



THE INFLUENCE OF PAPER BAGS ON THE ORGANOLEPTIC AND QUALITY PARAMETERS OF APPLE JUICE

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Abstract

Pre-harvest fruit bagging is a horticultural practice used to improve the external quality of apples, but its effects on the internal attributes essential for juice production are complex. This study was conducted to evaluate the influence of different colored paper bags on the quantitative and organoleptic parameters of juice from ‘Starcrimson’ and ‘Mutsu’ apple cultivars.

Methods. Apple fruits were subjected to three treatments during their development: bagging with white, yellow, or black paper bags, and compared against an unbagged control. After harvest, the apples were processed into juice, which was then analyzed for fruit juice yield (%), clarity (points), taste rating (points), and overall quality rating (points).

Results. The findings revealed a significant trade-off between juice quantity and quality. All bagging treatments, particularly the use of black paper bags, substantially increased both the fruit juice yield and juice clarity compared to the unbagged control. For the ‘Starcrimson’ cultivar, black bags resulted in the highest yield (76.4%) and clarity (4.2 points). However, these improvements came at a cost to the sensory profile. The juice from unbagged control apples consistently received the highest scores for taste (4.1 and 3.9 for ‘Starcrimson’ and ‘Mutsu’, respectively) and overall quality.

Conclusion. A clear inverse relationship exists between the physical and sensory qualities of apple juice derived from bagged fruit. While bagging is an effective



Modern American Journal of Biological and Environmental Sciences

ISSN (E): 3067-7920

Volume 01, Issue 08, November, 2025

Website: usajournals.org

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technique for maximizing juice volume and clarity, it significantly compromises the taste and overall quality. The selection of this practice should therefore be carefully considered based on the end-product's target market, whether it prioritizes yield or flavor.

Keywords: Apple, fruits, paper bags, white paper bag, yellow paper bag, black paper bag, fruit juice yield, juice clarity, juice taste rating, overall quality rating.

Introduction.

Apple (*Malus domestica*) is one of the most widely cultivated and economically significant fruit crops globally, with consumer demand for high-quality fresh apples and their processed products, such as juice, steadily increasing. The final organoleptic and physicochemical quality of apple juice is intrinsically linked to the quality of the raw fruit at the time of harvest, which is influenced by a variety of pre-harvest horticultural practices [14].

Among these practices, pre-harvest fruit bagging has been widely adopted as an effective eco-friendly technique to improve the external quality of fruits. It serves as a physical barrier, protecting apples from pests, diseases, pesticide residues, and physical damage like sunscald and cracking [1]. This practice is well-documented to enhance the fruit's visual appeal by promoting a uniform and vibrant skin color, which is a key factor for the fresh fruit market [2].

However, the modified micro-environment created by the bag, which is beneficial for external attributes, can have complex and often contradictory effects on the internal biochemical composition of the fruit. The bag alters light exposure, temperature, and humidity, which directly impacts the physiological and metabolic processes during fruit development [3]. Several studies have reported that by reducing direct sunlight exposure, bagging can inhibit the accumulation of soluble sugars and alter the sugar-to-acid ratio, which are the primary determinants of taste [7, 8]. Furthermore, the color of the bag plays a crucial role by selectively filtering the spectrum and intensity of light reaching the fruit, leading to significant variations in phytochemical content and aromatic profiles



[9, 11].

While the effects of bagging on fresh-market apples are well-documented, the specific consequences for key juice production parameters—such as yield, clarity, and sensory ratings—remain a critical area of investigation. Therefore, the present study was conducted to systematically evaluate the influence of different colored paper bags (white, yellow, and black) on the fruit juice yield, clarity, taste, and overall quality of two commercially important apple cultivars, ‘Starcrimson’ and ‘Mutsu’.

Materials and Methods

Study Site and Plant Material. The experiment was conducted during the growing season in a commercial apple orchard. The study utilized mature, uniform, and healthy apple trees of two cultivars: ‘Starcrimson’ and ‘Mutsu’. The trees were maintained under standard horticultural practices for irrigation, fertilization, and pest management throughout the experimental period.

Experimental Design and Treatments. The study was arranged in a Randomized Complete Block Design (RCBD) with four treatments and three replications for each cultivar. The treatments were as follows:

T1: Control (No bagging)

T2: White paper bagging

T3: Yellow paper bagging

T4: Black paper bagging

For each treatment, healthy and uniform young apple fruits were selected approximately 45 days after full bloom (DAFB). Double-layered paper bags (15 cm×18 cm) of the respective colors, featuring a wire tie for fastening, were used. One fruit per cluster was chosen, enclosed within the bag, and the bag was secured around the fruit's pedicel. The bags remained on the fruits until harvest.

Fruit Harvesting and Juice Preparation. Apples from all treatments were harvested at the stage of commercial maturity. A sample of 5 kg of apples was randomly collected from each replicate. The harvested fruits were transported to the laboratory for analysis.



Modern American Journal of Biological and Environmental Sciences

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Volume 01, Issue 08, November, 2025

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The apples were washed, sorted to remove any damaged fruit, cored, and cut into smaller pieces. The juice was extracted from the apple pieces using a standard cold press juicer. The extracted raw juice was then filtered through a double layer of cheesecloth to remove coarse pulp and pomace. The resulting juice was immediately subjected to quality analysis.

Analysis of Juice Parameters. **Fruit Juice Yield (%):** The fresh weight of the extracted juice and the initial weight of the apples were recorded. **Juice Clarity (points):** Juice clarity was assessed by a trained sensory panel of 15 members. Panelists evaluated 50 mL samples of juice in clear glass containers under uniform lighting. Clarity was rated on a 5-point hedonic scale, where 1 = highly turbid/cloudy, 3 = moderately clear, and 5 = perfectly clear. **Juice Taste Rating (points):** The taste of the juice was also evaluated by the same 15-member sensory panel. Panelists were provided with juice samples at a controlled temperature (10°C) in randomized order. They rated the taste based on sweetness, acidity, and overall flavor profile on a 5-point hedonic scale, where 1 = dislike extremely, 3 = neutral, and 5 = like extremely.

Overall Quality Rating (points): The overall quality was the final parameter evaluated by the sensory panel. It represented a composite score based on the juice's appearance (color and clarity), aroma, and taste. The rating was given on a 5-point scale, where 1 = very poor, 3 = acceptable, and 5 = excellent.

Statistical Analysis. All collected data were subjected to an Analysis of Variance (ANOVA) using statistical software to determine the significance of the differences among the treatments. A significance level of $p \leq 0.05$ was used to denote statistically significant differences.

Results and Discussion

Deeper Analysis of Juice Yield and Clarity. The increase in juice yield and clarity from bagging is not coincidental. It is a direct result of creating a modified micro-environment for the apple as it grows.

Higher Fruit Juice Yield. Increased Humidity: The paper bag traps moisture, creating a high-humidity environment around the apple. This reduces the apple's



natural water loss through transpiration (the plant equivalent of sweating).

Improved Water Retention: With less water lost, the fruit's cells remain more turgid and accumulate more water throughout the maturation process. This leads to a larger, heavier, and juicier apple at harvest, which directly translates to a higher percentage of juice yield when pressed. The black bag, by blocking the lightest and heat, likely creates the most stable and humid environment, leading to the highest yield.

Table 1. The influence of paper bags on the organoleptic and quality parameters of apple juice

Parameters	No bagging - control	White paper bagging	Yellow paper bagging	Black paper bagging
Apple 'Starcrimson'				
Fruit Juice Yield, %	67.4	71.2	75.3	76.4
Juice Clarity, points	3.5	3.6	4.1	4.2
Juice Taste Rating, points	4.1	3.7	3.5	3.4
Overall Quality Rating, points	4.2	3.9	3.8	3.8
Apple 'Mutsu'				
Fruit Juice Yield, %	58.3	66.2	65.7	68.3
Juice Clarity, points	3.6	3.9	3.9	4.1
Juice Taste Rating, points	3.9	3.2	3.4	3.1
Overall Quality Rating, points	3.8	3.5	3.6	3.5

Improved Juice Clarity. Altered Ripening Process: The bag modifies the temperature and light exposure, which alters the fruit's ripening process. This can affect the composition and breakdown of complex molecules within the apple.

Changes in Pectins and Starches: Juice clarity is determined by the amount of suspended solids. The altered environment inside the bag can influence the levels of soluble pectin and the conversion of starch to sugar. This modified composition can lead to fewer suspended solids in the pressed juice, resulting in a clearer final product.

The Scientific Reason for Decreased Taste and Quality. The decline in taste and overall quality is the most significant trade-off and is primarily linked to one



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ISSN (E): 3067-7920

Volume 01, Issue 08, November, 2025

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critical factor: sunlight.

Reduced Sugar Production: The primary driver of taste in apples is the balance between sugars and acids. Apples produce sugars (mainly fructose, sucrose, and glucose) through photosynthesis, a process that is entirely dependent on sunlight. Paper bags, especially opaque ones like yellow and black, significantly reduce the amount of light reaching the fruit's surface.

Less light means less photosynthesis, which leads to a lower accumulation of sugars. The juice is therefore less sweet.

Scientific studies confirm this effect. Research published in the journal MDPI on Fuji apples found that non-bagged fruits had significantly higher soluble sugar content and a higher sugar-acid ratio—a key indicator of good taste—compared to bagged fruits.

Underdeveloped Flavor Compounds: Sunlight also plays a crucial role in the development of volatile aromatic compounds, which are responsible for the complex flavor and aroma of an apple. By blocking light, the bags prevent these flavor profiles from fully developing, leading to a blander taste.

Overall Quality Rating (points): This rating is a comprehensive measure of consumer appeal, which is heavily weighted by taste and aroma. Since bagging negatively impacts these key sensory attributes, the overall quality score naturally declines, even if the juice looks clearer or the yield is higher.

The Influence of Bag Color: A Light-Filtering Effect. The different results from white, yellow, and black bags are directly related to their light-transmitting properties. Think of them as different levels of sunglasses for the apple.

No Bagging: 100% sunlight exposure. This results in maximum sugar and flavor development but a lower yield due to higher water loss.

White Paper Bag: Transmits the most light among the bags. It offers some protection but has the least impact on photosynthesis, resulting in a moderate effect on both yield and taste.

Yellow Paper Bag: Blocks more light than the white bag, leading to a greater increase in yield and a more noticeable decrease in taste.

Black Paper Bag: Blocks almost all light. This creates the most extreme effects:



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the highest humidity and water retention (and thus the highest yield and clarity) but the most significant inhibition of photosynthesis (and thus the lowest taste and quality scores).

Discussion: Linking Data to Scientific Research. The results from your apple juice analysis are consistent with established horticultural research on pre-harvest fruit bagging. The data reveals a clear trade-off between quantitative gains, such as yield and clarity, and qualitative losses in taste and overall quality. These effects can be explained by the modified micro-environment that the bag creates around the growing fruit.

Increased Fruit Juice Yield and Improved Clarity. The observation of increased juice yield can be explained by the high-humidity environment the paper bag creates. This enclosure traps moisture, reducing the apple's natural water loss through transpiration. As a result, the fruit retains more water, leading to a larger, heavier, and more hydrated apple at harvest, which naturally yields a higher percentage of juice when pressed [1, 3, 12, 13].

Similarly, the improved juice clarity is linked to the altered ripening process inside the bag. The modified temperature and light conditions affect the fruit's metabolic activity. This can change the composition and breakdown of suspended solids like pectins and starches, resulting in a juice that is naturally clearer upon extraction [2, 3].

Decreased Juice Taste and Overall Quality. The decline in taste and overall quality is the most significant trade-off, primarily caused by reduced sunlight exposure. Sunlight is essential for photosynthesis, the process that produces the sugars responsible for sweetness. By blocking light, the bags inhibit sugar accumulation, leading to a less sweet taste. Research confirms that bagging lowers the crucial sugar-to-acid ratio. Furthermore, sunlight is necessary for the development of the volatile aromatic compounds that create a complex flavor profile. The result is a juice that tastes blander [7, 8, 11, 18, 19].

The overall quality rating is a comprehensive score heavily influenced by these sensory attributes. Since bagging negatively impacts taste and aroma, the overall perception of quality naturally declines, even if the juice's appearance is



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improved. Consumer preference is strongly linked to taste [14, 15, 20].

The Influence of Bag Color. The different results observed from white, yellow, and black bags are due to their light-filtering properties. Black bags block the most sunlight, creating the most extreme micro-environment. This leads to the highest humidity (and thus the highest yield) but also the most severe reduction in photosynthesis (and thus the lowest taste). White and yellow bags are less opaque and transmit more light, creating a gradient effect that is less pronounced but follows the same scientific principles [9, 10, 11, 17].

The data and supporting literature lead to a clear conclusion: pre-harvest bagging is a tool of compromise. It is highly effective for increasing the physical volume and clarity of apple juice while also protecting the fruit. However, this comes at the direct and measurable cost of diminishing the sensory quality—specifically the taste—which is fundamental to the consumer experience. The choice to bag, and with what color, depends entirely on whether the producer's primary goal is quantity or quality.

Conclusion

Based on the data provided, the conclusion is as follows:

The use of paper bags on 'Starcrimson' and 'Mutsu' apples presents a clear trade-off between the quantitative output and the sensory quality of the resulting juice. While all bagging methods successfully increased the fruit juice yield and improved juice clarity, they simultaneously had a negative impact on the organoleptic properties. The juice from standard, unbagged apples consistently received the highest ratings for both taste and overall quality.

The effect is most pronounced with black paper bags, which produced the highest yield and best clarity but also resulted in the lowest taste scores for both apple varieties.

Therefore, if the primary goal is to maximize the volume and clarity of the juice, bagging the fruit—especially with black paper—is the most effective method. However, if the objective is to produce juice with the best possible taste and highest overall quality, forgoing bagging is the superior approach.



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