OBJECTIVE: To Analyze the Shelf life extension of apples, during simulated transit periods of 2+ weeks.

STORAGE PROTOCOL: A chamber was used, with the average temperature inside the chamber maintained at an average of 37°C (98.6 °F)

PACKAGING PROTOCOL: Different Modified Atmosphere Packaging (MAP) based packaging was used for this shelf life extension trial.

APPLE VARIETY: SHIMLA AND KINNOUR

Protocol 1: CA FILMS based packaging

Protocol 1 a: CA FILMS based packaging – Yellow – (10 KGS)

Protocol 1 b: CA FILMS based packaging – Blue – (10 KGS)

Protocol 1 c: CA FILMS based packaging – Yellow – (20 KGS)

Protocol 1 d: CA FILMS based packaging – Blue – (20 KGS)

Protocol 2: Control

Protocol 3: Apples stored in Controlled Atmosphere chambers, were used for base lining quality standards.

QUALITY METRICS: During the duration of the trials, apples will test for the following quality parameters to determine shelf life:

Skin Firmness: Using a penetrometer, the Skin Firmness of apples will be measured on 7^{th}, 10^{th}, 13^{th} and 16^{th} day of the trial period. Figure 1.

Figure 1: Skin Firmness Testing of Apples

Weight Loss (%): Weight loss will be evaluated at the end of the 16th day for each protocol.

External Defects: Defects such as shrinkage, russet ting, fruits rotting, and insect damage will be documented on 7th, 10^{th,} 13th and 16th day of the trial period.

Initial Quality: For the trial, the following quality of the apple was documented:

Skin Firmness (Shimla Apple): 16.0 pounds.

Skin Firmness (Kinnour Apple): 16.5 pounds.

Starch Index (Shimla): 2.4-2.5, See Figure 2.

Starch Index (Kinnour): 2.5-2.8, See Figure 2.

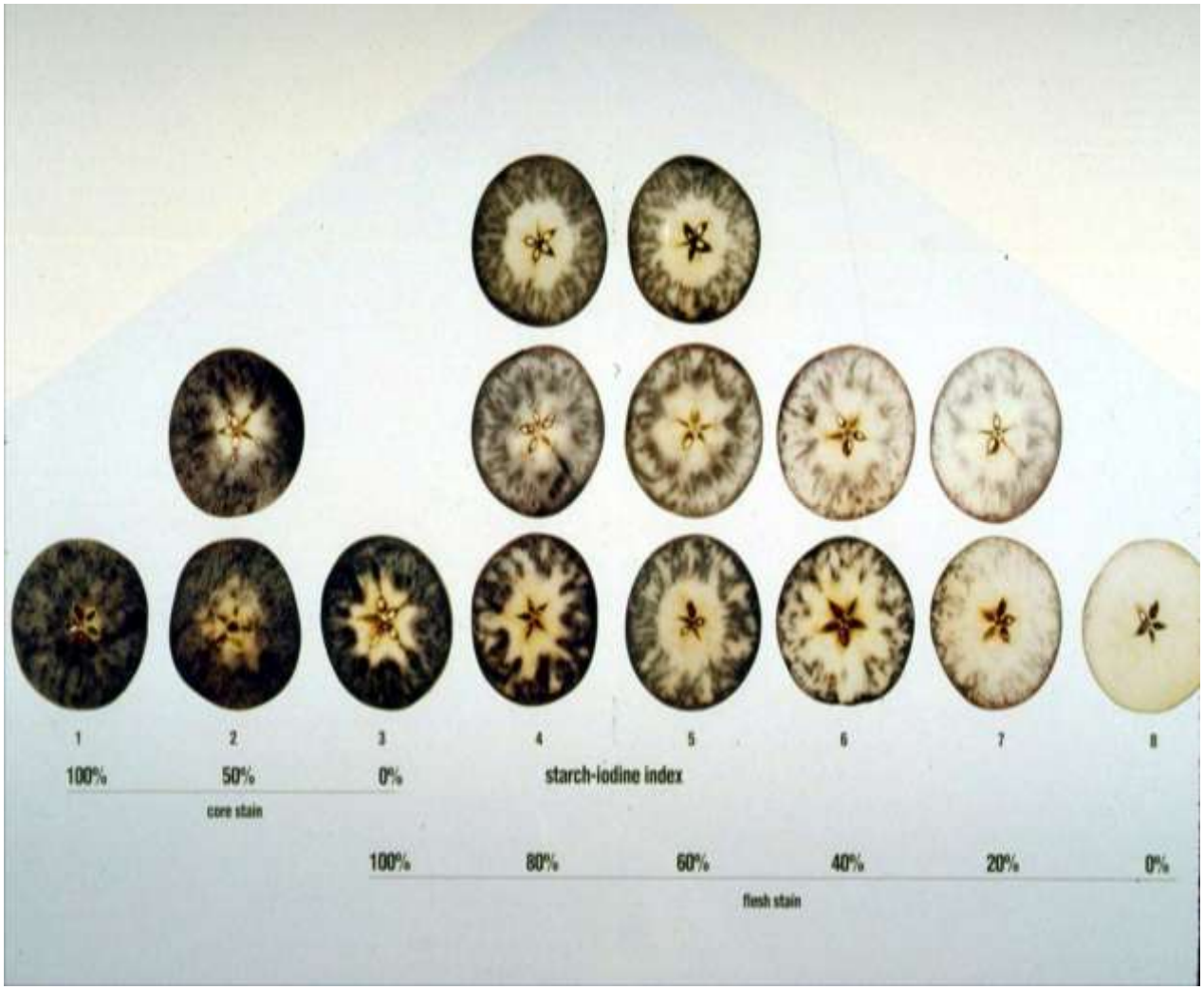

Figure 2: Apple Starch Staining Pattern Chart (Cornell University)

External Defects (Shimla Apple): Slight Rusetting, insect damage, touching

External Defects (Kinnour Apple): Slight Rusetting, sunburn, touching

Quality Parameters at the end of Days 7, 10, 13 and 16:

SKIN FIRMNESS:

Apple Skin Firmness is used worldwide as a measure of ripeness and "condition" of the fruit.

Based upon the Figure 3, the skin firmness of apples (Shimla apple) in Protocol 1-CA FILMS-Yellow(10 & 20 kg) is **comparable** to the maturity of the apples taken from the Control Atmosphere Chamber, even though the apples in Protocols 1 were stored in ambient temperatures in excess of 37 °C for 16 days.

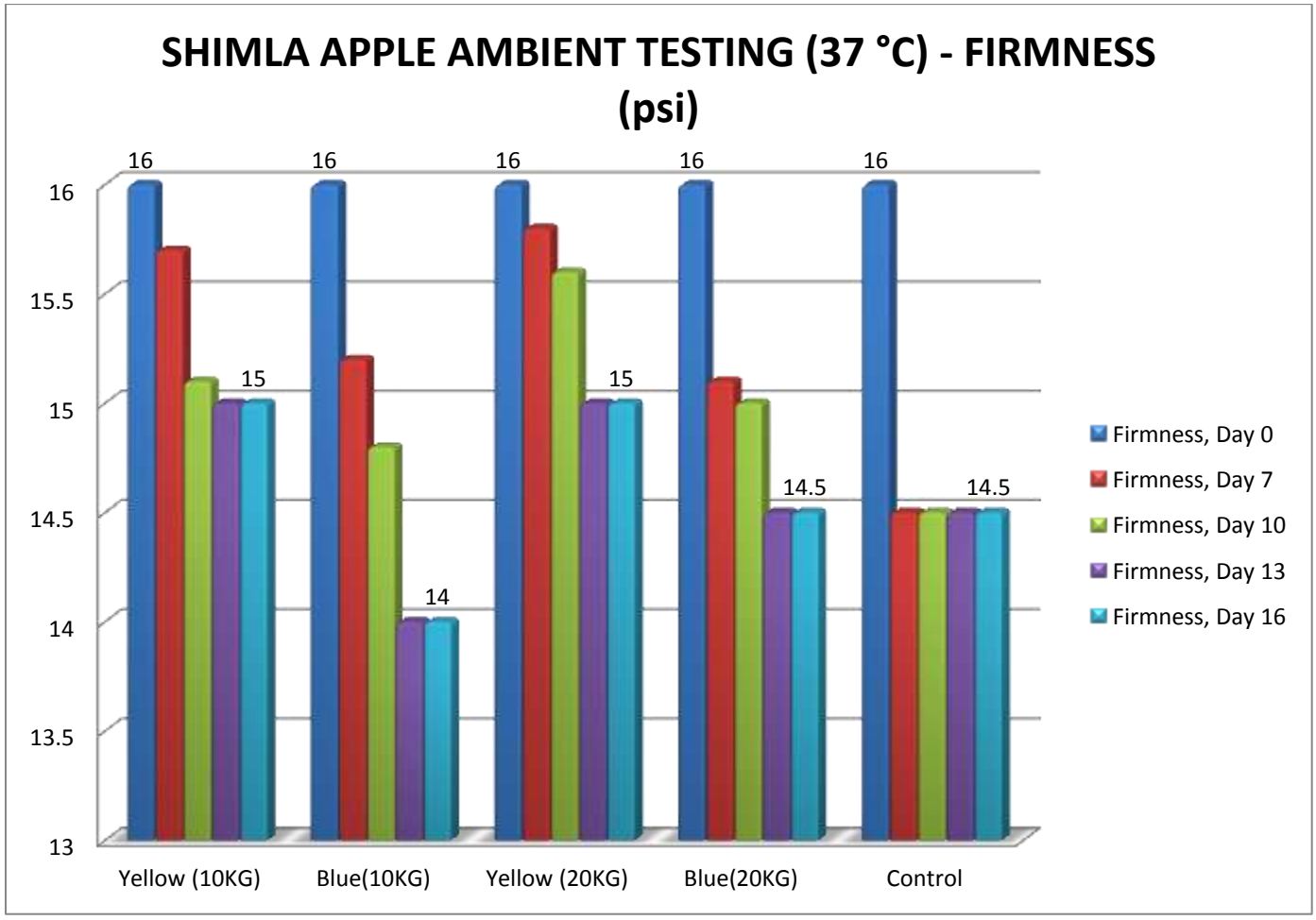

Figure 3: Skin Firmness of the different protocols (Shimla) during the 16-day trial period

Based upon the Figure 4, the skin firmness of apples (Kinnour apple) in Protocol 1-CA FILMS-Yellow(10 & 20 kg) is **comparable** to the maturity of the apples taken from the Control Atmosphere Chamber, even though the apples in Protocols 1 were stored in ambient temperatures in excess of 37 °C for 2+ weeks.

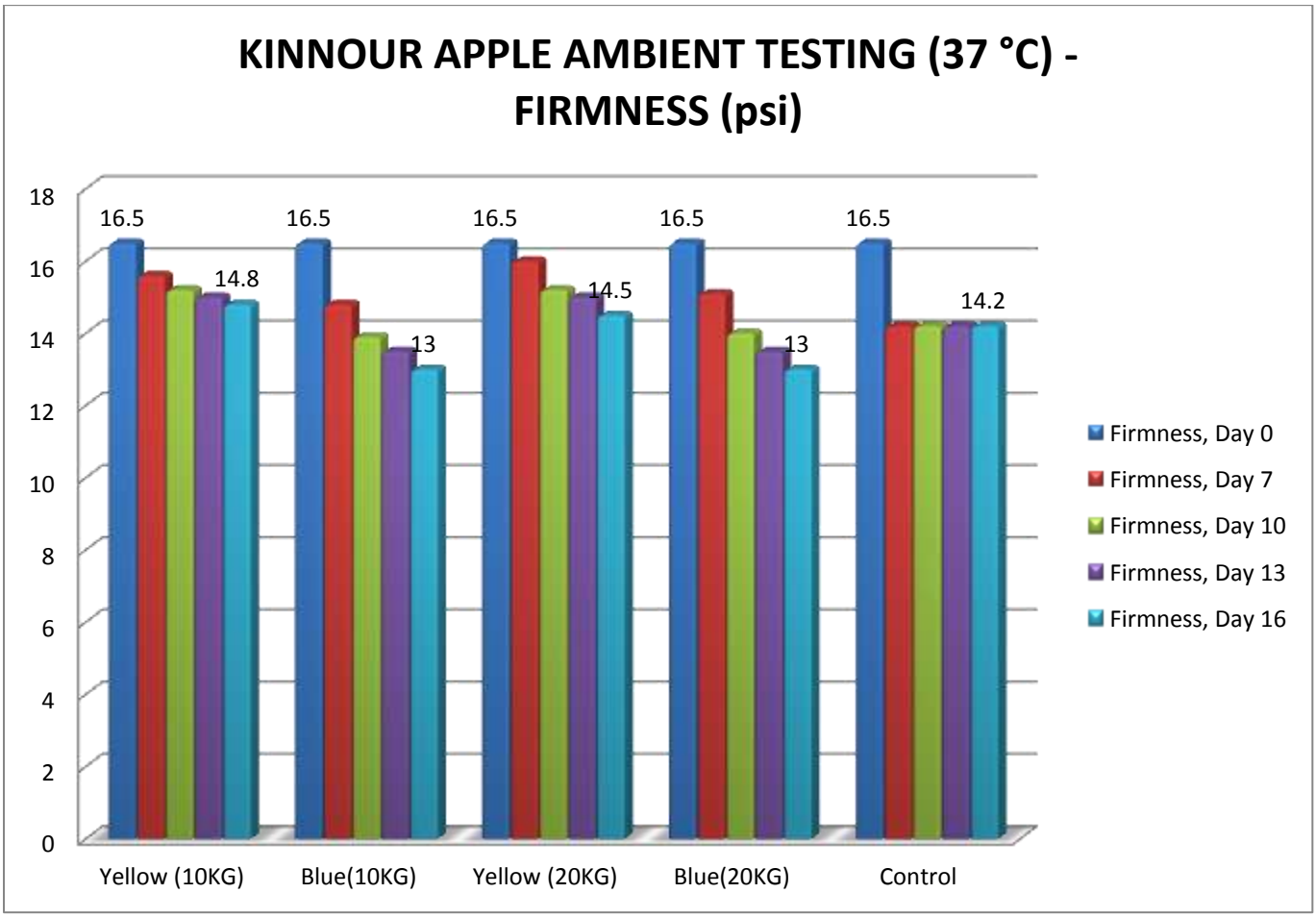

Figure 4: Skin Firmness of the different protocols (Kinnour) during the 16-day trial period

SHRINKAGE (%): Based upon data available from Figure 6, there is a substantial shrinkage in protocols from Control for both apple varieties as early as Day 7 (30 % for Shimla and 35% for Kinnour). For the CA FILMS based protocols, there is no loss by Day 7 for both apple varieties.

Apart from the russetting, which was visible on the initial sample used, and on the sample taken from Control Atmosphere chambers, and all the CA FILMS protocol based apples, no shrinkage was recorded for the CA FILMS. Substantial shrinkages were recorded for apples in the Control Protocols for Days 10, 13 and 16. See Figures 5 and 6.

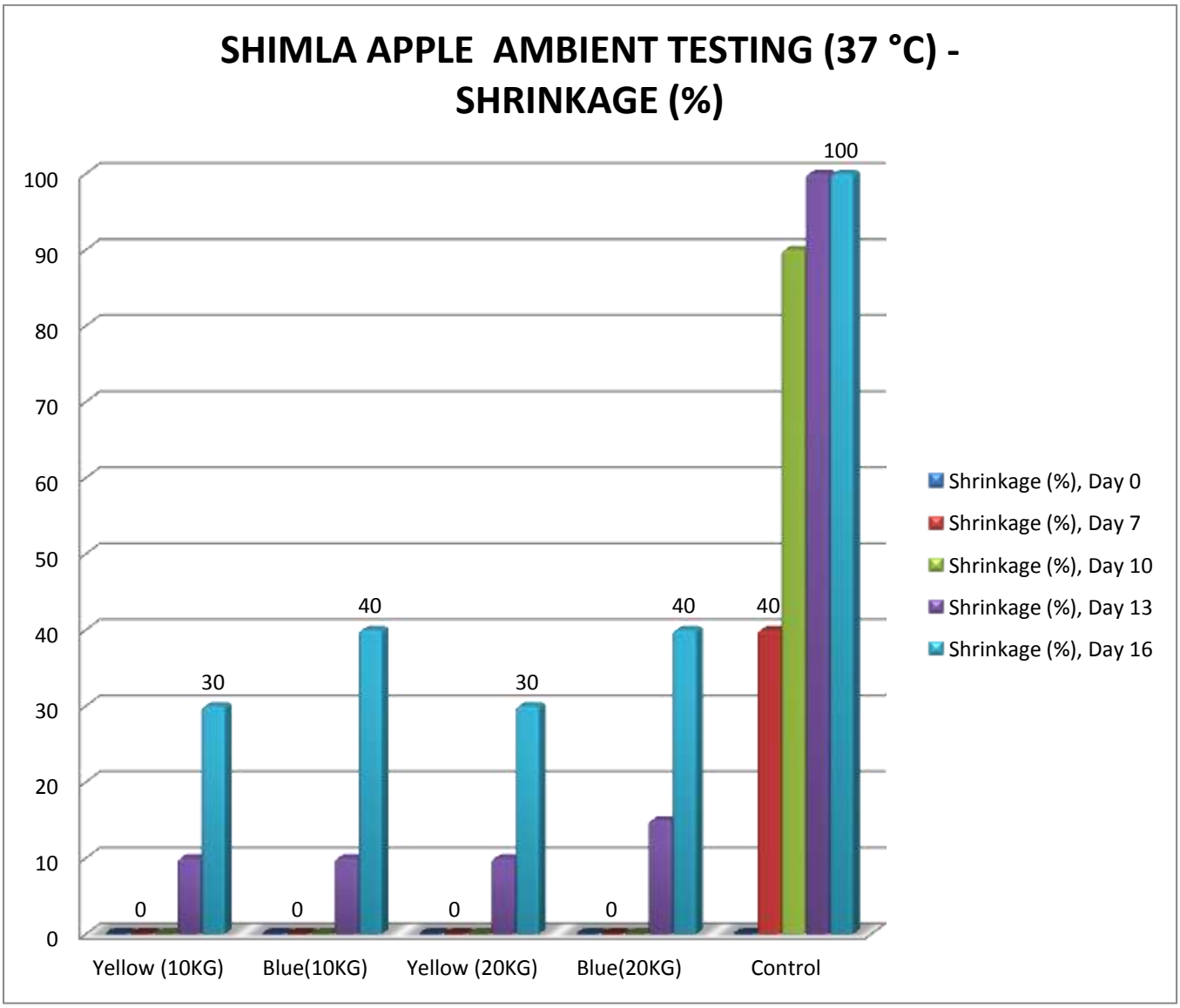

Figure 5: Shrinkage (%) of the different protocols (Shimla Apple) during the 16-day trial period

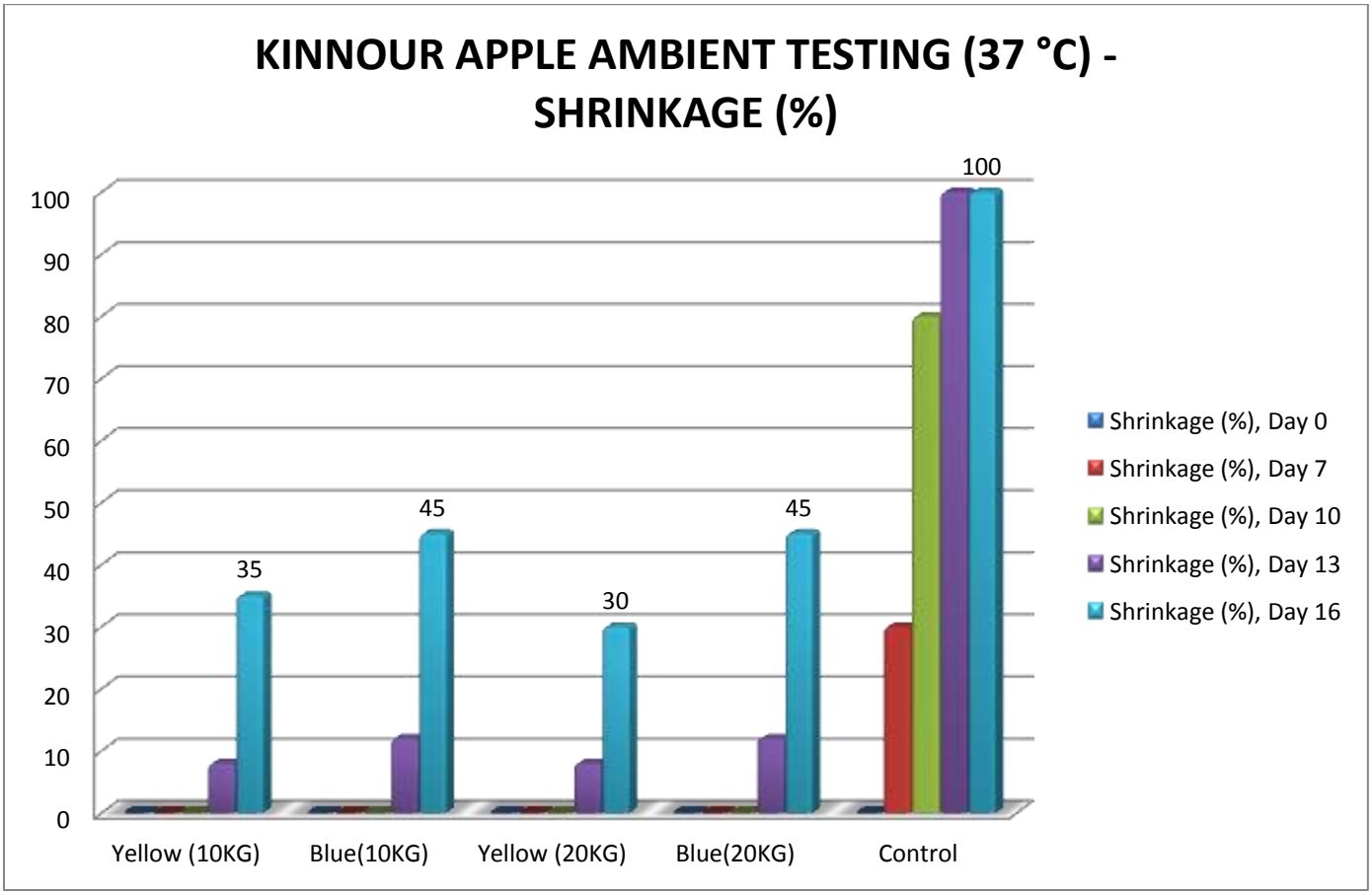

Figure 6: Shrinkage (%) of the different protocols (Kinnour Apple) during the 16-day trial period

WEIGHT LOSS (%): Based upon data available from Figure 7, there is a substantial weight loss in protocols from Control for both apple varieties by Day 16. The weight loss for CA FILM protocols is less than the weight loss from sample taken from the CA Chamber. See Figures 7 and 8.

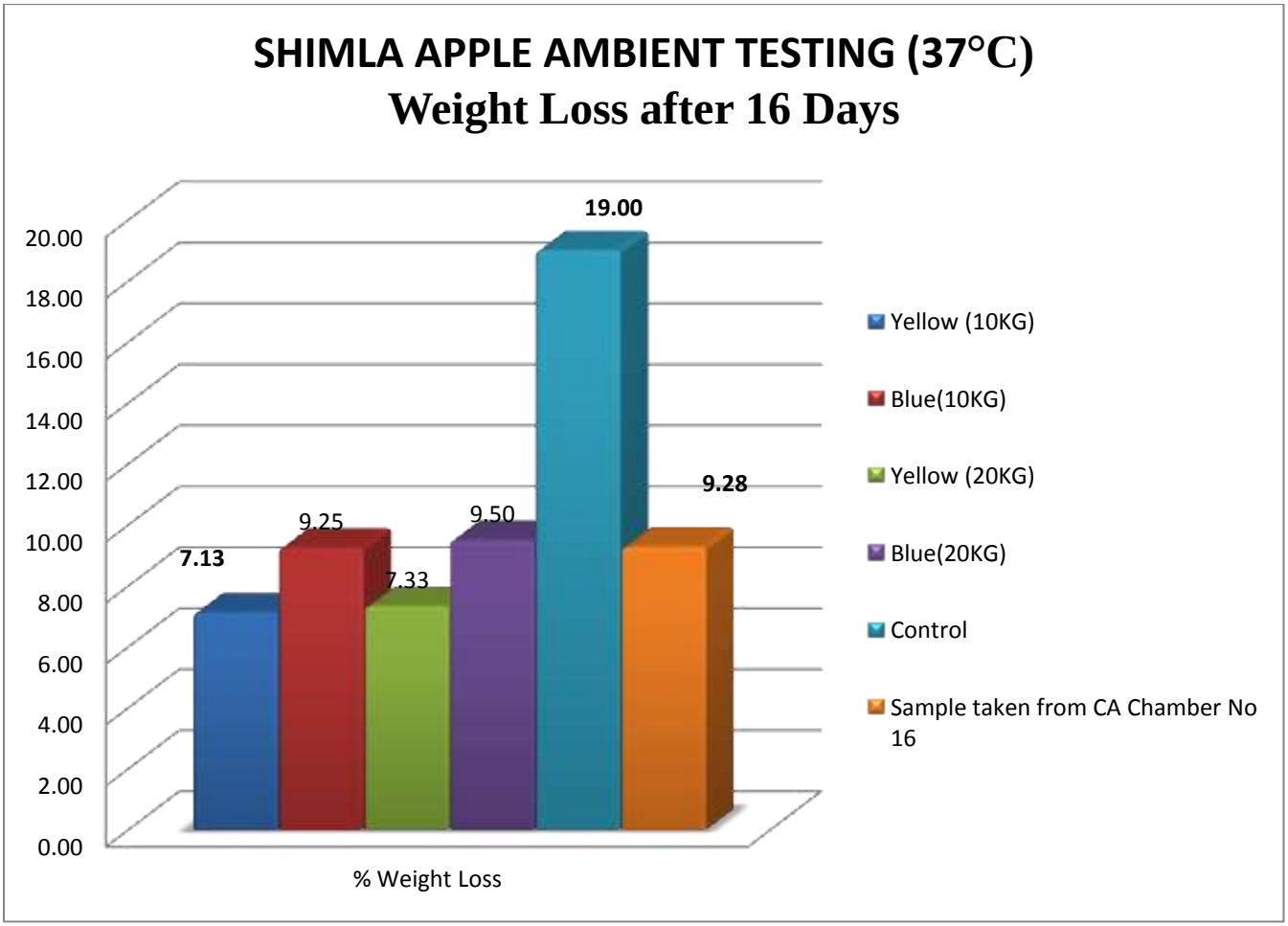

Figure 7: Weight Loss (%) of the different protocols (Shimla Apple) during the 16-day trial

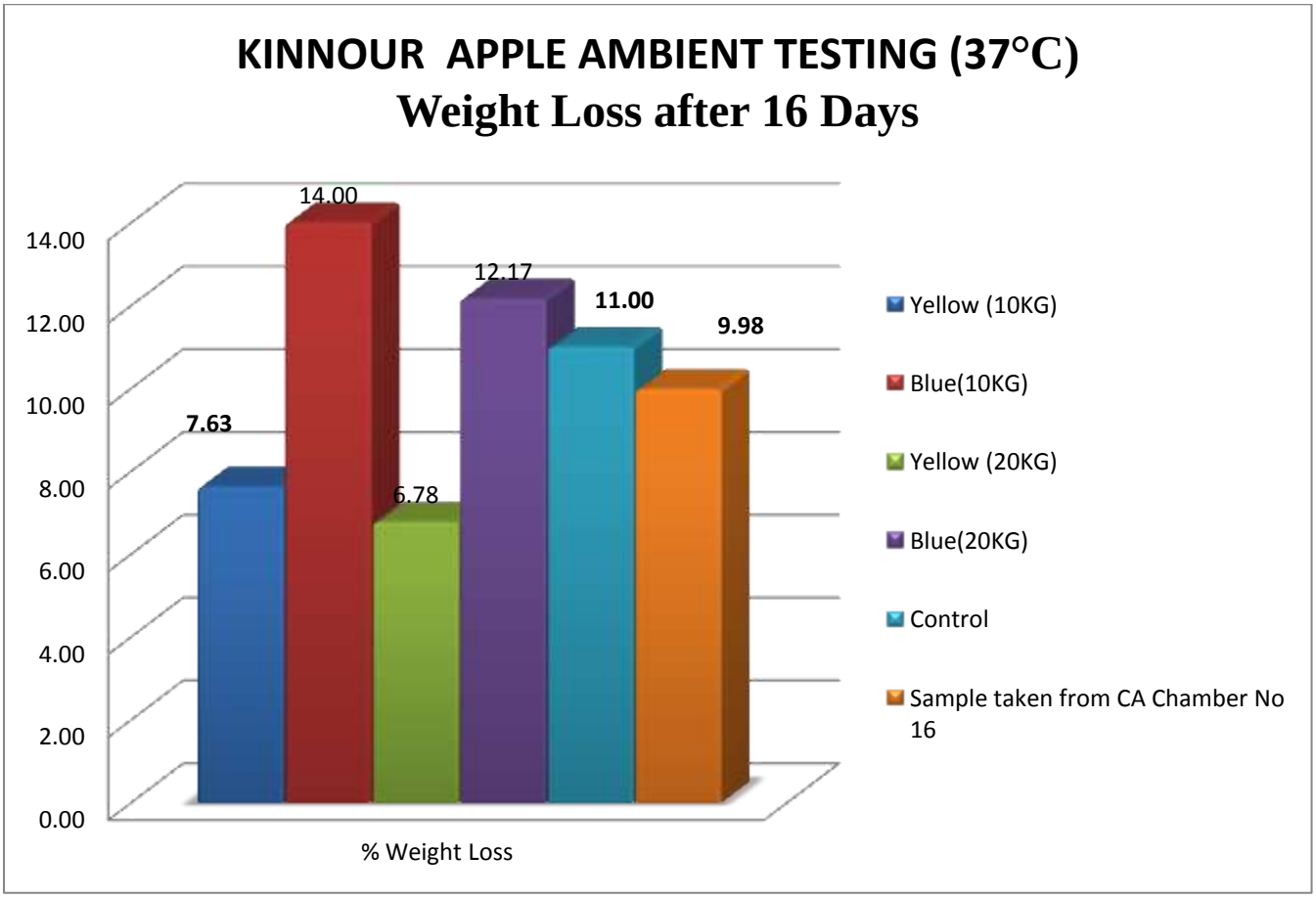

Figure 8: Weight Loss (%) of the different protocols (Kinnour Apple) during the 16-day trial

CONCLUSIONS:

Based upon the trial results the following conclusions can be made:

- CA FILMS based protocols, especially the yellow protocols, allow the shelf life extension of apples to up to 16 days, in ambient temperatures of 37 °C.
  - The trial results have documented extensive quality loss for the Control protocol based apples (shrinkage is very high, and the firmness is very low).
  - The best protocol to use for optimal shelf life extension is CA FILMS –yellow, which provides quality parameters comparable to apples stored in Control Atmosphere based chambers at cold chain temperatures.
- The trial results have documented minimal weight loss for the CA FILMS based protocols apples for the 16 days shelf life extension period. The CA FILMS can extend the shelf life of apples, irrespective of variety to **12** days with zero shrinkage.
  - Extensive weight loss has been documented for the apples in the control protocols.
- **CA FILMS will allow potential apple growers to transit apples to long distances even at high ambient temperatures for 12 days without any loss in quality and weight loss.**

Other photographs.

Figure a: Yellow, Day 16 (kinnour)

Figure b: Yellow, Day 13 (kinnour)

Figure c: Yellow, Day 10 (kinnour)

Figure d: Yellow, Day 7 (kinnour)

Figure e: Control, Day 16 (kinnour)