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Organoleptic characteristics evaluation of Diab mango fruits as affected by hot water treatments

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Abstract

Mango, a highly perishable fruit, faces challenges in maintaining its quality during postharvest handling due to rapid ripening. To address this, hot water treatment (HW) has gained global recognition for its potential in enhancing the shelf life and overall quality of mango produce. This study, spanning the 2019 and 2020 seasons, focused on hot water dipping (HWD) treatments at 45 or 50°C for 5 and 10 minutes, followed by simulated shipping storage at 8±2°C and 90-95% relative humidity for three weeks, and subsequent ripening at 20°C. Using sensory evaluations through the Hedonic test, our findings after 21 days of ripening storage revealed that the HWD treatment at 50°C for 10 minutes yielded significantly higher scores for firmness, texture, and pulp color (3.49, 3.00, and 5.00, respectively) compared to untreated mangoes, which scored lower (1.15, 2.00, and 4.67). A gradual improvement in aroma and flavor scores was observed, with the 50°C, 10-minute treatment recording the highest scores (4.67 and 3.67), while control fruits exhibited the lowest taste scores (3.00 and 2.33). These results highlight the potential of HWD treatments, particularly at 50°C for 10 minutes, in enhancing mango quality and extending its shelf life.

Key words: Mango fruit, ripening, sensory evaluation, texture, aroma and flavor

Introduction

Mango (*Magifera Indica* L.) is a widespread fruit and one of the most consumed fruits in the world as an item of international trade and widely cultivated in the tropics and subtropical regions. (Liguori *et al.,* 2020). It is known as the king of fruit for its excellent attractive appearance and flavor characteristics. Mango fruit supply is limited in the local market as well as for export due to its highly perishable, climacteric nature and short shelf-life (El Hadi *et al.,* 2013 and Hossain *et al.,* 2021). The ripening of mango fruit is a complex biological process characterized by a sequence of metabolic activities. These activities result in notable physical and chemical transformations, including the softening of fruits, degradation of chlorophyll, and the biosynthesis of carotenoids. Additionally, starch undergoes hydrolysis, converting into sugars, ultimately contributing to the desired ripening quality of the fruit (Gill *et al.*, 2017).

Mango consumption offers a rich source of bioactive compounds renowned for their antioxidant properties. The expression of ripening quality in mangoes is multifaceted, encompassing attributes such as exquisite taste, distinctive flavor, alluring aroma, and elevated nutritional content (Farzana and Baloch, 2014). In the realm of consumer preference, sensory characteristics play a pivotal role, including parameters such as flavor, aroma, color, texture, and overall acceptability. Consequently, studies have been undertaken on sensory evaluation to discern the most preferred mango sample as determined by panelists (El Hadi *et al.*, 2013).

The visual appeal of fruit is intricately linked to its physical attributes, encompassing size, shape, gloss, and consistency, while also demanding freedom from imperfections such as blemishes and bruises. Simultaneously, the tactile experience of fruit, expressed through texture, is influenced by factors like turgor pressure, cell wall composition, and the cohesive middle lamella binding individual cells (Sivakumar *et al.*, 2011; Hossain *et al.*, 2021). Furthermore, the multifaceted concept of flavor extends beyond the taste buds, encapsulating both taste and aroma perceptions in the mouth, including sweetness, acidity, bitterness, and aromatic nuances. The four primary tastes (sweet, sour, salty, and bitter) contribute to the intricate palate experience. Aroma, a pivotal facet of fruit appreciation, comprises a bouquet of volatile compounds unique to each fruit variety, playing a paramount role in consumer acceptance (Bonneau *et al.*, 2016; Lui *et al.*, 2020). Studies engaging panelists in palatability tests encompassing taste, after-taste, color, aroma, and overall acceptability have beenn conducted. Interestingly, no significant differences were observed among the studied products concerning aroma, taste, and color in the collected data (El Hadi *et al.*, 2013; Lui *et al.*, 2020).

Mangoes are climacteric fruit with a short and limited shelf life when held at ambient temperatures and is sensitive to chilling injury when stored below 10 °C. To maintain fruit quality, it is important to control deterioration processes and damaging problems. Therefore, tropical fruits such as mangoes are commonly required to have a thermal treatment against invasive pests, to prolong shelf life and preserve fruit quality (Djioua *et al.,* 2009).

Postharvest heat treatment offers a pesticide-free method to kill or weaken plant pathogens, control insect infestations inhibit ripening, soften and maintain fruit storage quality (Shao *et al.,* 2007). Hot water treatment was the most effective for retarding the ripening process and spoilage of mango fruits (Hossain *et al.,*

2021). HW extended the shelf life of mango fruits by slowing down the ripening and delaying the onset of climacteric, which in turn maintained the compositional quality and physical integrity of the fruits during the storage period (Hossain, *et al.,* 2021).

Among different heat treatments, the use of hot water as a disinfestation treatment has been widely adopted because of its efficacy and low cost. The additional benefit of hot water treatment is that it can control postharvest diseases such as anthracnose and stem end rot. The quality of mango fruits during export was greatly improved by hot water dipping treatments as quarantine against invasive pests for expanding the market and shelf-life duration (Anwar and Malik, 2007).

Therefore, this study was conducted to evaluate the effectiveness of hot water dipping (HWD) treatments at 45 and 50°C for 5 and 10 minutes on enhancing mango quality and extending shelf life. Specifically, assess key attributes such as firmness, texture, pulp color, aroma, and flavor using sensory evaluations.

Materials and methods

Plant materials: Mango fruits (*Mangifera indica* L.) cv. Diab was obtained from a private orchard (Nemous), Katta district, Giza Government and was used in this study. Mango fruits were harvested at the maturity stage with indices recorded (firmness 13.45 Ib/inch^2, TSS 10.50% and acidity 0.20%) in the two successive seasons of 2019 and 2020. Mango trees were 15 years old, grown in sand-loam soil and were similar in growth and received common horticulture practices. Fruits were collected and transported to the ADS project laboratory at Cairo University, prioritizing minimal physical damage. Upon arrival, a careful selection process ensured uniformity in shape, color, and size, excluding visible wounds. Decontamination involved immersing fruits in 100 ppm free chlorine for 10 minutes, minimizing microbial contamination. After decontamination, gentle drying occurred to eliminate excess water, maintaining consistency in subsequent treatments. Random distribution of selected fruits for different treatmnts minimized bias during hot water treatments, enhancing experimental reliability. Harvest assessments, including color and firmness, provided crucial insights into initial fruit quality before treatments.

The hot water treatment was performed by subjecting mango fruits to hot water dipping (HWD) at 45 or 50 ºC for 5 and 10 min., and then cooled for 10 min. too. During HWT, fruit core temperature was confirmed by using a digital thermometer with an electronic probe. After treatments, fruits in each treatment were packed in corrugated cardboard boxes. All HW-treated and non-treated fruits (control) were stored at 8±2ºC as shipping simulation with 90-95% relative humidity for 3 weeks and then ripened for one week at 20 ºC. Each treatment constituted three replications for each sampling date and each replicate consisted of 5 fruits. Fruit organoleptic measurements were assessed after each sampling date at 8 ºC and ripened at 20 ºC for one week.

Organoleptic evaluation

Panel test: Mango fruit organoleptic evaluation was determined using a hedonic scale (Larmond, 1987). Sensory characteristics like firmness (hardness/softness), texture (texture, grit, character, succulence, and fiber), aroma (Aroma, ripeness, sweetness, and fruitiness), taste (sweet, sour, salty, and bitter) and overall acceptability (taste great, acceptable, and unacceptable) for all the samples was done. A panel of 7 judges with ages ranging from 25-40 years was made on their consistency and reliability of judgment.

Sensory evaluation score: The mango fruits obtained were equally divided among the experts. Panelists were asked to score the difference between samples by allowing the numbers from 0-5, where 0 represents excellent, 2 for very good, 3 for good, 4 fair and 5 for bad (poor) properties of firmness, texture, aroma, and taste. Five mangoes from each treatment were taken for the sensory evaluation with three replications. Panelists put their consensus average scores of sensory evaluations of the mango samples for pulp color, aroma, texture, taste and overall acceptability. After scoring, the acceptability of the mango fruit quality properties as per the scoring form was measured. The results were evaluated and statistically analyzed (Kader, 2008).

Statistical analysis: The design for this experiment was a completely randomized design (CRD) with three replications. Data were analyzed with the analysis of variance (ANOVA) procedure of the MSTATC program. When significant differences (P>0.05) were detected, data was treated by analysis of variance with standard deviation (Steel and Torrie, 1980). Data was treated by analysis of variance with standard deviation.

Results and discussion

Organoleptic fruit measurements

During storage: The study investigated the impact of different temperature and duration treatments on the firmness and texture of mango fruits during varying storage durations (Table 1). In the control group, mango firmness started at 9.73 lb/in² at 7 days, gradually decreasing to 3.00 lb/in² by day 21, with a consistent texture score of 3.76. The treatment at 45°C for 5 minutes resulted in increased firmness at 7 days (12.17 lb/in²), maintaining a texture score of 3.67 throughout the storage period. Mango fruits treated at 45°C for 10 minutes exhibited enhanced firmness at 7 days (12.55 lb/in²) and sustained higher values at 15 days, with an improved texture score of 4.00 at 15 days. Treatment at 50°C for 5 minutes led to improved firmness at 7 days (12.75 lb/in²), gradually declining over the storage period, while texture remained constant at 3.67. The most effective treatment was observed at 50°C for 10 minutes, resulting in the highest firmness (13.22 lb/in²) at 7 days, gradually decreasing but remaining superior to other treatments, with texture improving to 4.00 at 7 days. These findings underscore the influence of temperature and duration on mango firmness and texture, with potential applications for enhancing mango fruit quality during storage.

The sensory attributes of mango fruit, such as aroma and flavour, exhibited a consistent and notable increase over a 21-day storage period. The treated fruits displayed the highest values for mango taste, with aroma scores of 3.67 and 3.33, and flavour scores of 5.00 and 4.67. In comparison, the control fruits had scores of 3.00 and 3.67 for aroma and flavour, respectively. The findings of our study align with the research conducted by Anwar and Malik (2007), which revealed that heat water treatment (HWT) is commonly used as a method to control decay in commercial settings. The specific temperature and duration of the treatment vary based on factors such as fruit maturity, cultivar type, growing conditions, and the type of disease. In

Table 1. Effect of hot water treatments dipping (HWD) on organoleptic parameters scores of Diab mango fruits during storage at 8°C for 21 days as an average of the seasons of (2019-2020)

Treatments	Storage duration (days)	Firmness (Ib/inch^2)	Texture	Pulp color	Aroma	Flavor	Acceptability
Control	7	9.73 c	3.76 a	2.00 c	2.67 a	2.33 d	3.67 d
	15	6.01 g	3.33 a	2.67 bc	3.00 a	3.33 bcd	4.00 cd
	21	3.00 h	3.00 a	3.76 a	3.33 a	3.67 ab	4.67 ab
45°C/5min	7	12.17 a	3.67 a	2.33 c	3.00 a	3.00 cd	4.00 cd
	15	8.00 ef	3.33 a	3.33 ab	3.33 a	4.33 abc	4.33b
	21	6.03 g	3.00 a	4.00 a	3.67 a	4.67 ab	5.00 a
45°C/10min	7	12.55 a	4.00 a	2.67 bc	2.67 a	3.00 cd	4.00 cd
	15	8.65 de	3.67 a	3.33 ab	3.00 a	4.00 abc	4.33 b
	21	7.30 f	3.33 a	4.00 a	3.33 a	5.00 a	5.00 a
50°C/5min	7	12.75 g	3.67 a	2.67 bc	2.67 a	3.33 bcd	4.33 b
	15	10.30 bc	3.33 a	3.63 bc	3.00 a	4.00 abc	4.67ab
	21	8.45 de	3.33 a	4.00 a	3.33 a	4.76 cd	5.00 a
50°C/10min	7	13.22 a	4.00 a	3.00 c	3.00 a	3.76 a-d	4.33b
	15	11.02 b	3.67 a	3.67 bc	3.33 a	4.33 abc	5.00 a
	21	9.25 cd	3.33 a	4.33 a	3.67 a	4.67 ab	5.00 a

addition, according to Gill *et al.* (2017), the fruits were firm in texture, highly acidic, and had low edible quality at the time of harvest. The sensory quality (SQ) of fruits stored at a temperature of 20°C consistently improved as the ripening period progressed. Furthermore, Hossain *et al.* (2021) demonstrated that the use of $CaCl_2$ in hot water treatment has beneficial and ongoing impacts on the sensory and quality characteristics of mango fruits. It also enhances enzyme activities and prolongs the shelf life of the fruits by retarding the ripening processes during storage, which is well-received by consumers.

At ripening stage

The organoleptic characteristics of fruits throughout ripening duration at 20°C for 3 weeks (7, 15 and 21 days) are shown in Fig. 1.

Firmness and texture: Throughout the ripening of mango fruits at 20°C, the fruits treated with different hot water treatments (HWT), cleared significant decrease with higher significant values compared with untreated fruits (control) with expanding ripening duration of both seasons of study as shown in Table 2. Hot water treatment at 50°C for 10 min was more effective in keeping fruit firm with the highest texture score (3.49 and 3.00 Ib/inch^2), followed by fruits dipped in HW at 50°C for 5 min. at the third week of ripening. Meanwhile, the lowest firmness and texture score (1.15 and 2.00 Ib/inch^2) was recorded by untreated mango fruits in the third week. According to the same direction, Bonneau *et al.* (2016) found that the textural properties of a food are the "group of physical characteristics that arise from the structural elements of the food, are sensed by the feeling of touch, are related to the deformation, disintegration and are measured objectively by functions of mass, time, and distance." Meanwhile, Liguori *et al.* (2020) reported that the loss of fruit juiciness during softening is due to the pectin polysaccharide metabolism. The reduction of its capacity to retain water leads to an increase in the perception of juiciness in fruit tissue, Moreover, Hossain, *et al.* (2021) found that fruit texture is one of the important parameters that play a crucial role when a consumer selects the fruits. Pectin is a structural polysaccharide present in the cell walls of cells and responsible for the firmness of fruits and it becomes loosened during ripening or softening due to hydrolysis by pectinase.

Table 2. Effect of hot water treatments dipping (HWD) on organoleptic parameters scores of Diab mango fruits during ripening at 20°C for 21 days as an average of the seasons of (2019-2020).

		Organoleptic parameter scores				
Hot Water Treatments	Ripening duration (Days)	Firmness (Ib/inch^2)	Texture	Pulp color	Aroma	Flavor
Control	7	2.09 e	3.00 b	3.00 c	2.67 e	1.33 c
	15	1.85ef	2.67 bc	4.00 b	2.67 e	1.67 bc
	21	1.15 fg	2.00 d	4.67 a	3 .00 de	2.33 bc
45°C/5min	7	2.49 e	3.00 b	4.00 b	2.67 e	2.00 bc
	15	1.99 e	2.67 bc	4.33 ab	3.67 bc	2.67 ab
	21	1.65 f	2.00 d	4.67 a	4.33 ab	3.67 a
45°C/10min	7	3.09 d	3.00 b	4.00 b	3.00 de	2.00 bc
	15	2.80 de	2.67 bc	4.33 ab	3.67 bc	2.67 ab
	21	2.79 e	2.33 cd	4.67 a	4.33 ab	3.67 a
50°C/5min	7	4.35 bc	3.33 ab	4.33 ab	3.00 de	2.00 bc
	15	3.10 d	3.00 b	4.67 a	3.67 bc	2.67 ab
	21	2.93 d	2.67 bc	5.00 a	4.33 ab	3.67 a
50°C/10min	7	5.20 a	3.67 a	4.33ab	3.33 cd	2.00 bc
	15	5.14 b	3.33 ab	4.67 a	4.00 b	2.67 ab
	21	3.49 cd	3.00 b	5.00 a	4.67 a	3.67 a

Color and appearance: Our findings indicate a significant increase in the pulp color of Diab mango fruit with the extension of the ripening duration. This trend was observed consistently in both treated and untreated fruits (control). Notably, the hot water treatments at 50°C, administered for either 5 or 10 minutes, demonstrated a more pronounced enhancement in mango pulp color scores. After 21 days of ripening at 20°C, these treatments were found to be significantly superior to the other tested methods.

These results align with the findings of Crisosto *et al.* (2004), who emphasized that the external appearance of the whole fruit serves as an indicator of ripeness, with consumers expressing a preference for a specific color. Additionally, Patil *et al.* (2017) added that color acts as a preliminary parameter influencing consumer demand and indicating the product's fitness.

According to Slaughter (2009), the primary factor influencing the distribution of light energy reflected from the fruit is the presence and concentration of pigments, including carotenoids, anthocyanins, other flavonoids, and chlorophylls in the skin. Changes in these pigments during fruit development impact the perception of fruit color, making it a frequently used index of maturity or ripeness.

Aroma: Aroma comprises a complex mixture of numerous volatile compounds, with composition specificity often tied to the species and variety of fruit. Recognized as a crucial indicator of fruit flavor quality (Bonneau *et al.*, 2016), the study observed that the concentration of volatile

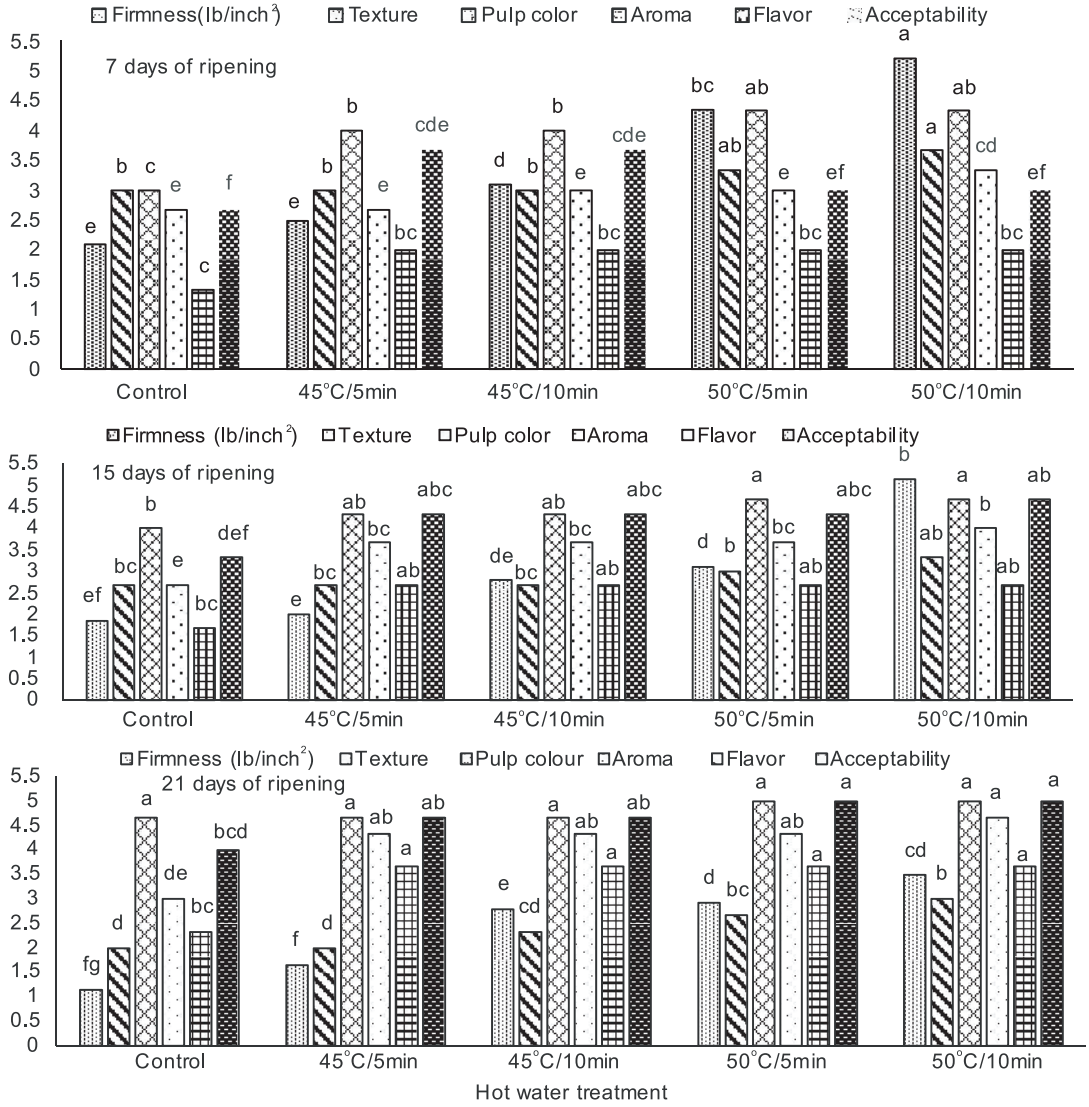

Fig. 1. Effect of hot water treatments dipping (HWD) on organoleptic parameters scores of Diab mango fruits for 7, 15 and 21 days during ripening at 20ºC as an average of the seasons of (2019-2020).

compounds increases with the ripening of fruits, as depicted in Table 2. Throughout the ripening stage, the aroma of Diab mango fruit exhibited a gradual and significant augmentation, evident for 7, 15, and 21 days in both treated and untreated fruit. Notably, hot water treatment at 50°C for 10 minutes proved significantly more effective, yielding the highest aroma score (4.67) compared to all fruits under investigation.

This outcome aligns with Slaughter (2009), who highlighted that fruits synthesize and emit a diverse array of aroma volatile compounds. The release of these volatiles contributes to the olfactory experience of consumers when consuming ripe fruit, enhancing their overall enjoyment. Moreover, El Hadi *et al.* (2013) emphasized that mango possesses an appealing aroma, with over 270 aroma volatile compounds identified in various mango varieties. The release of these volatiles significantly contributes to the sensory pleasure of ripe fruit consumption.

Adding to this perspective, Liguori *et al.* (2020) reported that the distinct aroma and flavor perception of specific fruits result from the intensity and range of different volatile compounds synthesized during ripening. These aroma and flavor characteristics play a pivotal role in influencing consumer preference and acceptance.

Flavor: The flavor of fruits and vegetables encompasses the sensory perception in the mouth, influenced by taste factors such as the balance between sweetness and sourness or acidity, and the presence or absence of astringency (El Hadi *et al.*, 2013). The results obtained from the hot water (HW) treatments, as presented in Table 2, revealed a gradual and significant increase in flavor scores, reaching their peak in all treated and untreated fruits during the third week of ripening at 20°C. Notably, all treated mango fruits exhibited the same maximum flavor score (3.67) after 21 days of ripening, in contrast to the untreated ones (control) with the lowest flavor score (2.33).

Our findings are consistent with Aberoumand (2015) and Siva Kumar *et al.* (2011), who noted that untreated mango fruits tend to have lower flavor scores. This observation could be attributed to changes in carbohydrates, proteins, amino acids, lipids, and phenolic compounds, all of which can influence the flavor profile of fresh fruits. Additionally, Anwar and Malik (2007) and Abbasi *et al.* (2009) reported in their studies on mango fruits that the flavor exhibited a significant positive trend after ripening, recommending the application of hot water treatment (HWT) within 24 hours post-harvest.

Furthermore, Hossain *et al.* (2021) found that hot water treatment was highly effective in retarding the ripening process

and preventing spoilage of mango fruits. However, limited information exists regarding the effects of CaCl2 in hot water on the organoleptic and biochemical characteristics of mango fruit.

Overall acceptability: In general, organoleptic parameters, such as flavor and taste, are the result of compounds that are either formed or undergo variations during the ripening process (Farzana and Baloch, 2014). The impact of hot water (HW) treatments at 50°C, applied for 5 or 10 minutes, was evident after 21 days of ripening at 20°C, achieving scores of 5.00 in overall acceptance. These scores ranked as the most significant effect on fruit acceptance compared to the control and all other HW applications, as illustrated in Table 2. These results align with the findings reported by Barrett *et al.* (2010) regarding the quality attributes influencing fruit acceptability.

Barrett *et al.* (2010) suggested that the sensory parameters of mango fruits could be influenced by storage temperature and/or treatments, being the outcome of compounds that either form or vary in content during the ripening process. Additionally, Aberoumand (2015) concluded that the sensory parameters, including flavor, aroma, color, texture, and overall acceptability, are crucial attributes of food. Furthermore, Liguori *et al.* (2020) emphasized that appearance, freshness, and peel color are relevant quality parameters in mango fruits, playing a significant role in consumer acceptability.

This study emphasizes the significant influence of temperature and duration treatments, specifically hot water treatments, on the sensory qualities of mango fruits throughout storage and ripening. Notably, the application of hot water at 50°C for 10 minutes proved to be the most effective treatment, consistently improving firmness, texture, aroma, and flavor scores. Exploring the underlying mechanisms of these effects holds promise for future research endeavors.

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