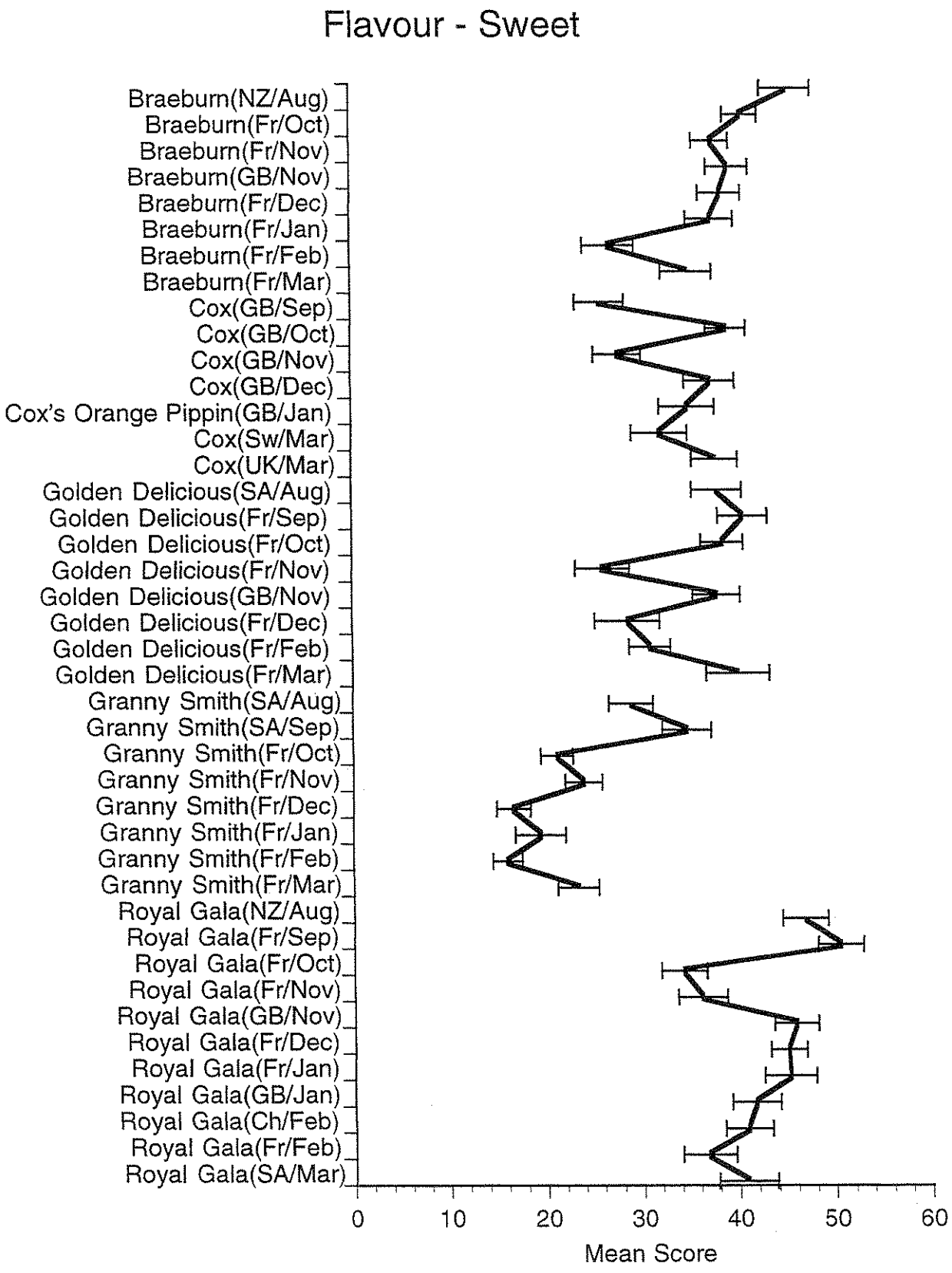


Figure 24


Flavour - Sweet
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Flavour - Sweet

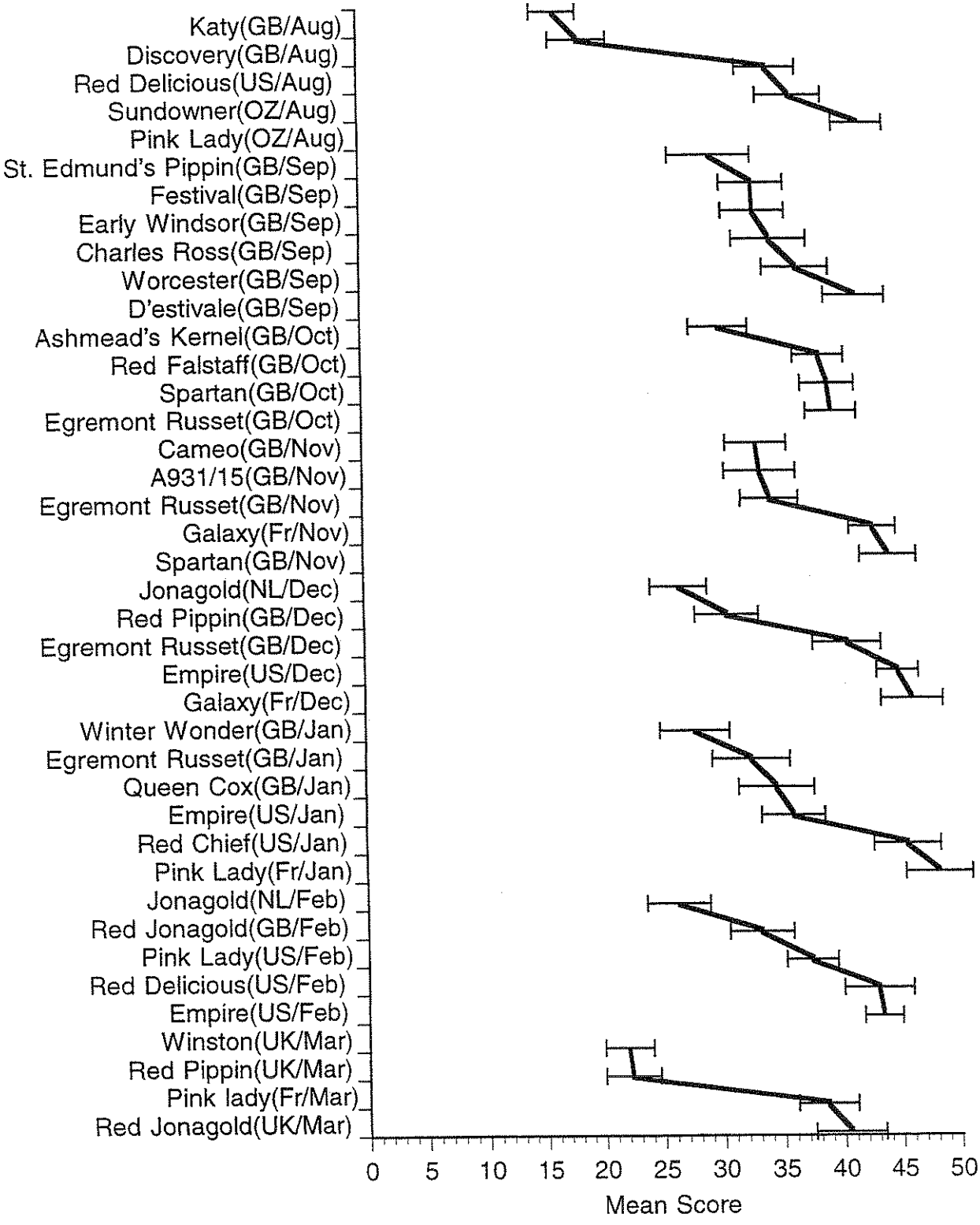
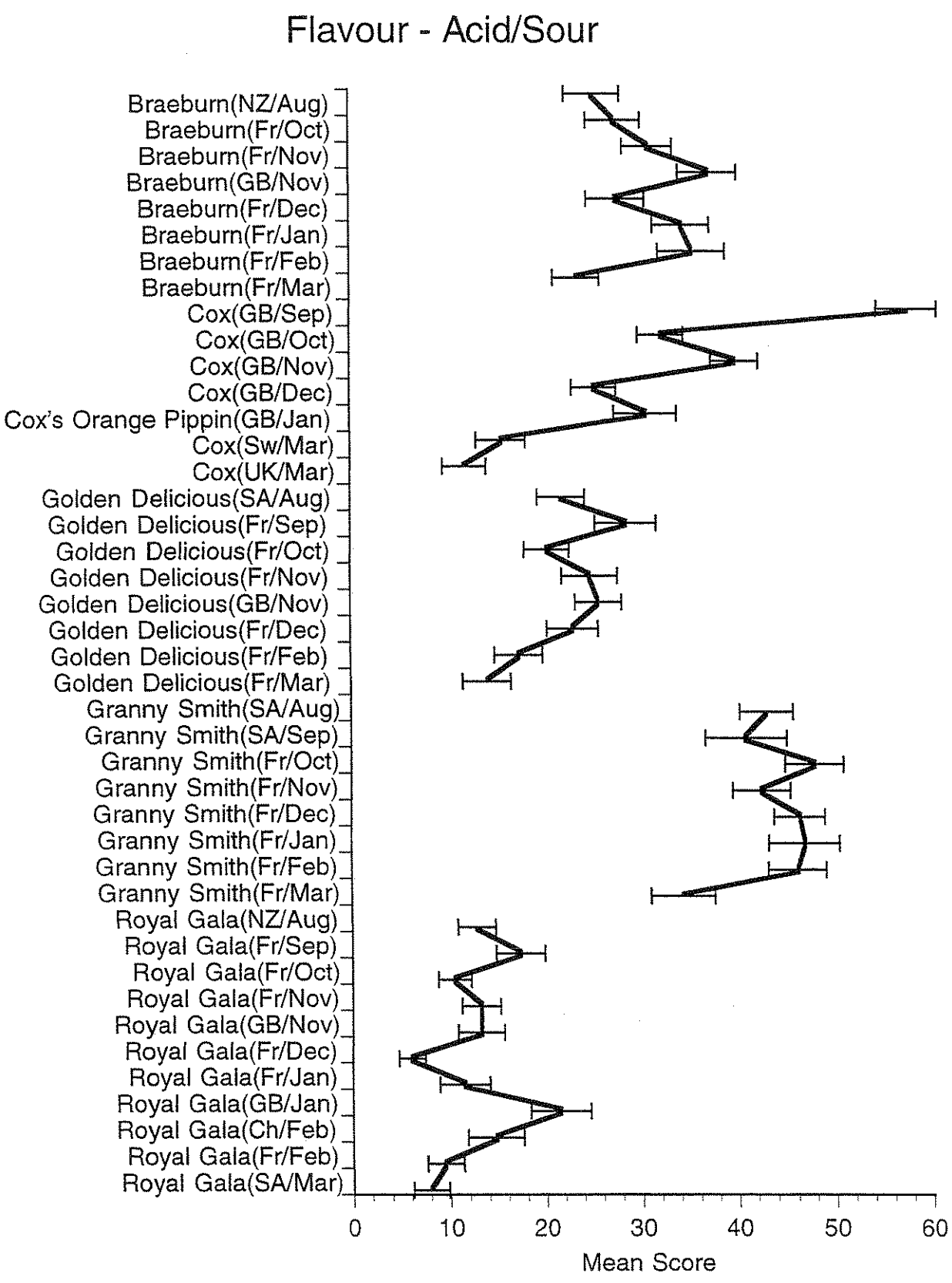


Figure 25


Flavour - Acid/Sour
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Flavour - Acid Sour

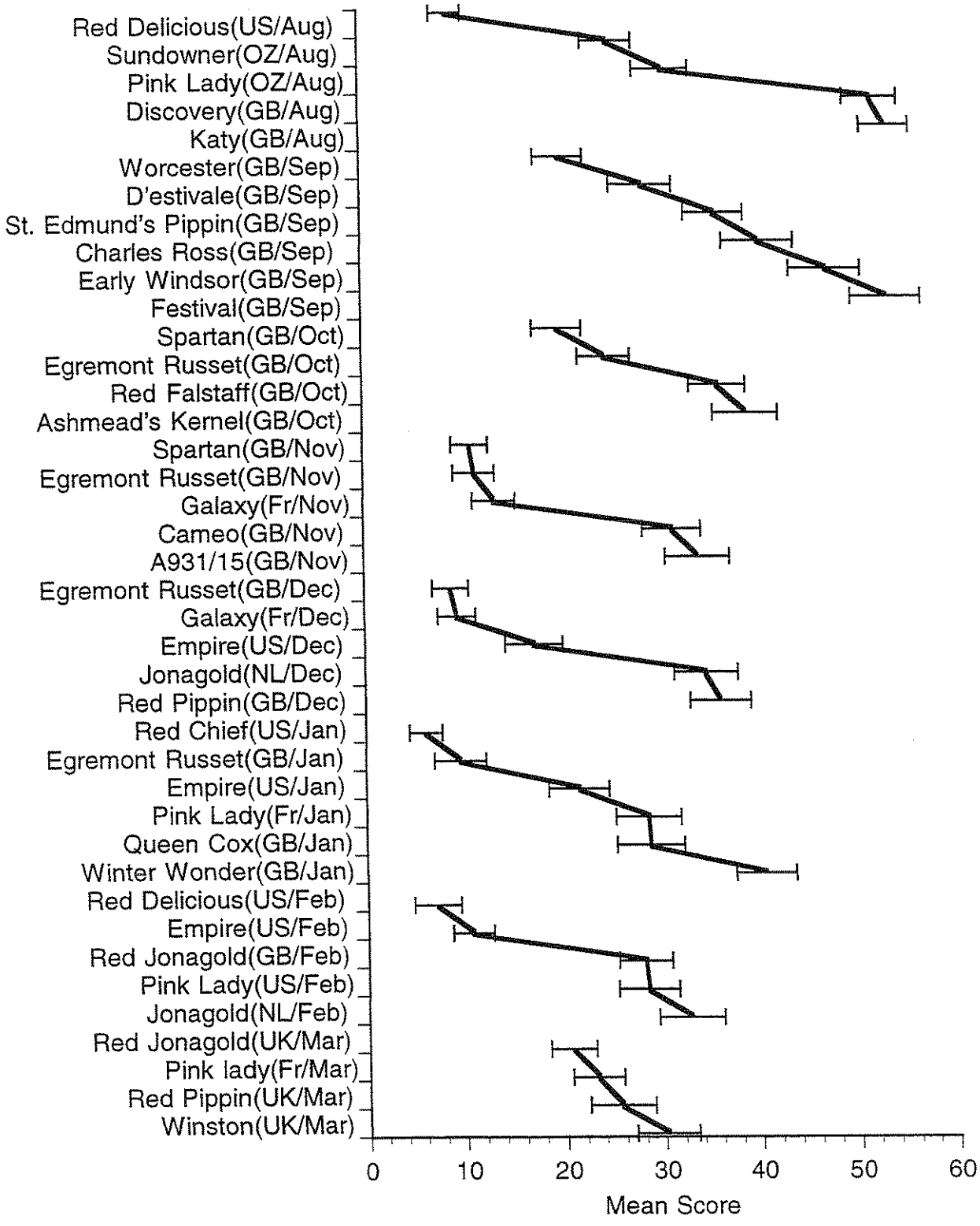
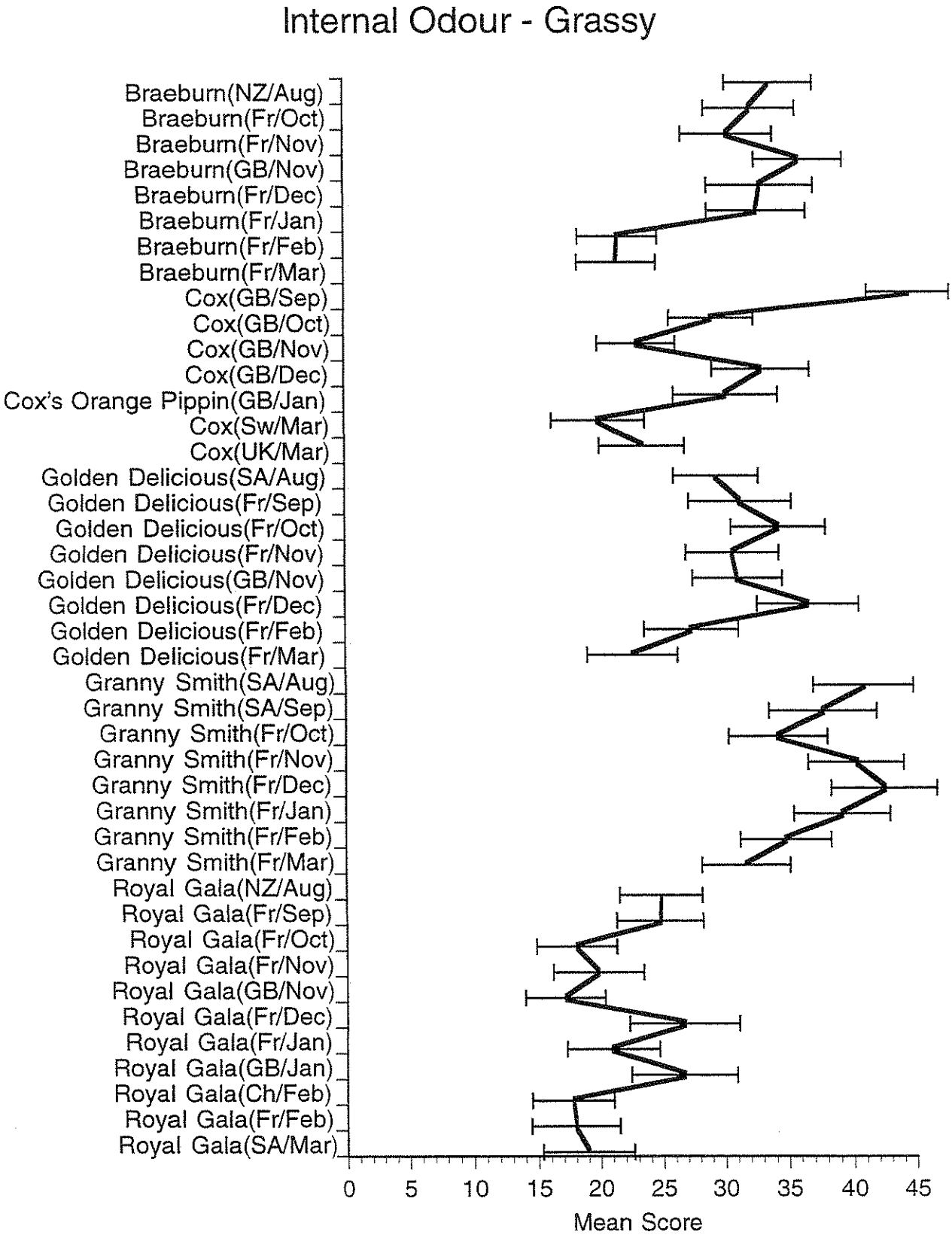


Figure 26


Internal Odour - Grassy
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
35
40
45
Mean Score

Internal Odour - Grassy

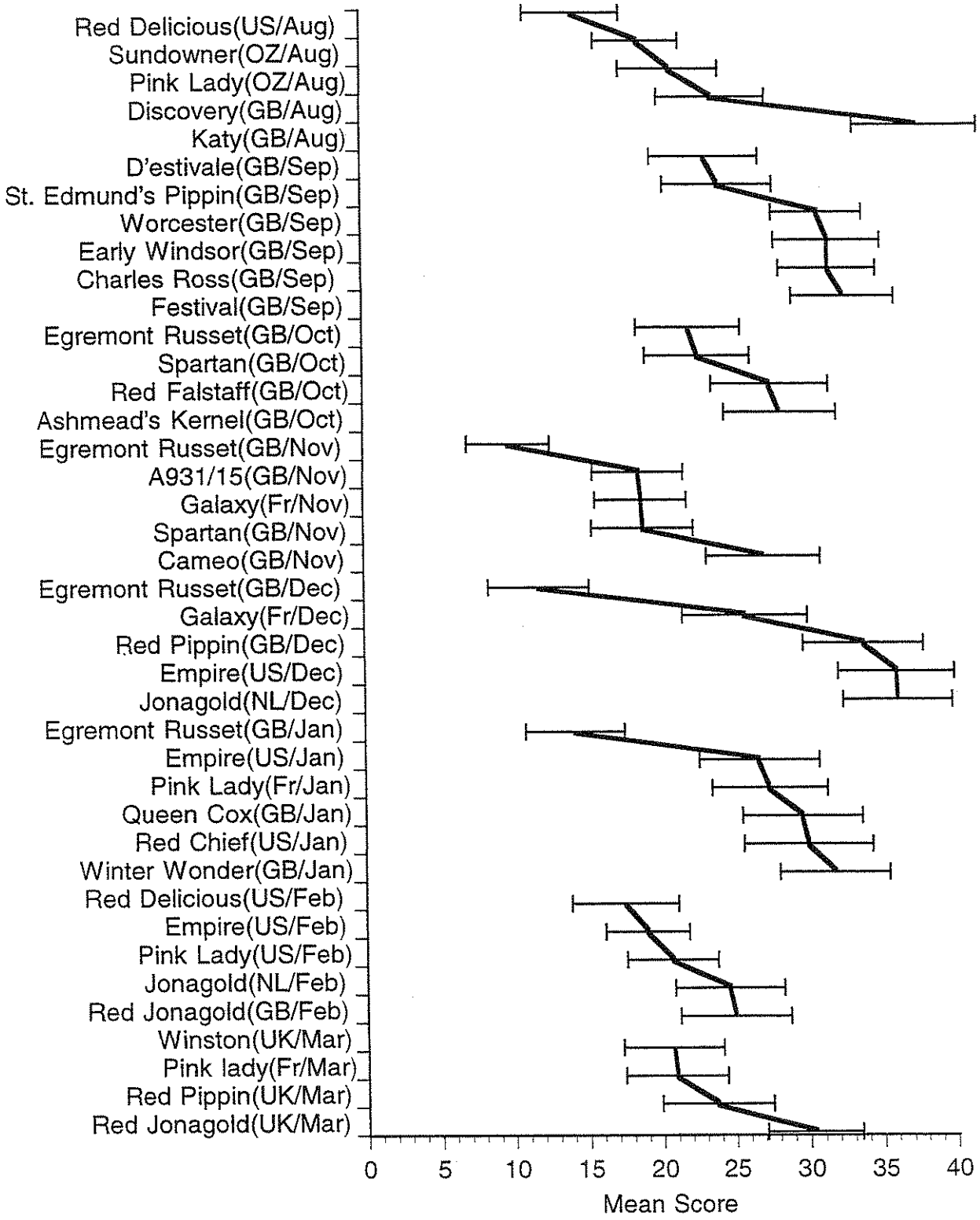
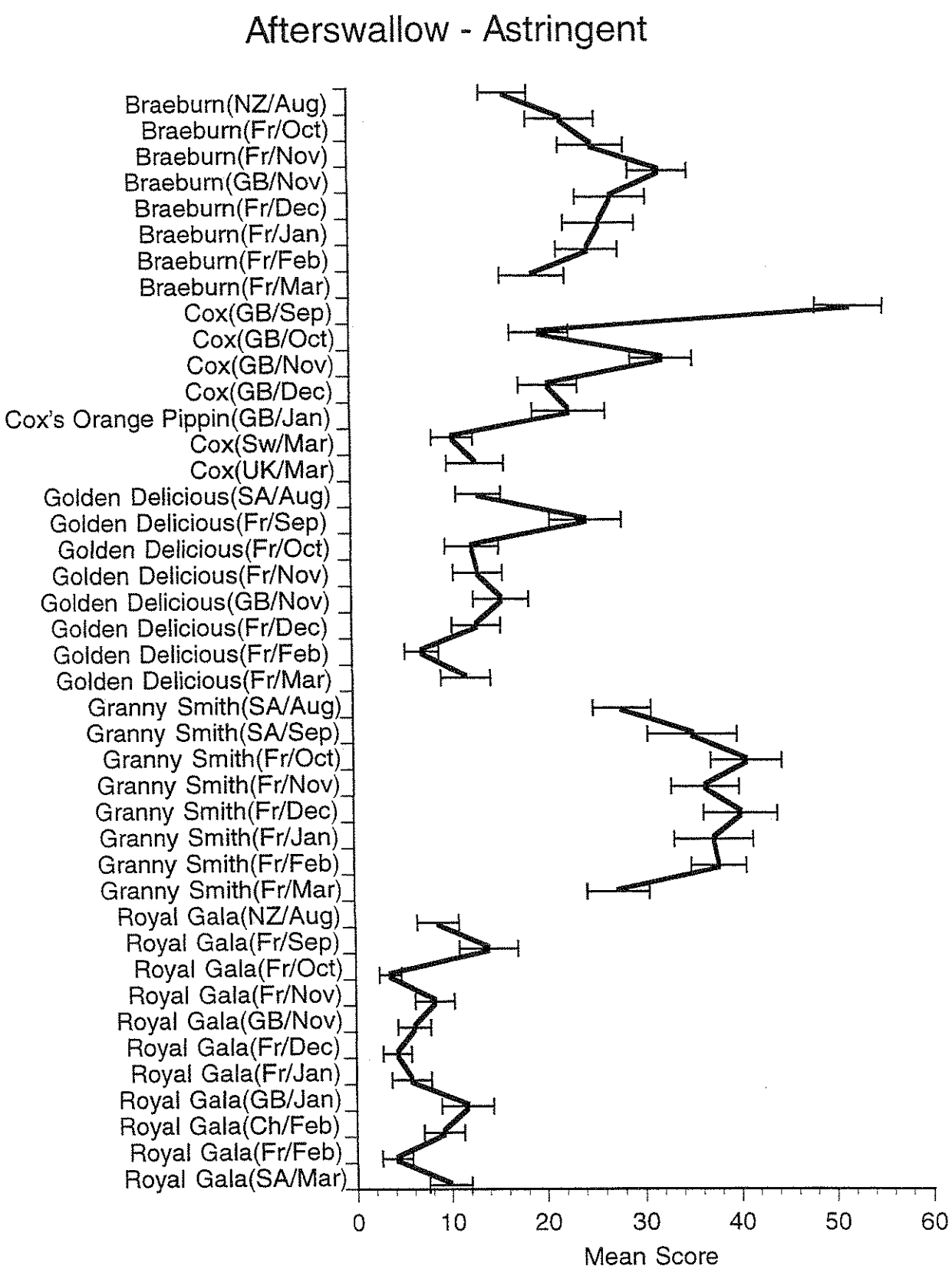


Figure 27


Afterswallow - Astringent
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Afterswallow - Astringent

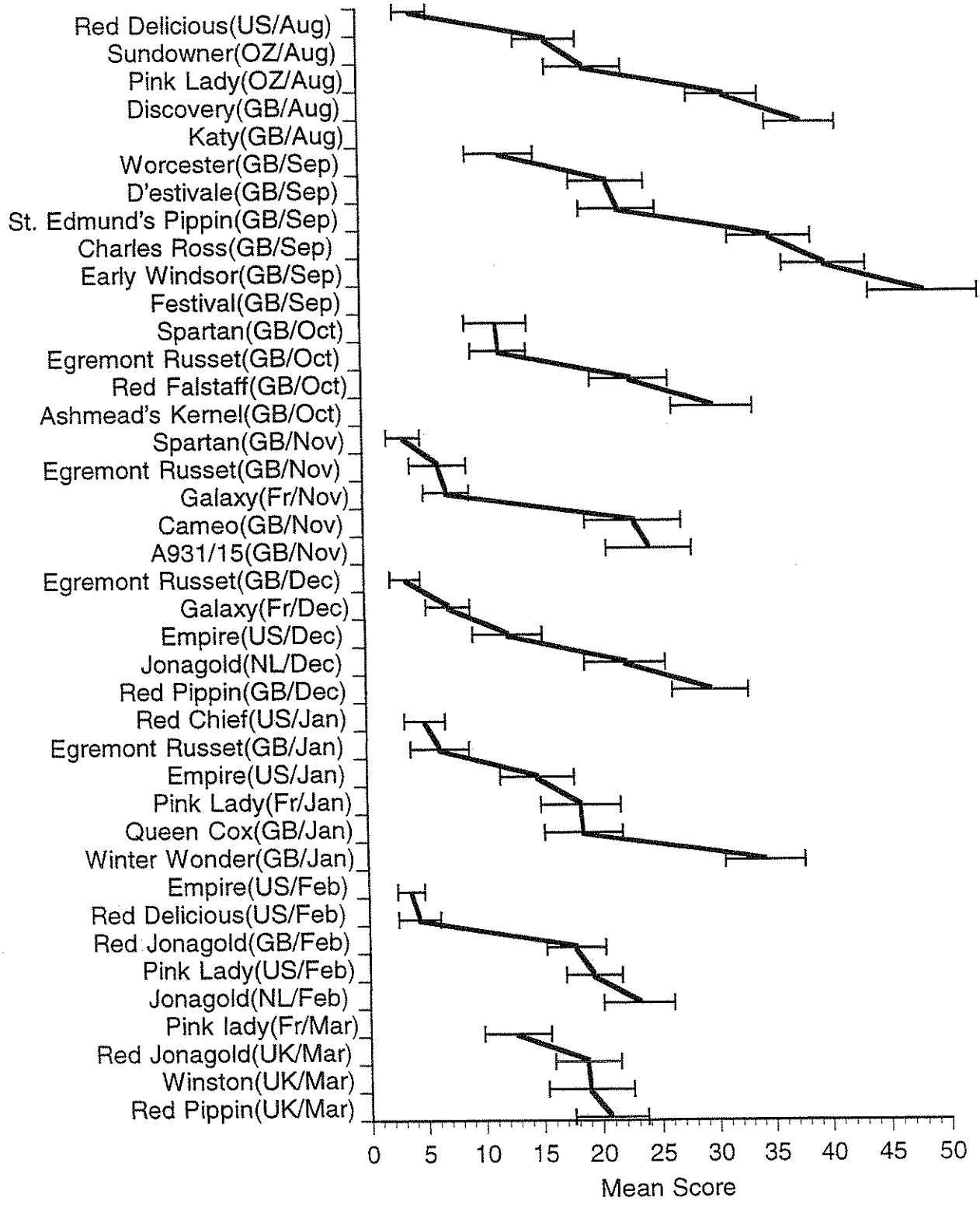
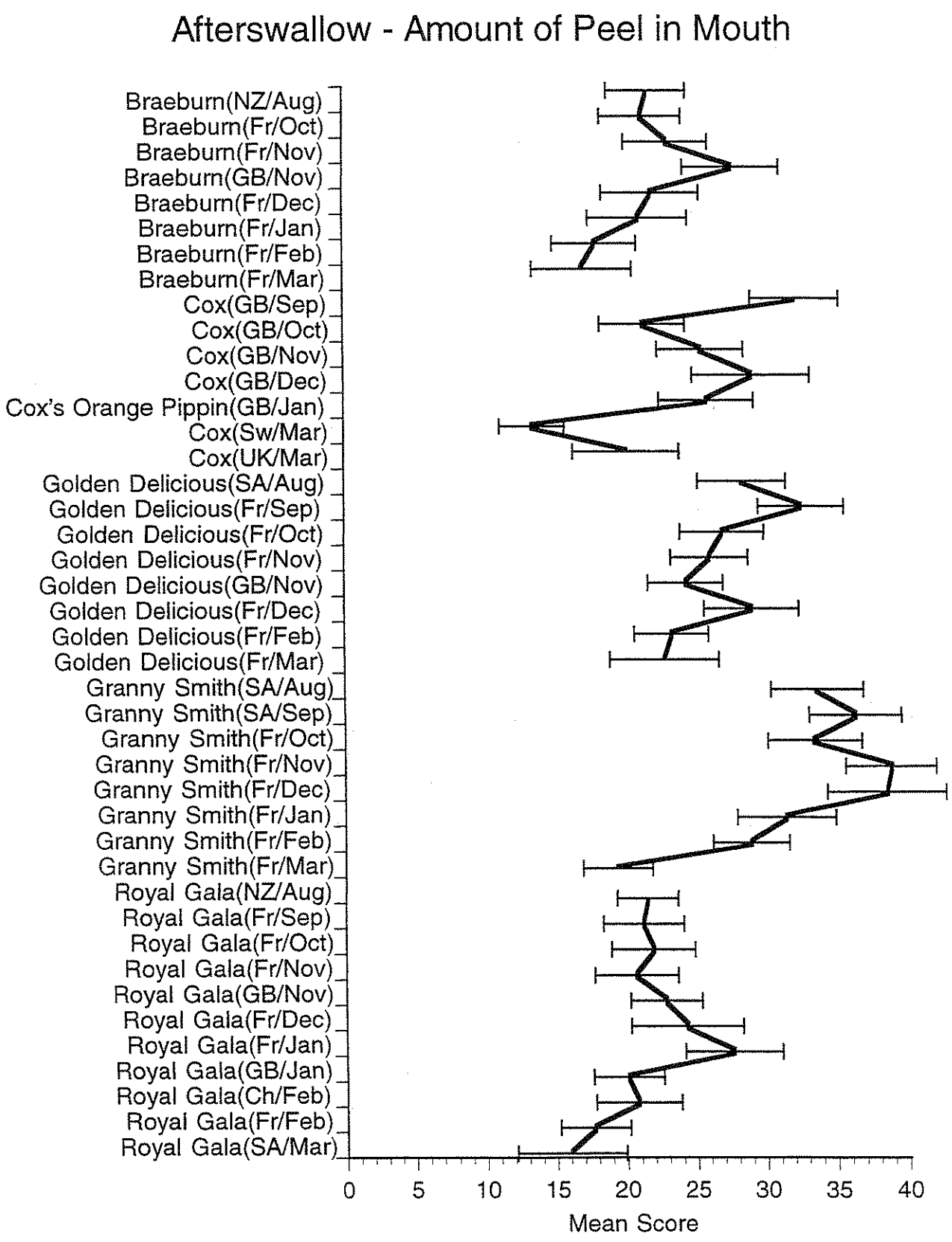


Figure 28


Afterswallow - Amount of Peel in Mouth
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
35
40
Mean Score

Afterswallow - Amount of Peel in Mouth

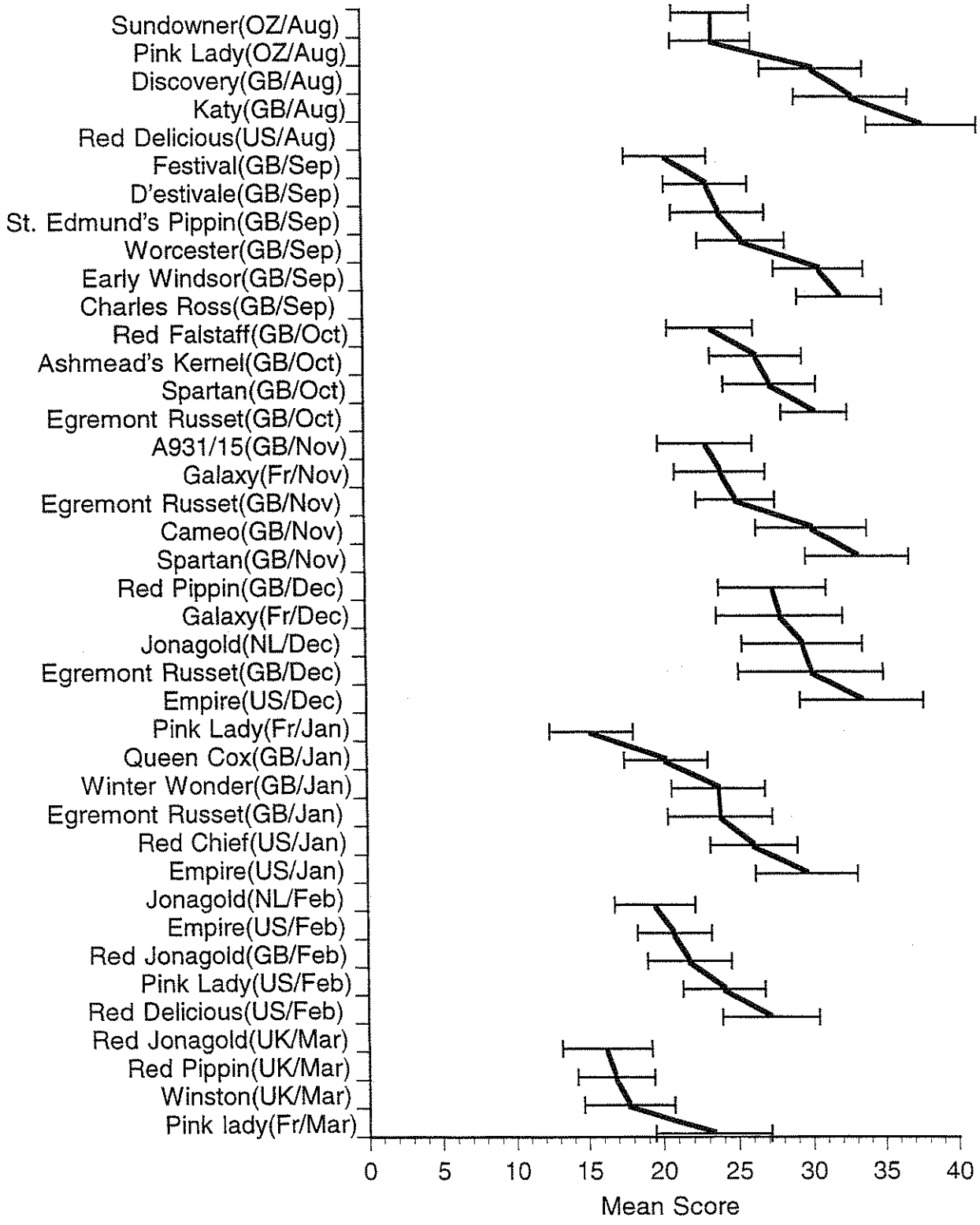
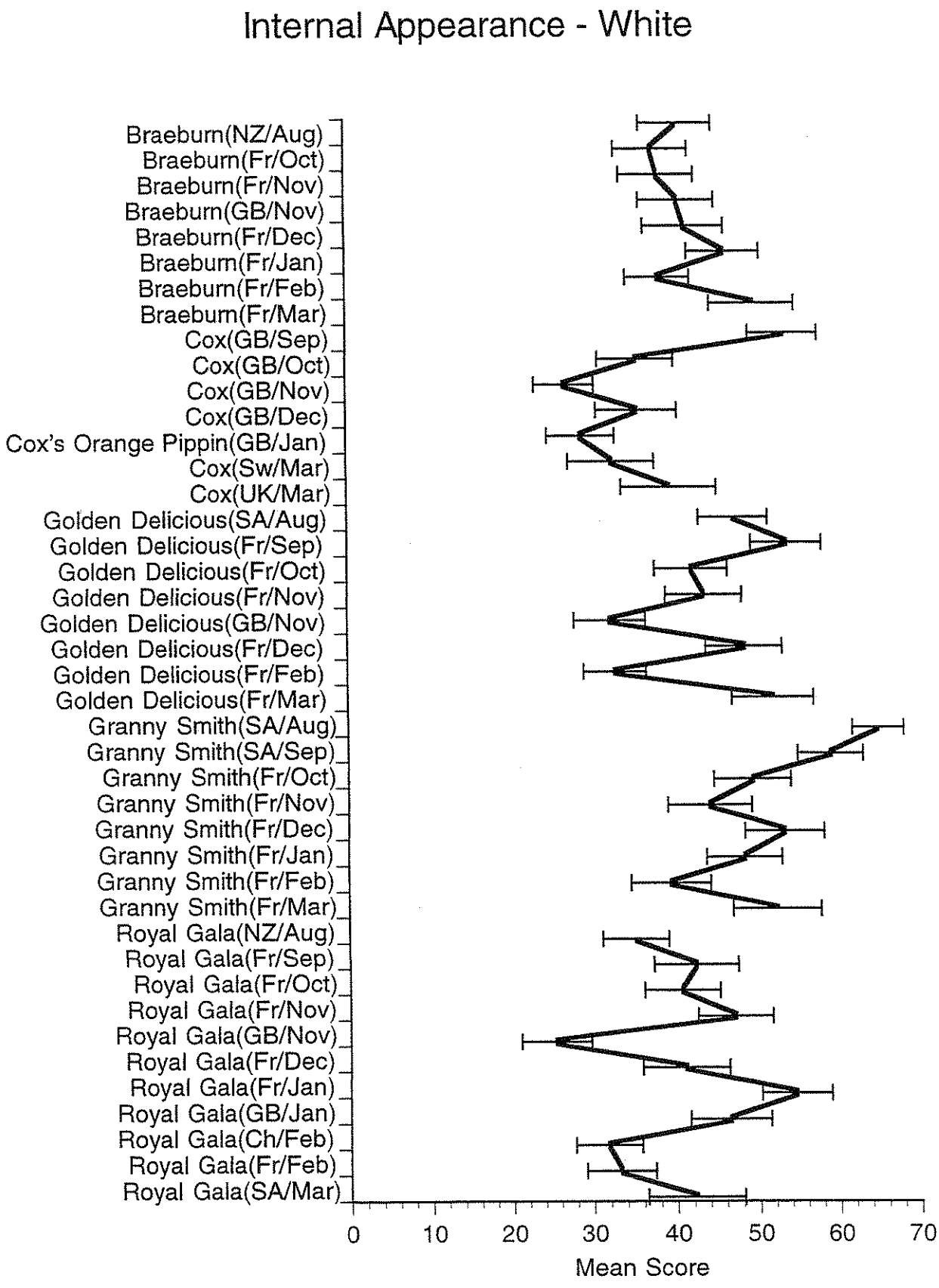


Figure 29


Internal Appearance - White
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
70
Mean Score

Internal Appearance - White

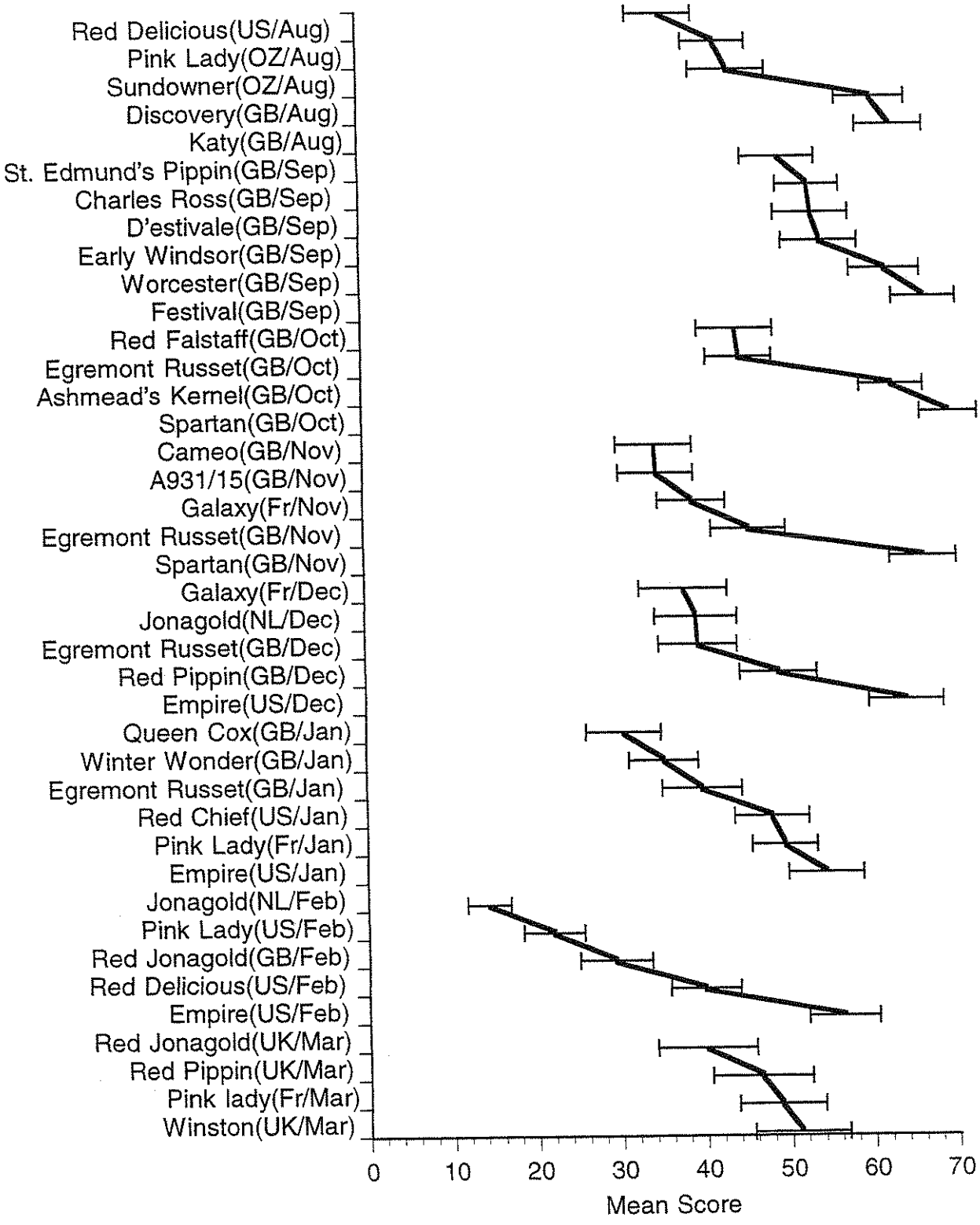
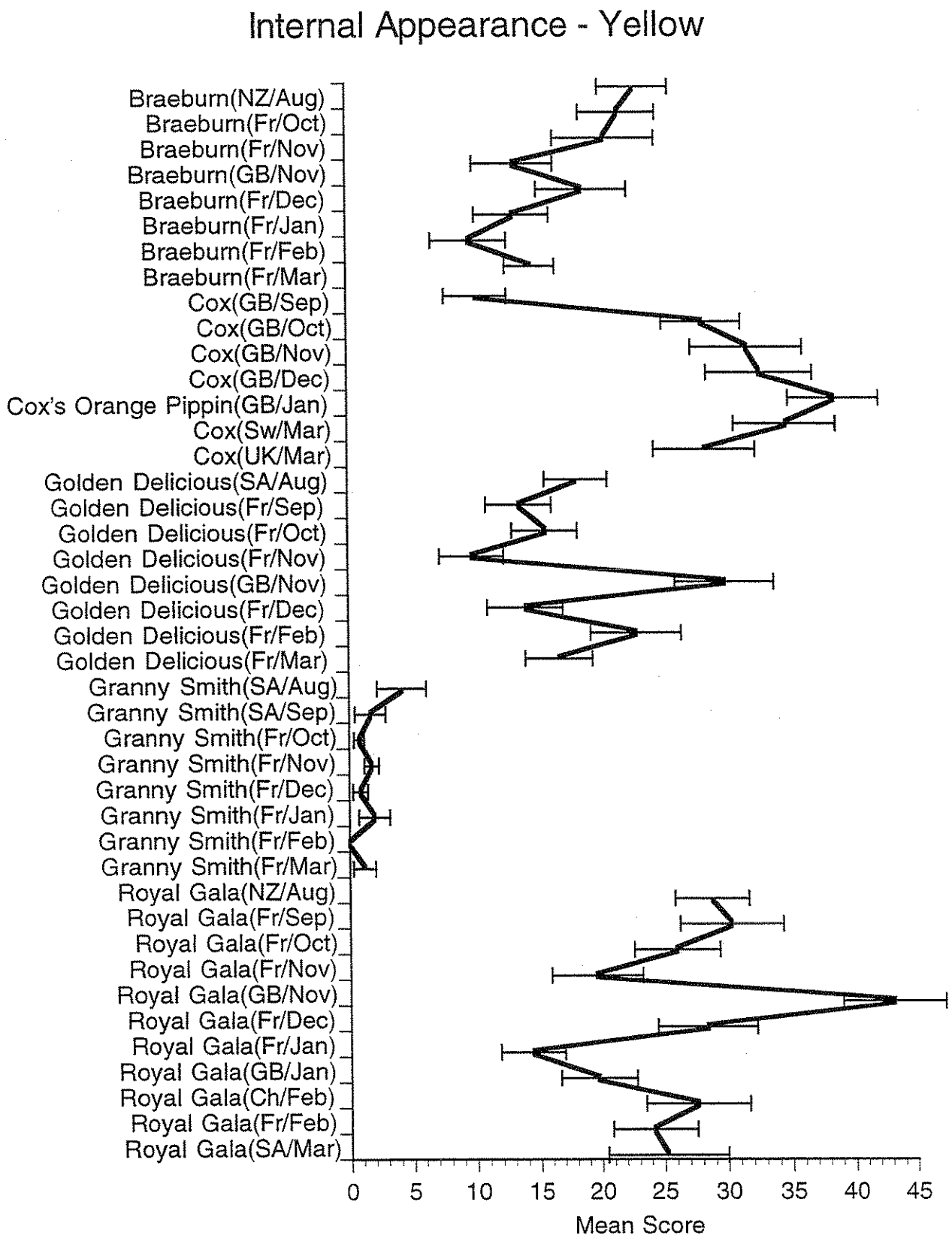


Figure 30


Internal Appearance - Yellow
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
35
40
45
Mean Score

Internal Appearance - Yellow

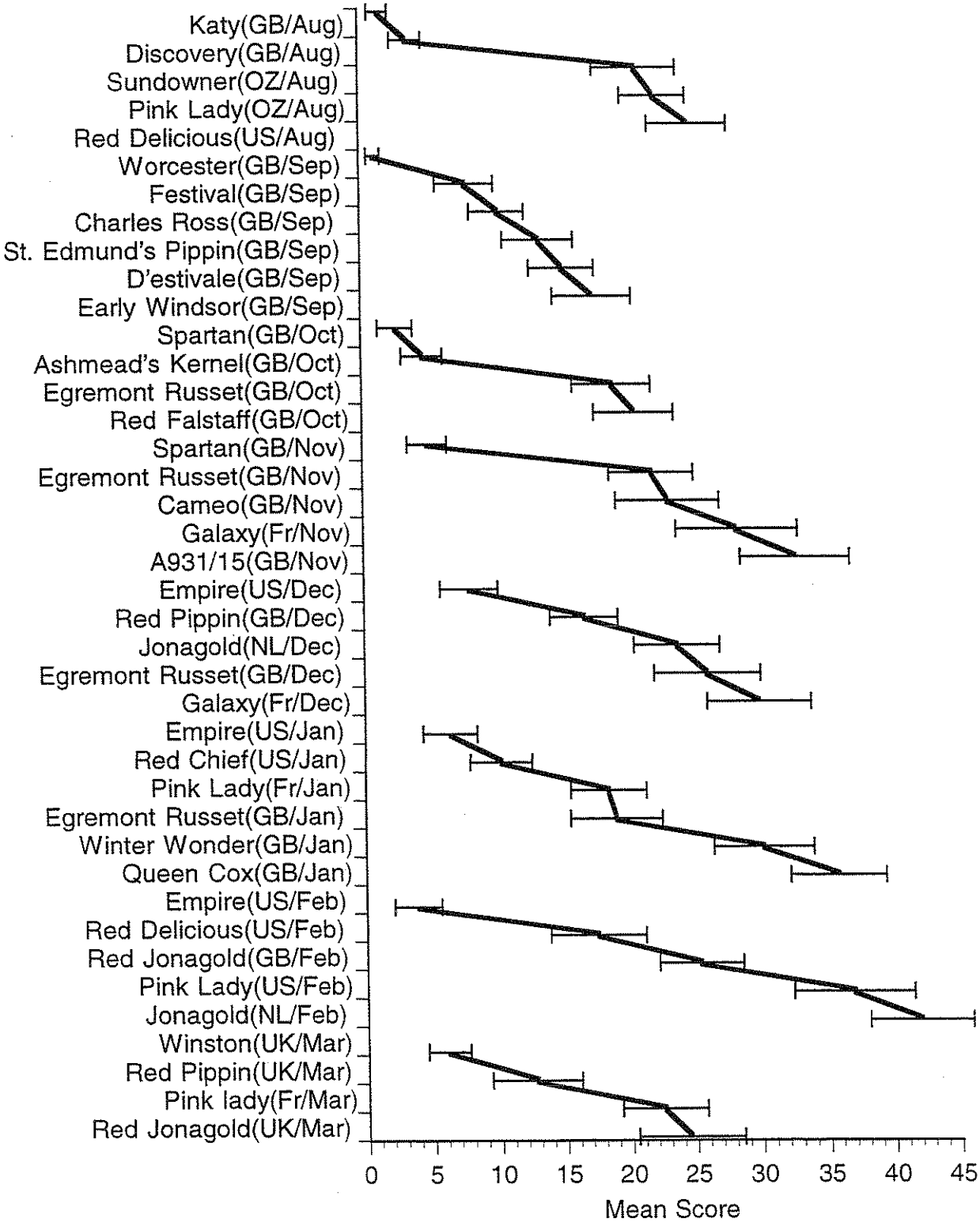
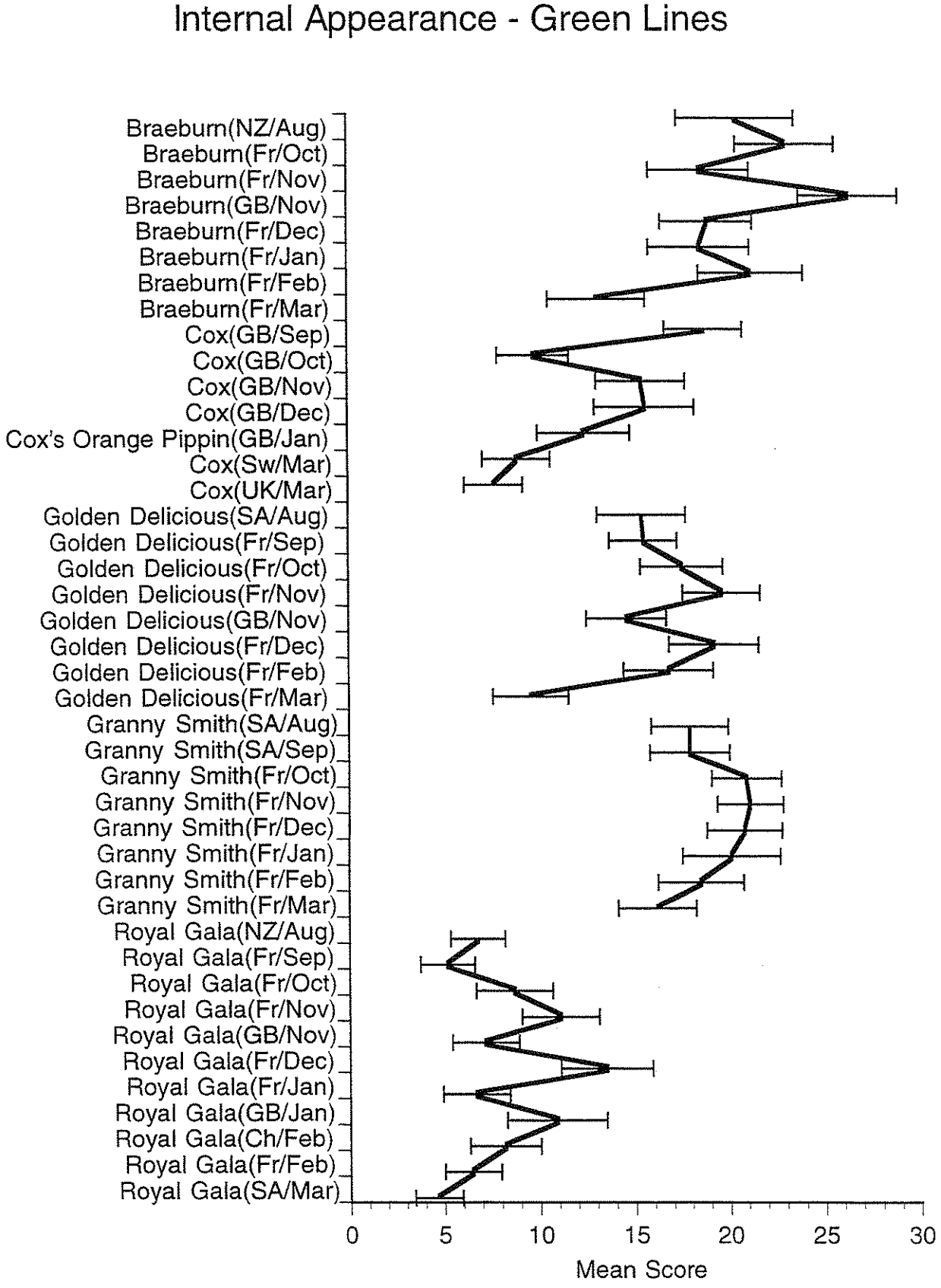


Figure 31


Internal Appearance - Green Lines
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
Mean Score

Internal Appearance - Green Lines

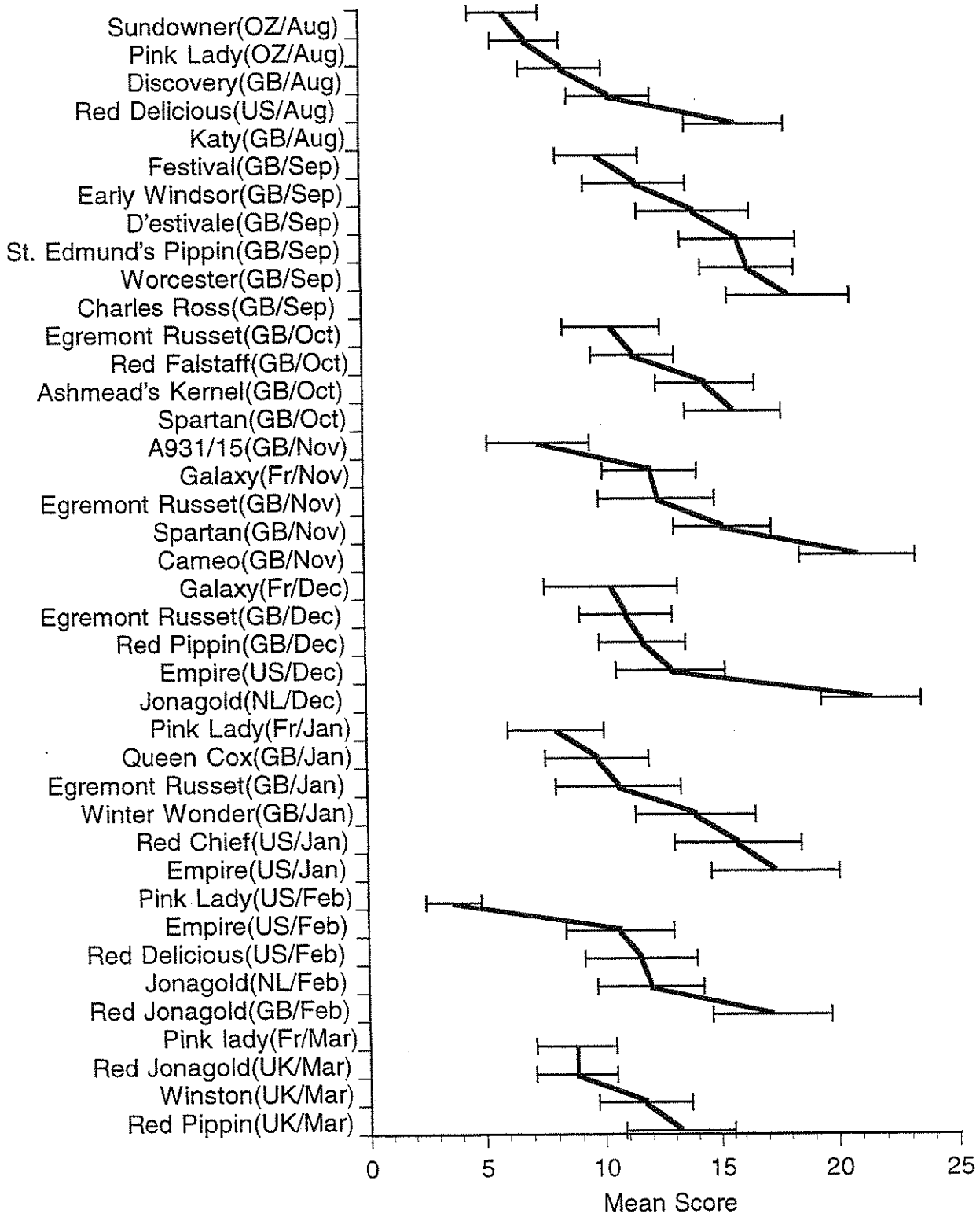
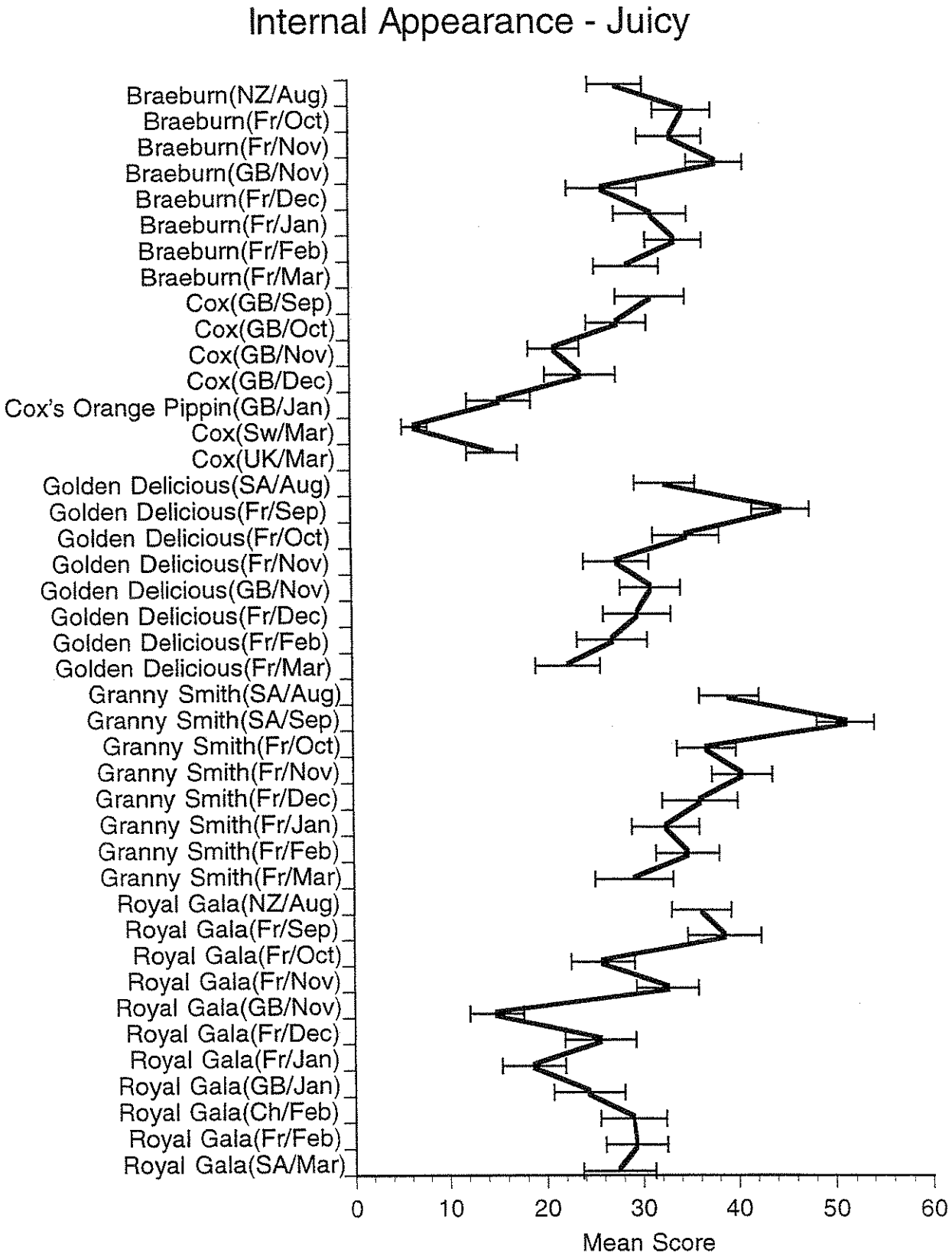


Figure 32


Internal Appearance - Juicy
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
10
20
30
40
50
60
Mean Score

Internal Appearance - Juicy

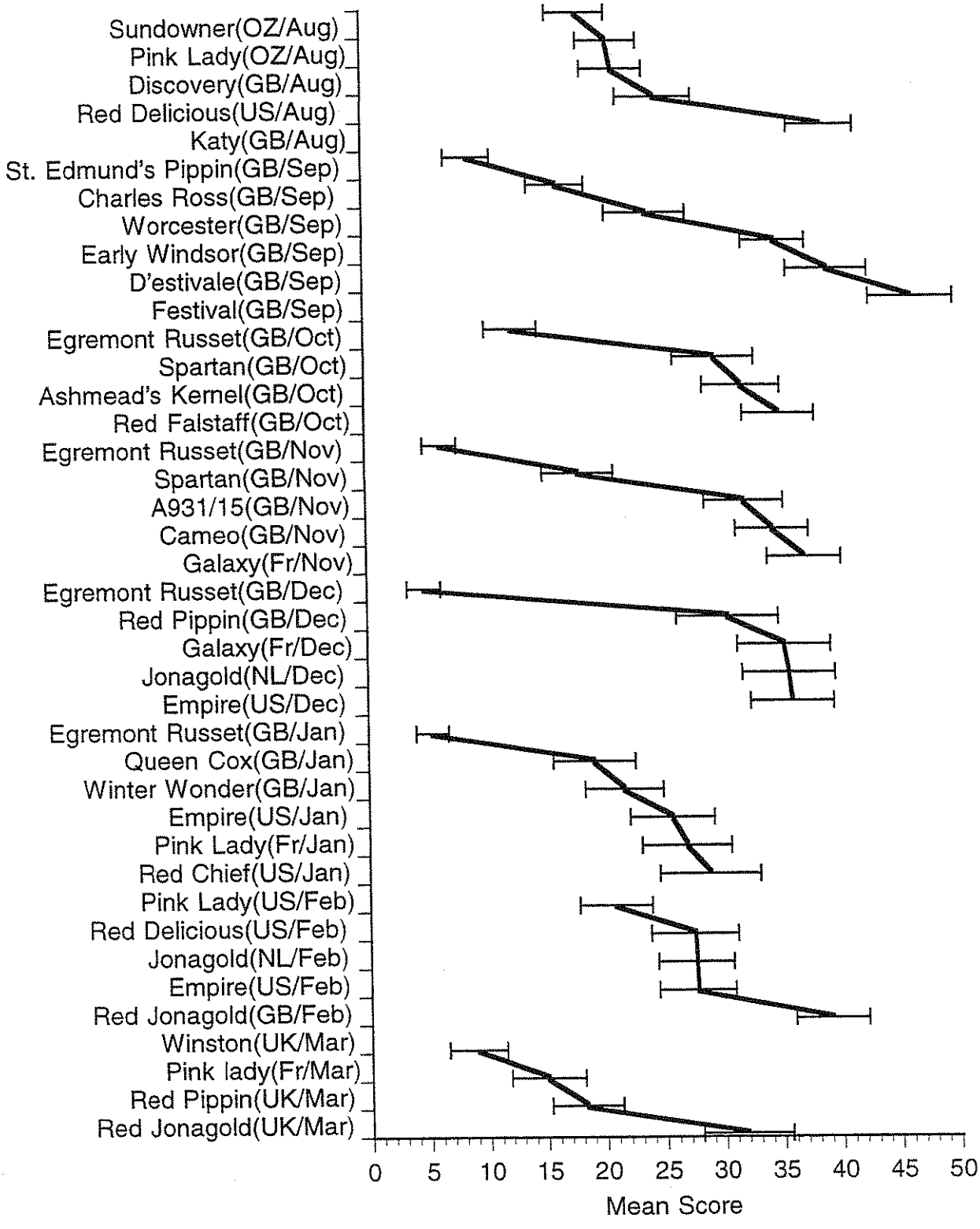
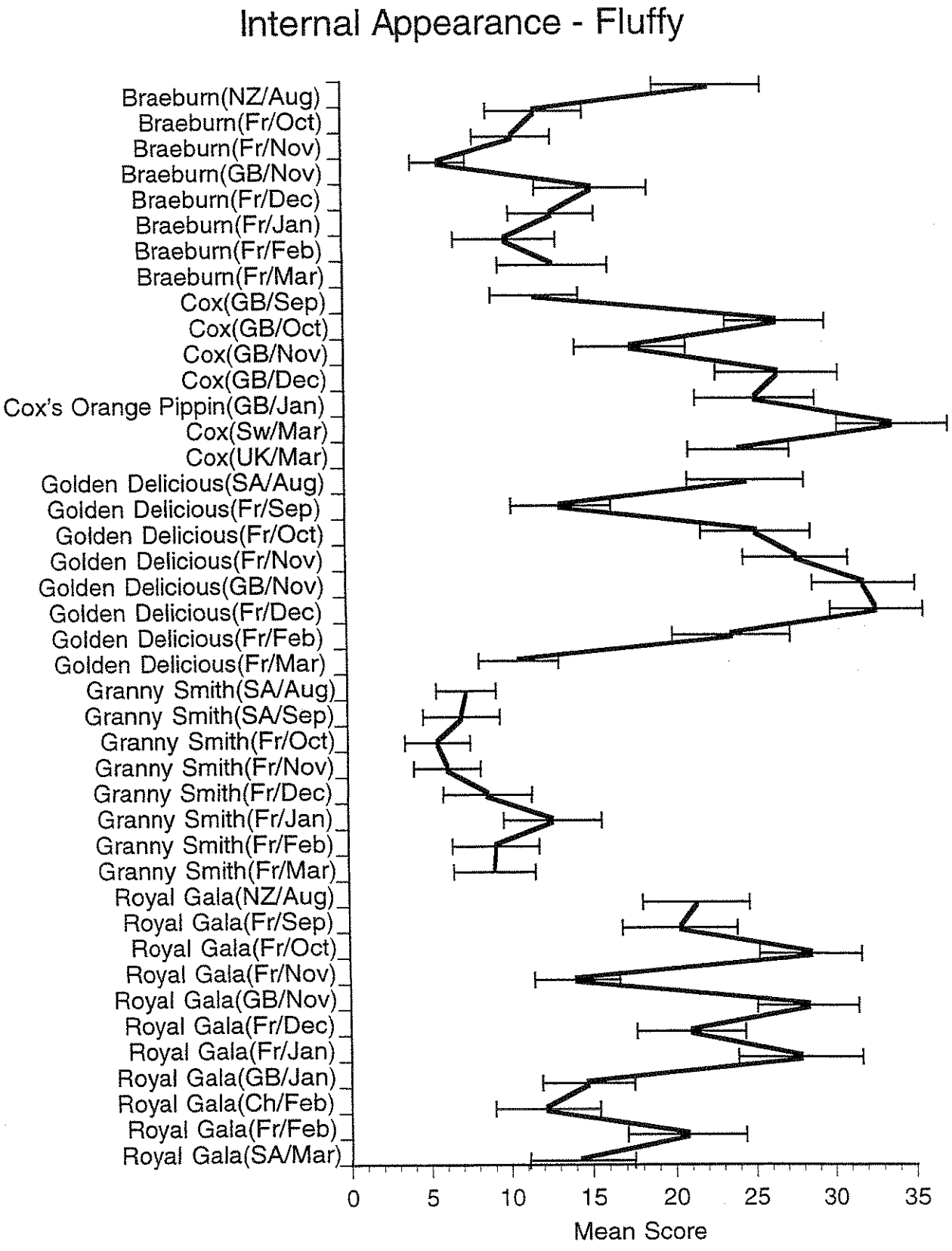
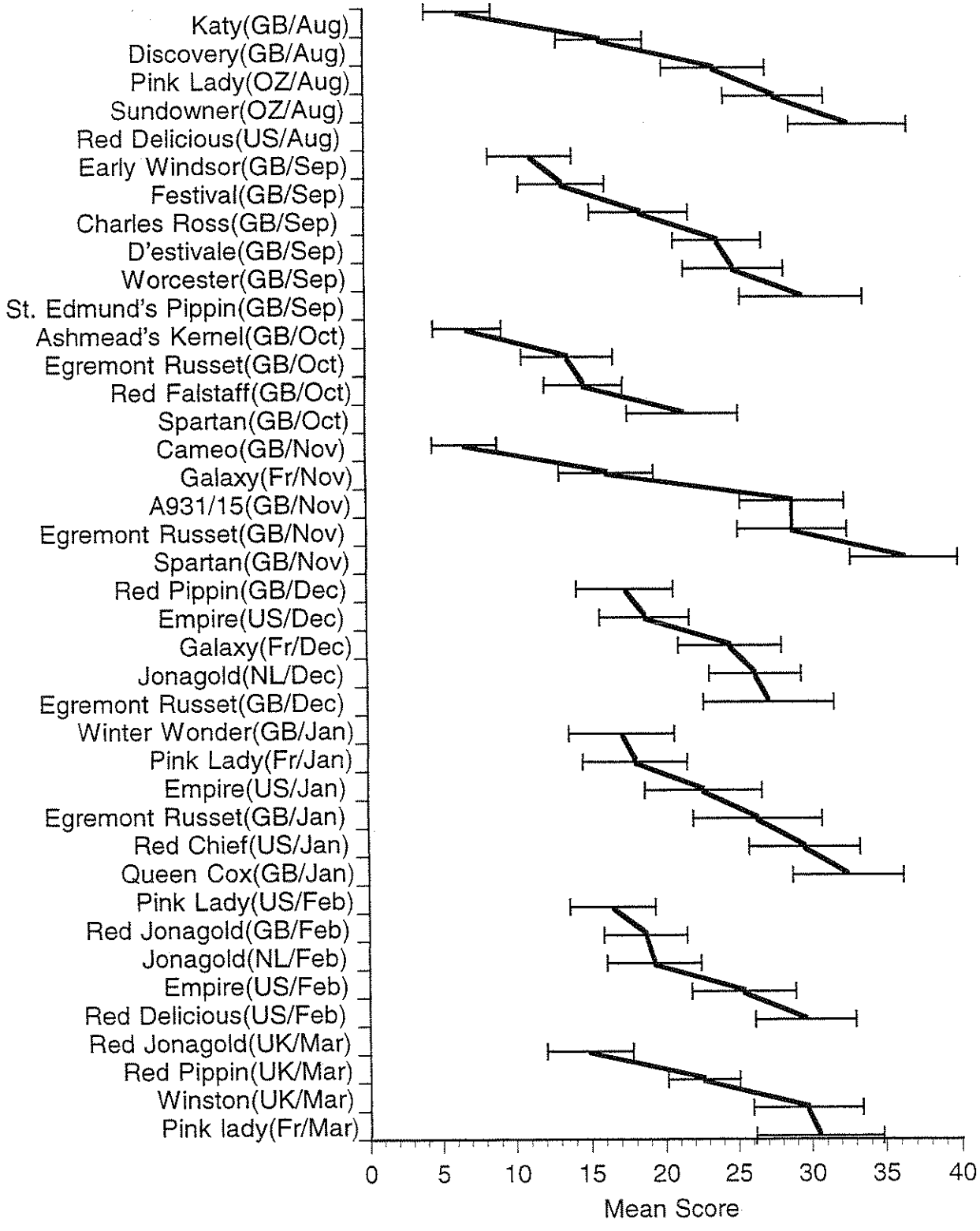


Figure 33


Internal Appearance - Fluffy
Braeburn(NZ/Aug)
Braeburn(Fr/Oct)
Braeburn(Fr/Nov)
Braeburn(GB/Nov)
Braeburn(Fr/Dec)
Braeburn(Fr/Jan)
Braeburn(Fr/Feb)
Braeburn(Fr/Mar)
Cox(GB/Sep)
Cox(GB/Oct)
Cox(GB/Nov)
Cox(GB/Dec)
Cox's Orange Pippin(GB/Jan)
Cox(Sw/Mar)
Cox(UK/Mar)
Golden Delicious(SA/Aug)
Golden Delicious(Fr/Sep)
Golden Delicious(Fr/Oct)
Golden Delicious(Fr/Nov)
Golden Delicious(GB/Nov)
Golden Delicious(Fr/Dec)
Golden Delicious(Fr/Feb)
Golden Delicious(Fr/Mar)
Granny Smith(SA/Aug)
Granny Smith(SA/Sep)
Granny Smith(Fr/Oct)
Granny Smith(Fr/Nov)
Granny Smith(Fr/Dec)
Granny Smith(Fr/Jan)
Granny Smith(Fr/Feb)
Granny Smith(Fr/Mar)
Royal Gala(NZ/Aug)
Royal Gala(Fr/Sep)
Royal Gala(Fr/Oct)
Royal Gala(Fr/Nov)
Royal Gala(GB/Nov)
Royal Gala(Fr/Dec)
Royal Gala(Fr/Jan)
Royal Gala(GB/Jan)
Royal Gala(Ch/Feb)
Royal Gala(Fr/Feb)
Royal Gala(SA/Mar)
0
5
10
15
20
25
30
35
Mean Score

Internal Appearance - Fluffy



4 - Changes in consumer preference for dessert apples

4.1 - Introduction

As with the sensory testing, the method used for the consumer testing was identical and is outlined again here.

Consumer preference trials operate by presenting consumers with a range of products in a hall or mobile unit near a supermarket entrance using very controlled methods of presentation. They are requested to give a simple score of how much they like the products. These kinds of tests are known collectively as central location tests or hall tests. They have several advantages over so-called home tests, where consumers take one or two products home to test. One advantage is that the consumers can assess many more products in a central location test and so they are generally cheaper to perform. Another is that the presentation and consumption of the products can be well controlled.

Previous research at the Institute of Food Research has explored the preference patterns of UK consumers for a range of 12 varieties of apples originating from the southern hemisphere (Daillant Spinnler et. al., 1996[2]) available in June, and 12 varieties of apple from the northern hemisphere available in November. A segmented market in terms of sensory preferences was identified in both cases, with one segment preferring a sweet apple and the other an acidic, hard apple. However, there were a number of subtle differences in the preference structures between June and November and it was not clear whether these were due to differences in the range of varieties available in those two months, or to some systematic shift in preference for particular sensory profiles as the season progresses.

The aim of the trial was to gain a detailed knowledge of consumer liking for specific varieties as they were presented throughout the season. To enable us to explore for possible segmentation among the consumers, a minimum of 100 were recruited each month.

4.2 – Materials and methods

4.2.1 - Samples

The samples used were the same as those used in the sensory testing (see section 2.2.1).

4.2.2 - Consumers

Each month 120 consumers from the Reading area were recruited, from the Institute of Food Research database of consumers, to participate in the study. Criteria used for

[2] *Daillant-Spinnler, B., MacFie, H., Beyts, P. and Hedderley, D. 1996 Relationships between perceived sensory properties and major preference directions of 12 varieties of apples from the southern hemisphere. Food Quality and Preference 7, 113-126.*

recruitment included; being between 18-60 years of age and regularly eating dessert apples. The aim was to use the same consumers each month, however this was not always possible for practical reasons.

4.2.3 – Consumer testing

Each month, consumer testing was carried out over three consecutive days. Consumers attended one session at the Institute of Food Research in Reading lasting between 30-45 minutes. The apples were tasted in a randomised order, balanced to minimise positional and carry over effects. For each study a 'dummy' sample was presented first to give consumers practice in using the rating scale and to reduce first order effects. Consumers received a third of an apple on a white plate and there was a knife available for those who usually used one. They were asked to taste the apple in the way that they normally ate an apple and then score it for liking using a nine-point category scale, from 'like extremely' to 'dislike extremely' (see Appendix 2). In between each apple they were asked to take a sip of water and eat a piece of cracker to cleanse their palates. After tasting consumers completed a usage/demographic questionnaire and finally received a payment of £5.

4.2.4 – Data analysis

The average liking scores for each variety for each month were calculated across all the consumers. To test whether there was evidence of segmentation among the consumers in their liking patterns, a technique called internal preference mapping was used to plot the apple varieties, and directions of preference for each individual consumer. The trained sensory panel data were also superimposed onto the preference plot.

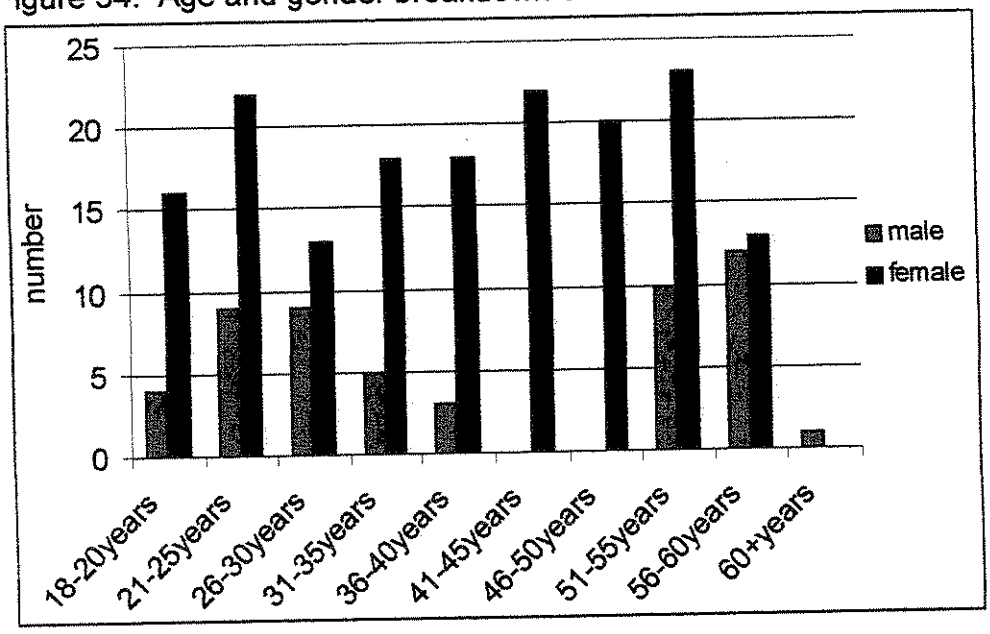
The preference mapping model uses the basic hypothesis that consumers are able to perceive products according to a common map based on their sensory characteristics. However since consumers may weigh these characteristics differently when forming their preference judgements the model also allows for individual differences. Internal preference mapping uses a mathematical technique closely allied to principal components analysis to produce a small number of preference dimensions along which the products are plotted. This summary is treated as an approximation to the underlying perceptual map which is the basis for consumers' preference assessments. The map is used to assess how well products are discriminated and also to look for segmentation among the consumers. When trained sensory panel scores for a set of descriptive attributes are available for the same set of products, these may be superimposed on the preference map to gain an insight into the product characteristics which drive preference for each segment of the consumer sample.

4.3 – Results of consumer preference testing

4.3.1 – Consumer demographic data

A breakdown of the age and gender of all consumers who participated in the testing is shown in Figure 34. As with the previous six months, more females than males participated in the testing. There was a good spread of ages for the females, however, there was a gap of males between the ages of 41 and 51.

Figure 34. Age and gender breakdown of consumers.



4.3.2 – Consumer liking, segmentation and market gaps month by month

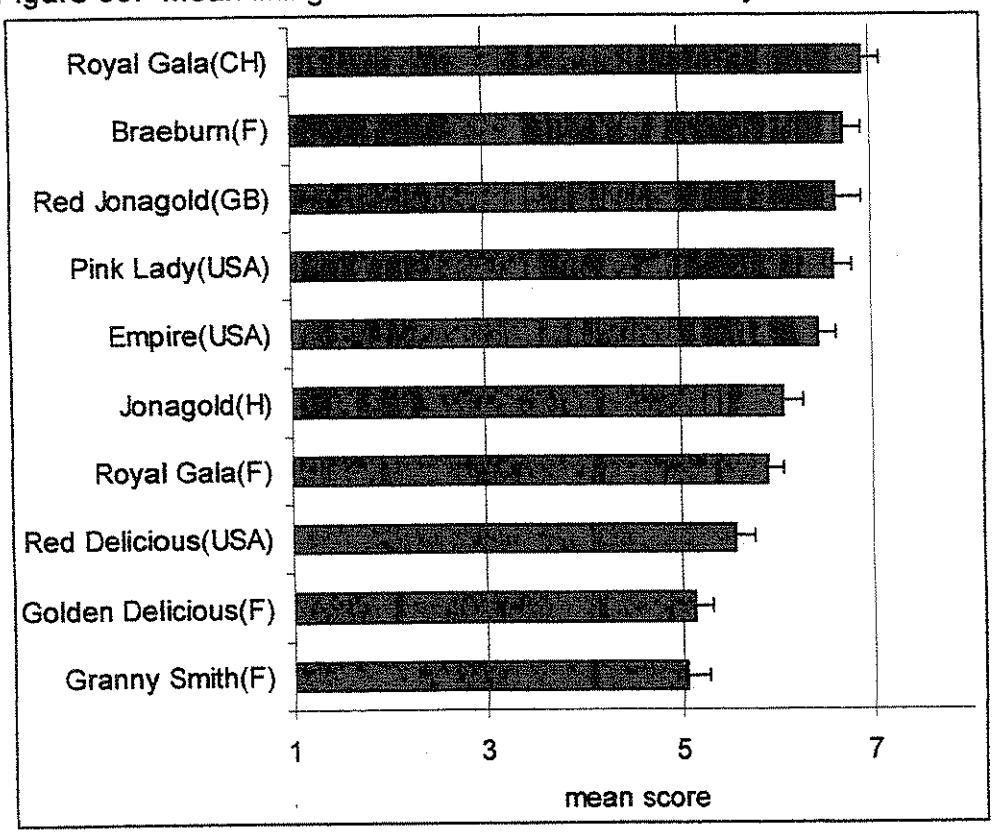
4.3.2.1 – February

Mean liking scores from the consumer testing are shown in Figure 35. The Royal Gala from Chile was liked the most, followed by the Braeburn, Red Jonagold and Pink Lady. Golden Delicious and Granny Smith were equally liked the least. There was a significant difference in liking for the two Royal Gala's, with the French variety liked less than those from Chile.

Internal preference mapping of the consumer liking data is shown in Figures 36 and 37. Figure 36 shows the positions of the apples that give the best two dimensional representation of their relative proximity in the preference space. The positions of the apple names represents the means and the ellipses around the names give an indication of the spread of the preference scores.

Figure 37 shows the positions of each consumer. A line drawn from the origin to a point representing a consumer gives their direction of increasing preference. The larger the distance of the point from the origin, the better the consumers' scores are explained in this space. The circle around the origin gives a very approximate idea of a significant 95% correlation region.

Figure 35. Mean liking and standard error - February.



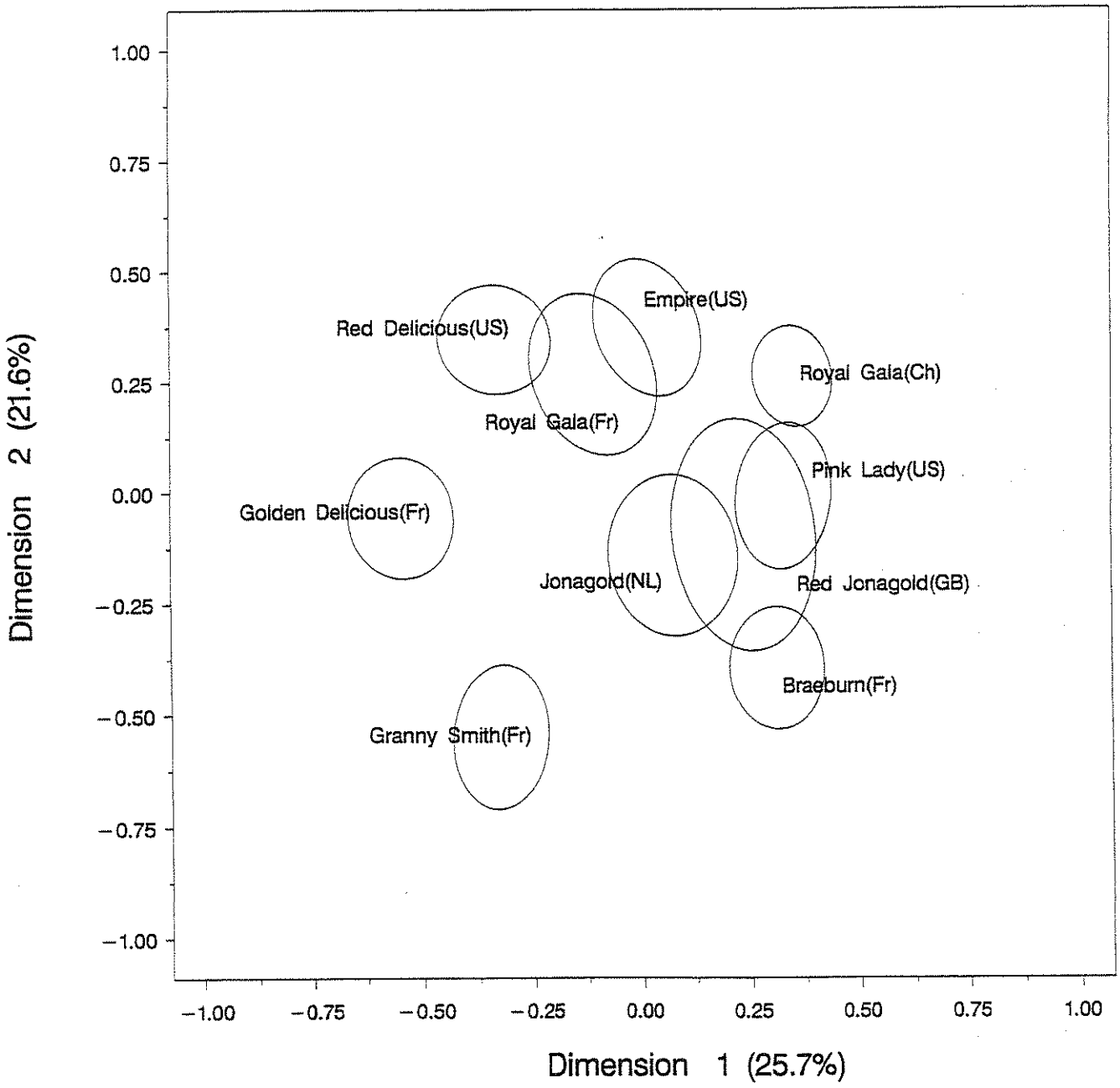
The consumer vectors in Figure 37 weigh predominantly on the horizontal axis. We interpret this plot to indicate that most consumers liked the Royal Gala from Chile, Pink Lady, Red Jonagold and Braeburn, but might segment in whether they disliked Red Delicious or Granny Smith. Consumers positioned to the top right did not like Granny Smith, and those in the bottom right did not like Red Delicious.

Correlating in the sensory attributes with a significant correlation (r^2>0.5) into the preference map, as has been done in Figure 38, appears to indicate that the Red Delicious Golden Delicious were distinguished by a pulpy texture and a watery flavour. The Granny Smith was seen as unripe and acidic/sour and the Royal Gala's and Empire as sweet with a red apple flavour. Looking at the consumer loading (Figure 37), there is some evidence of segmentation with some consumers preferring a sweeter apple (in the top right) and others preferring an acidic/sour, crisp apple (in the bottom right).

Figure 36

Internal Preference Mapping of APRC Apples February 1999

Product Scores : Dimension 2 vs Dimension 1



Internal Preference Mapping of APRC Apples February 1999

Consumer Loadings : Dimension 2 vs Dimension 1

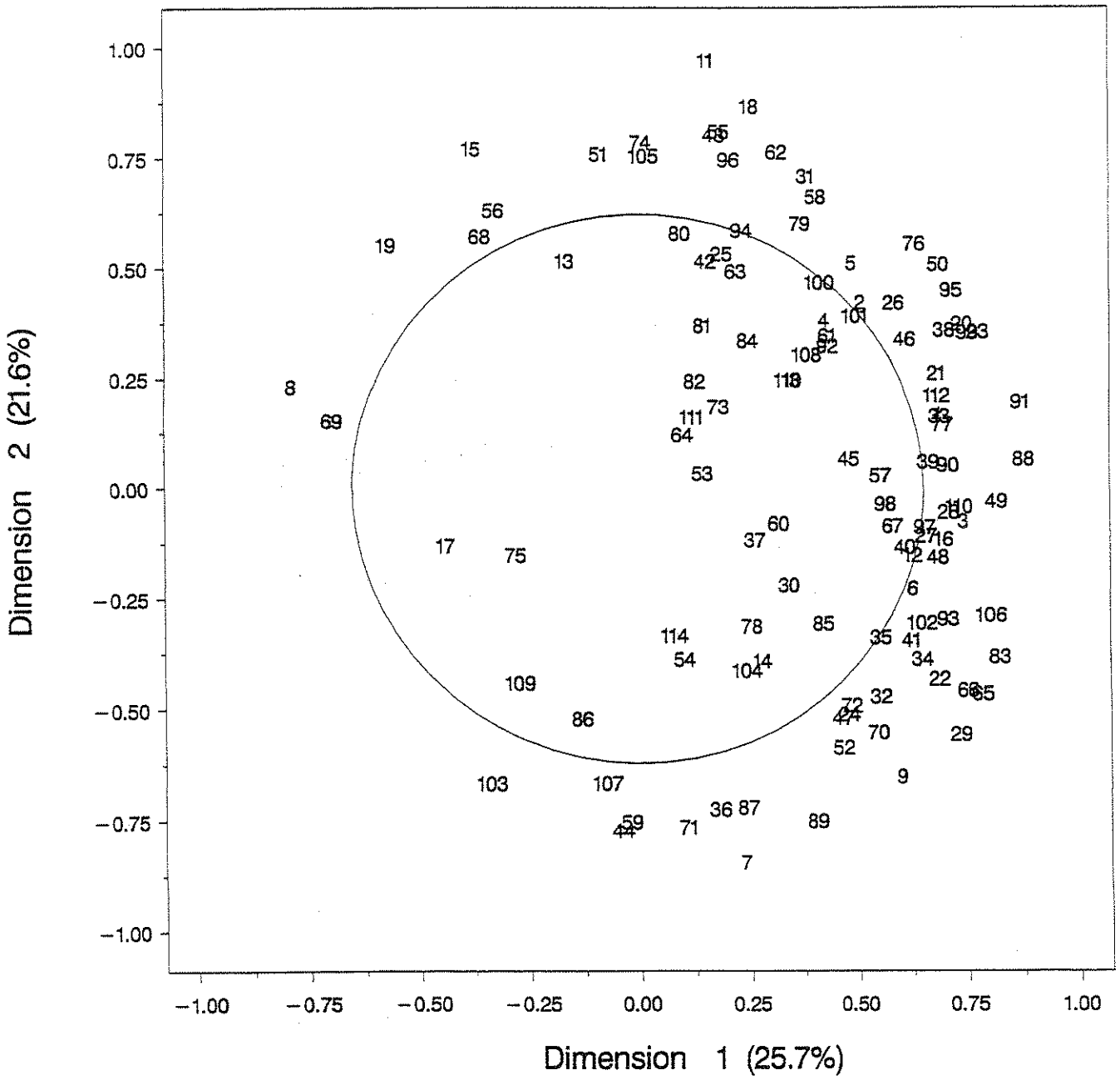
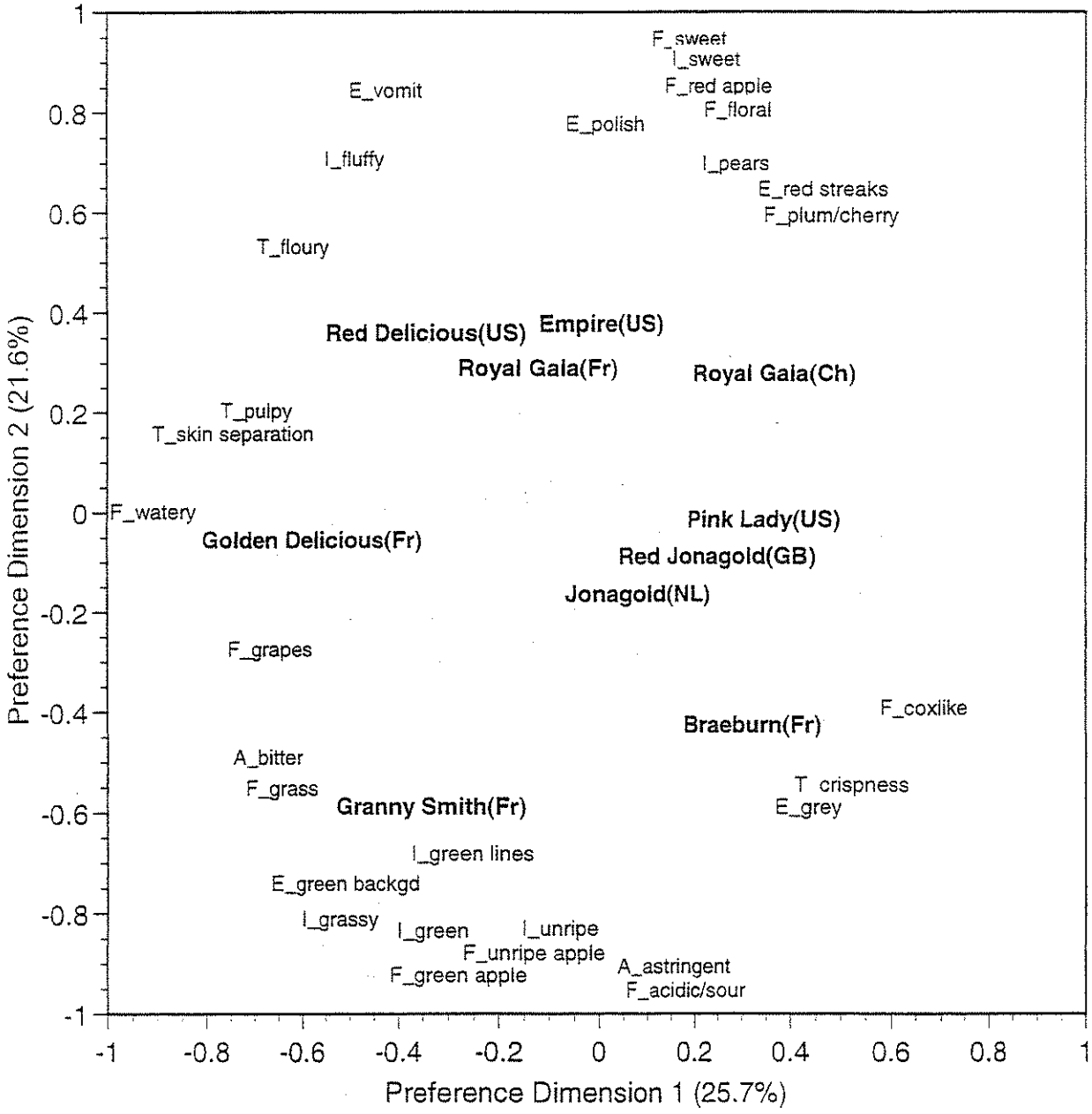


Figure 38

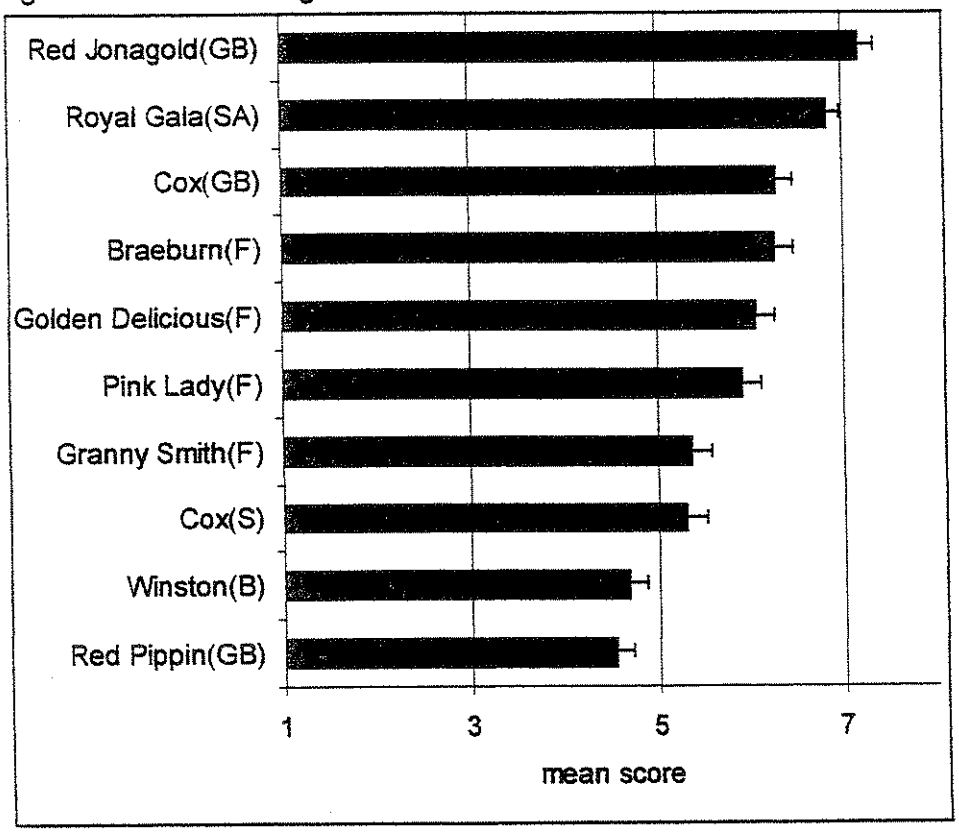
Internal Preference Mapping of APRC Apples February showing projections of Significant Sensory Panel Attributes (r^2>0.5)



4.3.2.2 – March

Mean liking scores are shown in Figure 39. Red Jonagold was liked the most and Winston and Red Pippin liked the least. The English Cox was significantly preferred than the Swiss Cox.

Figure 39. Mean liking and standard error - March.



Internal preference mapping plots for the apple positions, consumer vectors and sensory attribute projections are shown in Figures 40, 41 and 42 respectively. Consumer preference lies to the right of the plot, showing a preference for the Red Jonagold, Golden Delicious, Royal Gala and Braeburn, with the corresponding sweet flavour attribute. As with February there may be segmentation. Consumers in the top right of the plot liked Red Jonagold and disliked the Swiss Cox and Red Pippin, whereas those consumers in the bottom right liked Braeburn and the Cox's, but disliked the Granny Smith.

Internal Preference Mapping of APRC Apples March 1999

Product Scores : Dimension 2 vs Dimension 1

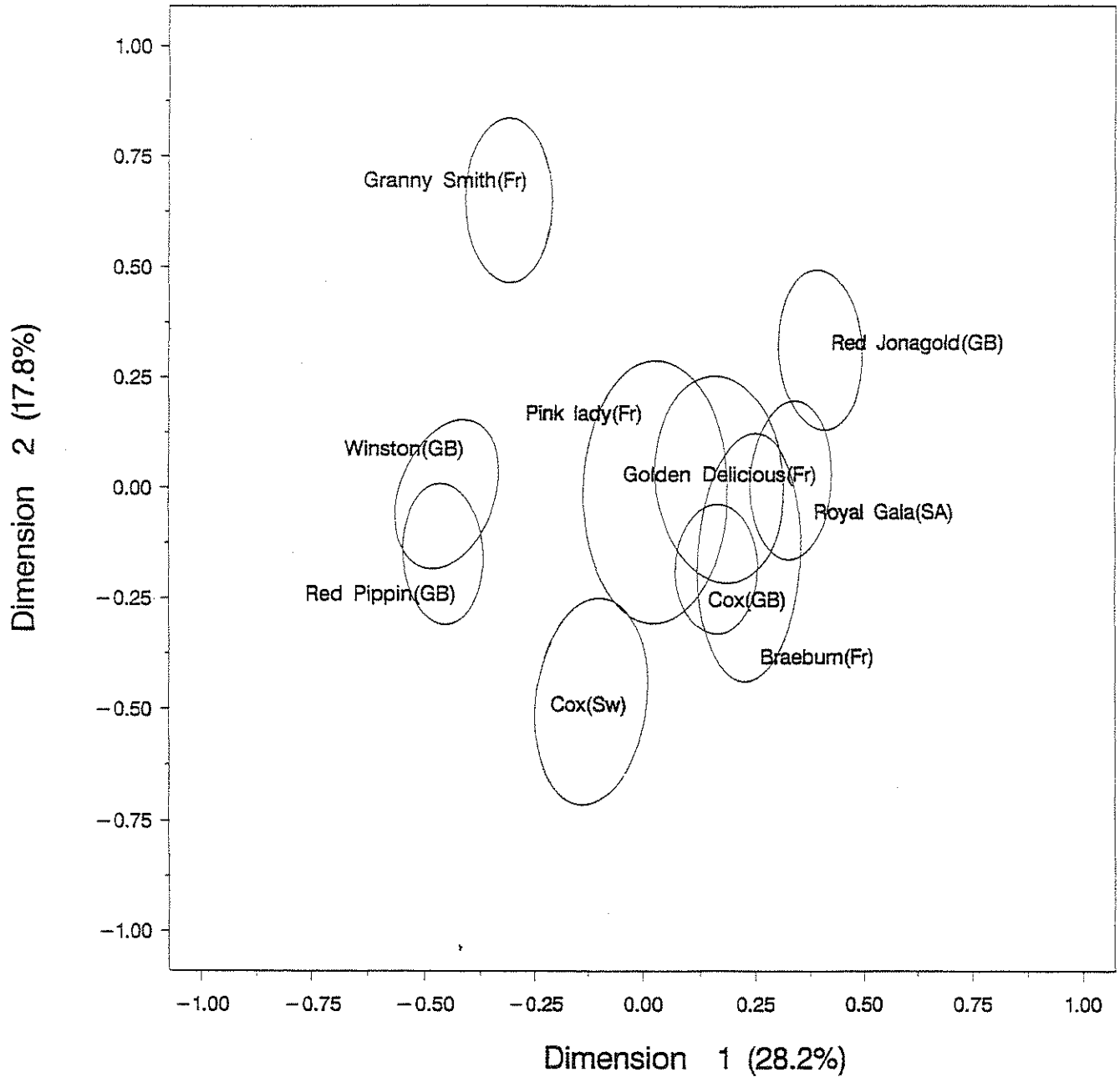


Figure 41

Internal Preference Mapping of APRC Apples March 1999

Consumer Loadings : Dimension 2 vs Dimension 1

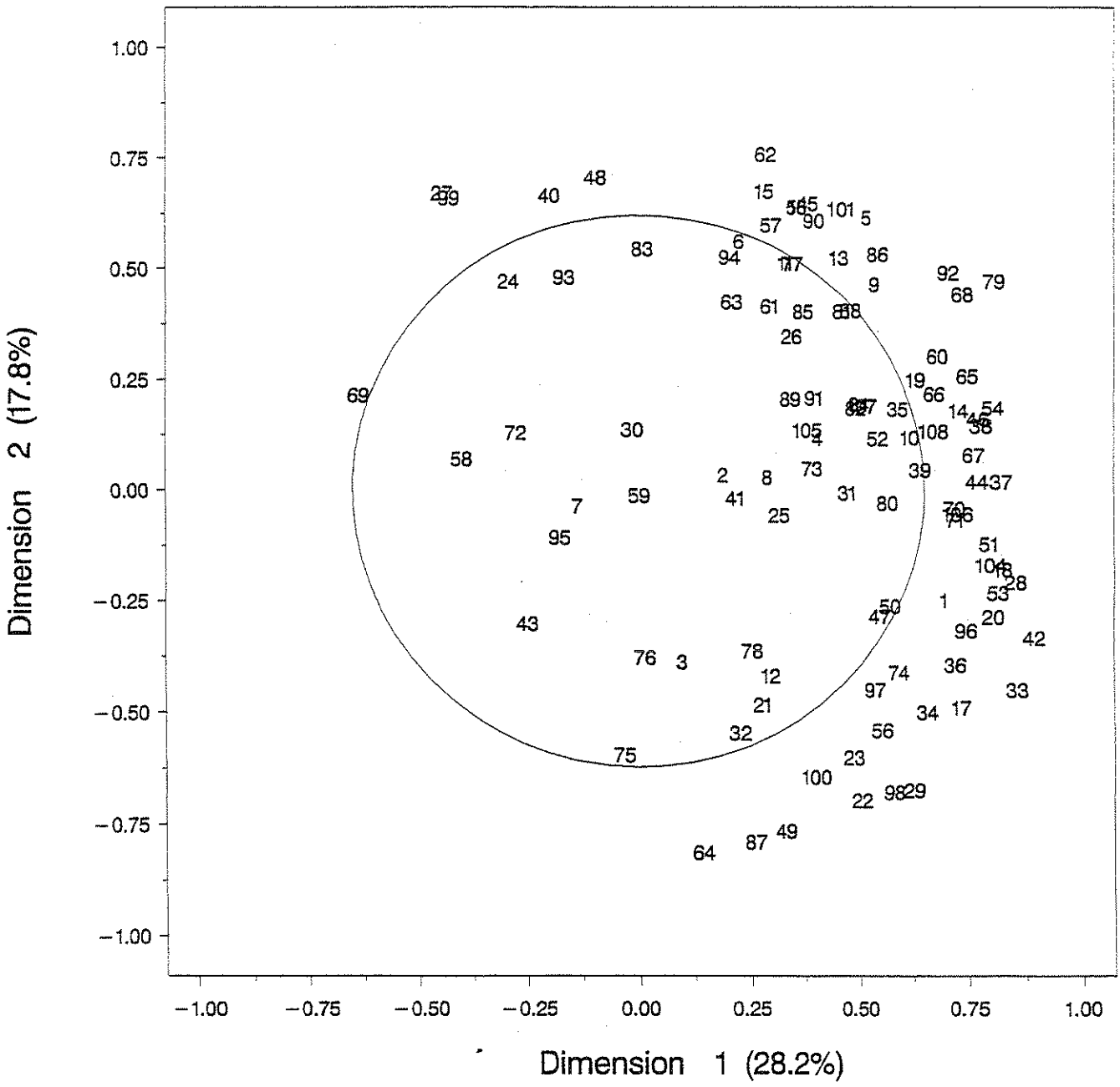
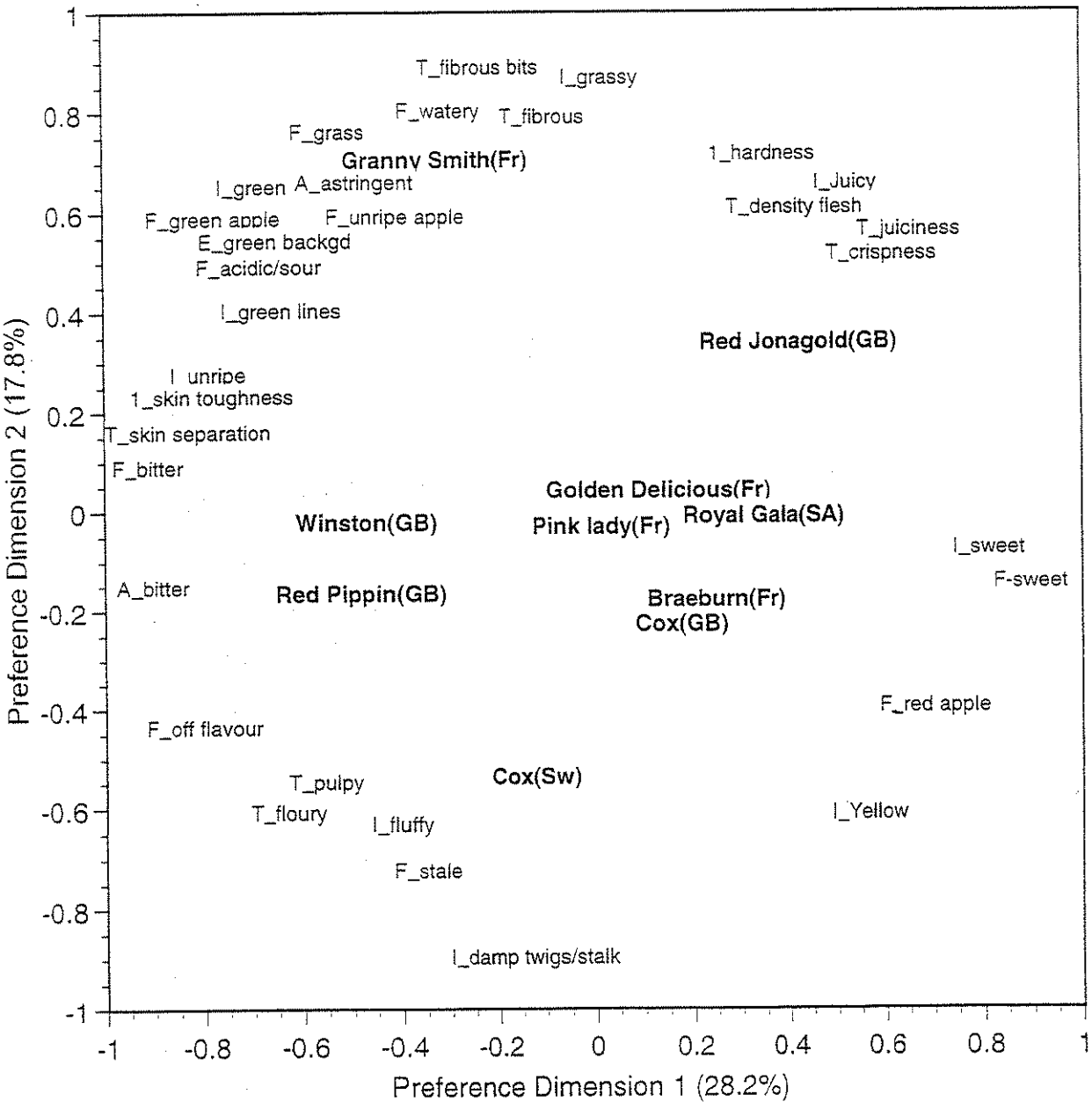


Figure 42

Internal Preference Mapping of APRC Apples March showing projections of Significant Sensory Panel Attributes (r^2>0.5)



4.3.2.3 – Summary

The preference data over the six months showed evidence of segmentation in some of the months with some consumers preferring a sweet apple and others preferring an acidic apple. There was also evidence of consumer segmentation not just based on preference, but also on apples that they disliked. There appeared not to be a systematic shift in preference; differences over the months are more likely due to differences in the range of varieties available. Of the five months that Russets were tested there was only one month, October, when they were preferred. For the next three months of the study the Russets were preferred significantly less. The Granny Smith apples were also preferred significantly less over the last three months of the season. Some varieties, for example Braeburn, received consistently high preference scores over the season. The recently bread apple, A915/15 was liked by consumers.

Clear differences in sensory properties and preferences were found for the same varieties from different countries in the November study for Golden Delicious, Royal Gala and Braeburn, with the UK apples equally or significantly preferred over the French equivalents.

4.3.3 – Consumer usage data

Consumers completed a brief usage/demographic questionnaire at the end of the two studies. When asked how many apples they ate per week, approximately half (49%) of consumers reported eating 4-6 apples per week, with 32% eating 1-3 apples and 15% eating 7-10 apples. The vast majority (94%) of consumers reported purchasing apples. Of these, 42% of consumers reporting buying 5-10 apples per week, followed by 24% buying 1-4 apples, 19% buying 11-15, 7% 16-25 and one person buying over 25 apples per week.

5 - Acknowledgements

The authors would like to thank Denise Welch, and Stuart Smith for their assistance with the project. We would also like to thank Simon Thirkell and Tim Homewood at Sainsbury's who provided the apples free of charge for the preference studies.

6 - Appendices

Appendix one Example of attributes used by trained sensory panel

Appendix two Example of nine-point category scale

Example of Attributes used by Trained Sensory Panel

PANEL ATTRIBUTE TERMS FOR APPLES - WHOLE APPLES,UNPEELED
FEB 99 (All attributes scored from NIL to EXTREME unless indicated)

EXTERNAL APPEARANCE

1	Yellow background	Refers to the depth of yellow colour in the background
2.	Green background	Refers to the depth of green colour in the background
3	Red streaks	Amount of red/pinkish red streaks or colouration over the background colour
4.	Brown by stalk	Amount of brown colouration next to stalk, occasionally spreading to made body of skin (technical term: russet)
5	Looks hard	The appearance gives the impression that the apple will have a hard texture. Scored from SOFT to HARD .
6	Shiny	Measure of how shiny the surface of the apple is. Scored from DULL to SHINY.
7.	White/yellow specks	Amount of white or yellow specks on the surface of the apple.(technical term: lenticels)
8.	Dark specs	Amount of black or brown specs on the surface of the apple.(technical term: lenticels)
9	Ridges	Measure of how ridged the surface is. Ridges run vertically down from the stalk.
10.	Feels hard	How hard the apple feels when gently squeezed. Scored from SOFT to HARD.
11	Pink blush	Amount of pink colouration - not streaks (not pink or red streaks)
12	Size	Size of apple - an average sized apple as bought in shops would be about the middle of the scale
13	Grey	Depth of grey tinge. Somewhat suggests underlying overall "bruise" (not an actual bruise though)
14	Waxy	Looks and feels waxy
15	Bruising	Blown marks on skin suggesting internal bruiring
16	White dust	Covering on skin resembling fine white dust (technical term Bloom)

EXTERNAL ODOUR

17	Sweet	One of basic tastes eg sucrose (table sugar)
18	Fresh	Like a freshly harvested apple
19	Polish	Like shoe polish
20	Old sacks	Like musty hessian sacks.
21	Vomit	Like vomit

FIRST BITE TEXTURE (Take one bite from the centre of the hemisphere with front teeth.)

22.	Skin toughness	Measure of how tough the skin is.
23.	Juiciness	Amount of juice from the first bite
24	Hardness	Resistance to bite. scored from SOFT to HARD.

TEXTURE(during chewing)

25	Crispness	How crisp the apple seems during chewing - brittle , makes a characteristic crunchy noise when chewing. Eg celery would be very crisp
26	Juiciness	Amount of juice produced during chewing
27	Skin separation	Extent to which skin separates from flesh
28	Toughness/chewiness	The amount of work required to break down the flesh (ignore skin)
29	Density of flesh	The degree of compactness of the cells. Scored from LOOSE CELLS to COMPACT
30	Fibrous	Presence of lengths of cellular material. Celery would be an extreme example.

31	Granular	Sensation that there are small balls of apple flesh in the mouth
32	Floury	Like mashed potato
33	Pulpy	Soft and mushy like baked apple
34	Fibrous bits	Amount of fibrous bits (of apple flesh)left in mouth after chewing
35.	Skin bits	Amount of tough skin bits in mouth

FLAVOUR DURING CHEWING

36	Green apple	Associated with green apples, sometimes grassy.
37	Red apple	Associated with red apples
38	Sweet	One of basic tastes eg sucrose (table sugar)
39	Acidic/sour	One of basic tastes, eg. citric acid
40.	Bitter	One of basic tastes (eg quinine)
41.	Stale	Like apples stored for some time or have been left in fruit bowl for some time
42	Pear drops	Flavour associated with pear drops sweets.
43	Floral	Like floral scented perfume
44	Watery	Tastes as if it is mainly water, lacking in flavour.
45	Off flavour	Off flavour described as similar to catarrh or stale mouths.
46	Plum/cherry	Flavour associated with fresh plums or cherries
47	Unripe apple	Associated with unripe apples, lacks maturity, lacks flavour
48	Pear-like	Like fresh pears
49	Grass	Like damp grass, almost hay-like
50	Cooked apple	Like stewed or baked apples
51	Cox-like	Flavour associated with a cox apple
52	Grapes	Like fresh green grapes
53	Almond	Like almond essence
54	Cider	Fermented flavour, like cider
55	Old sacks	Like musty hessian sacks.

AFTERSWALLOW (15 secs after swallowing)

56	Bitter	
57	Peel	Amount of peel left in mouth
58	Astringent	Dries surface of the mouth (as tannic acid), mouthpuckering
59	Drying	Dry sensation in the mouth, lack of salivation

INTERNAL APPEARANCE

60	White	% white colour
61	Green	% green colour
62	Yellow	% yellow colour
63	Green lines	Amount of green lines or strands present
64	Juicy	How juicy or watery the apple looks
65	Fluffy	How fluffy or spongy the flesh looks

INTERNAL ODOUR

66	Grassy
67	Unripe
68	Damp twigs/stalks/woody
69	Pears
70	Sweet

Apple Study

ID:??

There are several different apples to taste. Please taste them as you would normally eat an apple- there is a knife available if you would normally use one.

You will receive the samples one at a time. Please check that the number on the plate matches the number on the score sheet.

Please answer all the questions by marking a 'X' in the relevant box.

Sample: 001

Please taste sample **001** and score it for how much you like it:

- ☐ Like extremely
- ☐ Like very much
- ☐ Like moderately
- ☐ Like slightly
- ☐ Neither like nor dislike
- ☐ Dislike slightly
- ☐ Dislike moderately
- ☐ Dislike very much
- ☐ Dislike extremely

When you have scored the sample, please pass it back through the hatch.

Then take a sip of water and eat a piece of cracker before tasting the next sample.