THE UNIVERSITY OF ARIZONA
Cooperative Extension

az2100 January 2025

Cantaloupe Carton Size Grades

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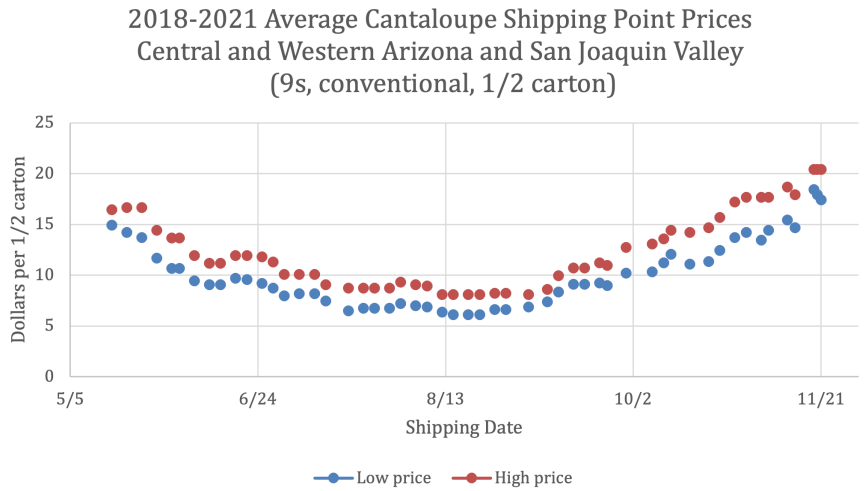

Figure 1. Cantaloupe prices fluctuate throughout the year, peaking in spring and late fall.

Arizona is one of the primary production regions of cantaloupes for the nation. Between 2013 and 2023, the annual Arizona cantaloupe harvest has ranged from 11,200 to 16,300 acres, making up 24.8% of national production, second only to California [1-6]. Cantaloupes produced in the U.S. Desert Southwest are traditionally harvested from May through November, with the highest market values associated with the earliest harvested fruit in spring and the latest harvested fruit in the fall (Figure 1) [6&7].

Cantaloupes are hand-picked several times over the course of a few weeks and are typically field-packed in cardboard cartons, cooled, and then shipped to the end user. Yield is determined by the number of cartons harvested per acre, which is highly impacted by melon and carton size. Fewer large melons can be packed into a standardized carton than small ones making sizing an important factor to report when calculating yield. Additionally, some melons are too small or large to hold market value and are left behind in the field, which also needs to be reflected in yield reports as losses in production. Commercially, melons are assigned size grades based on how many fit in a carton: grade six fits six melons per carton and is considered large fruit, which may not be harvested depending on customer or market demand. Similarly grades 18 and 25 are considered small and may also be left unharvested. Like size melons are packed together and size grades are typically printed on the carton, which most often include 6, 9, 12, 18, and 23. At harvest the packer sorts fruit by feel, grouping similarly sized fruit into separate cartons. They then mark or circle the corresponding printed size grade on the carton (Figure 2).

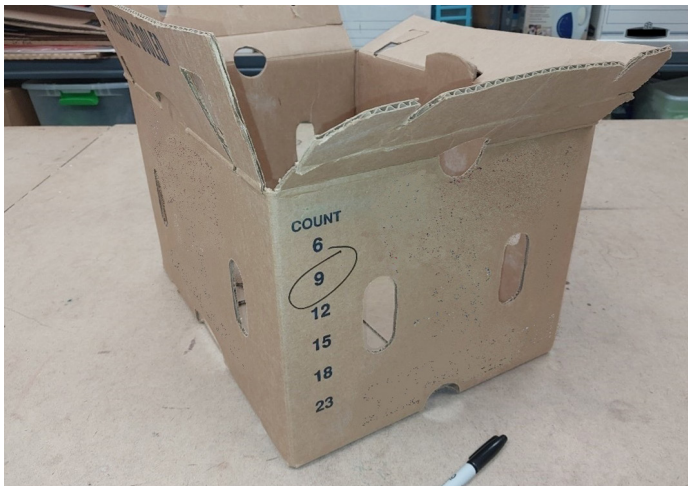

Figure 2: A typical 'eight down', double walled, cantaloupe carton, with common size grades printed on the outside, which are then marked at packing with the number of fruit within.

Standardizing yield becomes more complicated as the carton size is regularly changed based on average fruit size coming out of the field, or supply chain demand. A local carton supplier identified three common carton sizes: a 'seven-down', 'eight-down', and 'nine-down', named after the stacking pattern used when shipping on standard 48x40 inch pallets. The larger cartons of a seven-down pattern sets-down a single layer of seven cartons, while a smaller nine-down has nine cartons at the base of each stack that are touching the pallet. Seven-down cartons are used when fruit sizes are larger than normal; eight-down are the most common 'standard' size used, and nine-down are used for small fruit harvested to meet specialty customer demands or when the market prices increase value [Table 1] (J. Sullivan., personal communication, July 22, 2024).

Table 1. Inner dimensions of different double walled cardboard cantaloupe cartons.

Cantaloupe Carton Type	Length (in.)	Width (in.)	Height (in.)
Seven-down	18.5	12.75	11.0
Eight-down	16.75	12.75	10.0
Nine-down	15.5	12.75	10.5

Industry has adopted and perfected the sizing-by-feel packing method, which works well for commercial production. However, these measurements are often not precise enough to determine impact of research trials that evaluate methods to improve yield, or understand drought, fertility, or pest effects, which may have small cumulative effects in need of closer observation. Additionally, artificial intelligence and machine learning require more detailed measurements if we wish to integrate automation into future growing, harvesting, and packing operations.

There are very few published references on converting individual melon measurements such as diameter, circumference, and weight to the carton size grades, likely because carton sizes must vary to accommodate the natural change in melon size. An experiment was conducted to correlate individual melon size (circumference) to carton size grade by filling an eight-down standardized carton with different sized spherical balloons and counting how many fit inside. Balloons were inflated with a mechanical pump and circumference measured with a flexible measuring tape. Balloons were inflated to seventeen different sizes, at half-inch intervals, between circumferences of 14 and 22 inches. The carton was packed with balloons of the same size and two values were recorded: 1. the number of balloons that fit inside, 2. the 'tightness level' reported as lose to very tight (Table 2) (Figures 3, 4).

Figure 3. Ballons were inflated to seventeen different sizes and packed into an eight-down carton.

Figure 4. Balloon circumference size of 20 in. could be considered a carton size grade nine, as nine melons fit very tightly into a carton.

Table 2. Balloons were inflated to specific sizes and packed into cartons to convert circumference measurements into cantaloupe carton size grades.

Melons Size (Inch)	Number of Melons per Carton	Tightness Level
14.0	21	Normal
14.5	18	Normal
15.0	18	Normal
15.5	18	Tight
16.0	15	Normal
16.5	12	Normal
17.0	12	Normal
17.5	12	Tight
18.0	12	Very Tight
18.5	9	Normal
19.0	9	Normal
19.5	9	Tight
20.0	9	Very Tight
20.5	6	Normal
21.0	6	Normal
21.5	6	Normal
22.0	6	Normal

Results

Initial information gathered from Table 2 showed a range in size grades from 6-21, and their corresponding circumferences from 22-14 inches. The information was cross-validated with measurements provided by Ines Bazan, a private industry agriculturalist of 30 years (Table 3) (Figure 5). Measured data was transformed to better fit the comparison between the two sets, which were found to be 99% correlated, and high degree of similarity was identified with a two-tail pairwise comparison test result with a p-value of 0.129 (Table 3). To further assist researchers with converting inches of fruit circumference to carton size grade a formula for use in Microsoft Excel is present in Table 4.

Table 3. Circumference to carton grade conversion measurements from Ines Bazan and balloon trial measurements. Two-tail pairwise t-tests of highlighted values produced a p-value of 0.129, indicating a high degree of similarity between the two datasets.

Carton Size Grades	Ines Data (IN Circumference)			Balloon Data (IN Circumference)	
	min	max		min	max
above std	24.38	.		.	.
5	22.81	24.35		.	.
6	20.45	22.78		20.5	22.00
9	18.47	20.42		18.5	20.49
12	16.9	18.44		16.5	18.49
15	15.74	16.87		16	16.49
18	14.95	15.71		14.5	15.99
22	14.17	14.92		14	14.49
under std		14.14			.

Table 4. Microsoft Excel formula to convert cantaloupe inch circumference sizes into cantaloupe carton size grades. Note: reference the circumference value placed in cell B2 for conversion.

=IF(B2>=24.38, "abv_std", IF(B2>=22.81, 5, IF(B2>=20.45, 6, IF(B2>=18.47, 9, IF(B2>=16.9, 12, IF(B2>=15.74, 15, IF(B2>=14.95, 18, IF(B2>=14.15, 22, IF(B2<=14.14, "under_std"))))))))

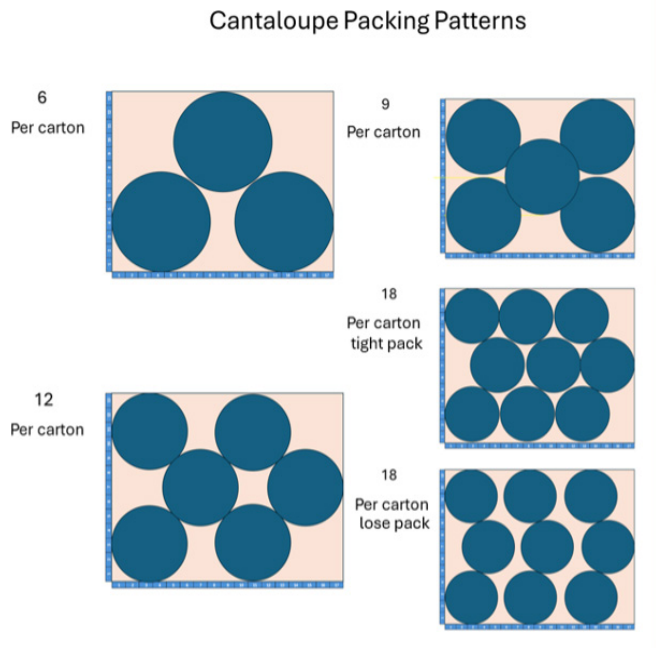

Figure 5. Melon size influence on cantaloupe packing patterns within shipping cartons.

After measurements for each melon is converted to the carton size grade number, the total for each grade can be counted and divided by the respective carton size grade number to determine the total number of boxes of each size grade. These numbers can then be set to an acre value and used to calculate yield divided by size grade.

Conclusion

In certain crops like cantaloupe there is an important difference between total crop yield, defined as all fruit produced by the plant, and marketable yield, fruit within industry specifications required for packing, transit, storage, and sale. Out-of-spec fruit is not harvested, labeled as 'walk-by' the fruit is disked back into the soil at the end of the season. To assist researchers develop ways to reduce food waste, assist with automated harvesting, and generate more revenue for the grower a conversion formula was made to estimate the industry carton grades with individual melon circumference measurements. It is important to note the limitations of this formula, as it is built around the most popular standard eight-down carton, which may be changed based on the melon type grown, seasonal growth habits, or shipping requirements. Future research is recommended to further validate the formula using actual cantaloupe fruit instead of the balloon simulants and using a quarter-inch size gradient instead of one-half inch. Additionally, current size graders from industry should be interviewed to uncover nuances in the grading system, such as the use of nine-jumbo, which are in-between a nine and a six, which are often used to finish off a box of smaller nines. The balloon trial should also be repeated with the larger seven-down and smaller nine-down boxes to understand how the formula could be adjusted based on packing method.

Special appreciation is given to Richard Tanaka with SMT Farms, LLC, Johnny Sullivan with Vegetable Growers Supply, and Ines Bazan from LIDA Plant Research Company for sharing their time and expertise with making this publication.

Citations

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