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Pre-cooling and cold storage of olives (cv Picual) in containers with a capacity of 400 kg

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SUMMARY: The cooling of olives stored in containers with a capacity of 400 kg risk accumulation of respiration heat and subsequent fruit deterioration. Pre-cooling the fruit to 5 °C before cold storage was studied as a possible solution to overcome this obstacle. The fruit temperature within the containers was recorded daily for 14 days and oil was extracted at days 0, 4, 8, and 14. A second experiment evaluated a rapid pre-cooling procedure at -18 °C for 3 min. No significant alterations at the level of the examined parameters were recorded. The internal temperature of the control container declined and stabilized at around 12 °C. The temperature of the pre-cooled fruit increased to up to 8 °C. The examined parameters showed no significant alterations in either experiment and the rapid pre-cooling treatment did not lead to any visible 'chill injuries'. A pre-cooling treatment at 5 °C was successfully introduced at the farm of a small producer.

KEYWORDS: *Conservation; Harvesting system; Olea europaea; Quality; Small producers*

RESUMEN: ***Preenfriamiento y conservación en frío de aceitunas (cv Picual) almacenadas en contenedores con una capacidad de 400 kg.*** El enfriamiento de aceitunas almacenadas en contenedores (400 kg) corre el riesgo de acumulación de calor respiratorio y posterior deterioro de la fruta. Se estudió el preenfriamiento de la fruta a 5 °C antes del almacenamiento en frío como una posible solución para superar este obstáculo. La temperatura de la fruta dentro de los contenedores se registró diariamente durante 14 días y el aceite se extrajo los días 0, 4, 8 y 14. Un segundo experimento evaluó un procedimiento de preenfriamiento rápido a -18 °C durante 3 min. No se registraron alteraciones significativas a nivel de los parámetros examinados. La temperatura interna del recipiente de control disminuyó y se estabilizó alrededor de 12 °C. La fruta pre-enfriada aumentó hasta 8 °C. Los parámetros examinados no mostraron alteraciones significativas en ambos experimentos y el preenfriamiento rápido no provocó "lesiones por frío" visibles. Se introdujo con éxito un tratamiento de pre-enfriamiento a 5 °C en la finca de un pequeño productor.

PALABRAS CLAVE: *Calidad; Conservación; Olea europaea; Pequeños productores; Sistema de recolección*

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1. INTRODUCTION

The production of 'premium' olive oil depends to a large extent on the quality of the harvested fruit (García and Yousfi, 2006; Ferguson, 2006; Rallo *et al.*, 2018; Faminiani, 2020). The mechanical harvesting of olives on an industrial scale differs when compared to manual picking with nets and sticks, as thousands of cooperatives in Spain still do (Junta de Andalucía, 2015; Sola-Guirado *et al.*, 2014). The degree of damage caused and the time elapsed from harvesting to storage prior to grinding stands out as crucial factors (Yousfi *et al.*, 2012; Dag *et al.*, 2012; Morales-Silero and García, 2015; Faminiani *et al.*, 2020). Moreover, the post-harvest conditions do vary along with the kind of harvesting employed as well as the processing and storing conditions at the mill (García and Yousfi, 2006; García and Yousfi, 2011).

To obtain 'premium' olive oils, small producers face additional challenges in this respect, especially when they do not possess a proper mill. Besides the fact that they need to look for an efficient and affordable harvesting method that guarantees the least damaged fruit possible, such as manual inverted umbrellas, they ought to take into account the particular conditions that are imposed by the mill they are working with and especially the minimum quantity per batch requested (Plasquy *et al.*, 2019). The characteristics of the mill, and especially its production capacity, define the time and the way olives are piled up, risking fermentation processes that compromise the final quality of the extracted oil (García and Yousfi, 2006, García and Yousfi, 2011). When this amount cannot be picked in one day, storage becomes inevitable.

Temporary cold storage at the farm could be a possible solution for maintaining a high product quality but comes along with specific problems. Several works clarified that the storage of olives at 5 °C for up to 4 weeks does significantly reduce the risk of fruit deterioration and subsequently olive oil defects (García *et al.*, 1996; Kiritsakis *et al.*, 1998; Canet and García, 1999; Clodoveo *et al.*, 2006; Kalua *et al.*, 2008). However, cold storage procedures imply the use of small boxes that can contain 40 kg at the most and ideally 20 kg of olives, instead of agricultural containers, or bins, with a capacity of 400 kg.

Empirical studies and simulations of the cooling process of fresh fruits and vegetables revealed complex interactions between the thermophysical properties of the commodity (heat generation due to respiration, specific heat and thermal conductivity), the kind of packaging and palletization, flow field parameters such as airflow rate and cooling temperature, and the accessibility of the cooling air to the produce (Becker *et al.*, 1996; Brosnan and Sun, 2001; Reading *et al.*, 2016; Mercier *et al.*, 2017; Plasquy *et al.*, 2021). It is well documented that fruit respiration involves the oxidation of sugars to produce carbon dioxide, water, and heat while at the same time, the respiration rate is itself a function of the commodity's temperature (Kader, 1985; Becker *et al.*, 1996, García *et al.*, 1995). García *et al.* (1994) and García and Yousfi (2006) reported that the inner part of a container of olives maintained its initial temperature while stored at 5 °C. As a consequence, the fruit respiration and accompanying heat production induced a self-reinforcing process that rapidly led to a severe deterioration process and the growth of decay-producing microorganisms.

Although most manual or semi-mechanical methods make use of small boxes to collect the fruit after harvesting, the further handling of a large number of boxes leads to large logistic problems once dealing with several tons of olives and especially when cold storage forms a crucial step in maintaining fruit quality. By applying a pre-cooling treatment to the olives manually harvested in the boxes before dumping them into a container for conservation at 5 °C, high-quality oils could be obtained. To explore this possibility, two experiments were set up. The first one monitored the evolution of the internal temperature of a container of 400 kg with or without a pre-cooling treatment at 5 °C and compared the effect of bulk storage at 5 °C on the quality parameters of the extracted oil up to 14 days. A second experiment probed the effects of a short cooling treatment at -18 °C to lower the fruit temperature rapidly to 5 °C. During the following 14 days' storage period at 5 °C, the presence of chilling injuries and quality defects were assessed. The results of the first experiment were used to implement concrete modifications in a family-run olive farm.

2. MATERIALS AND METHODS

2.1. Fruit and storing

Olives of the 'Picual' cultivar were harvested with a manual inverted umbrella (MIU) and branch

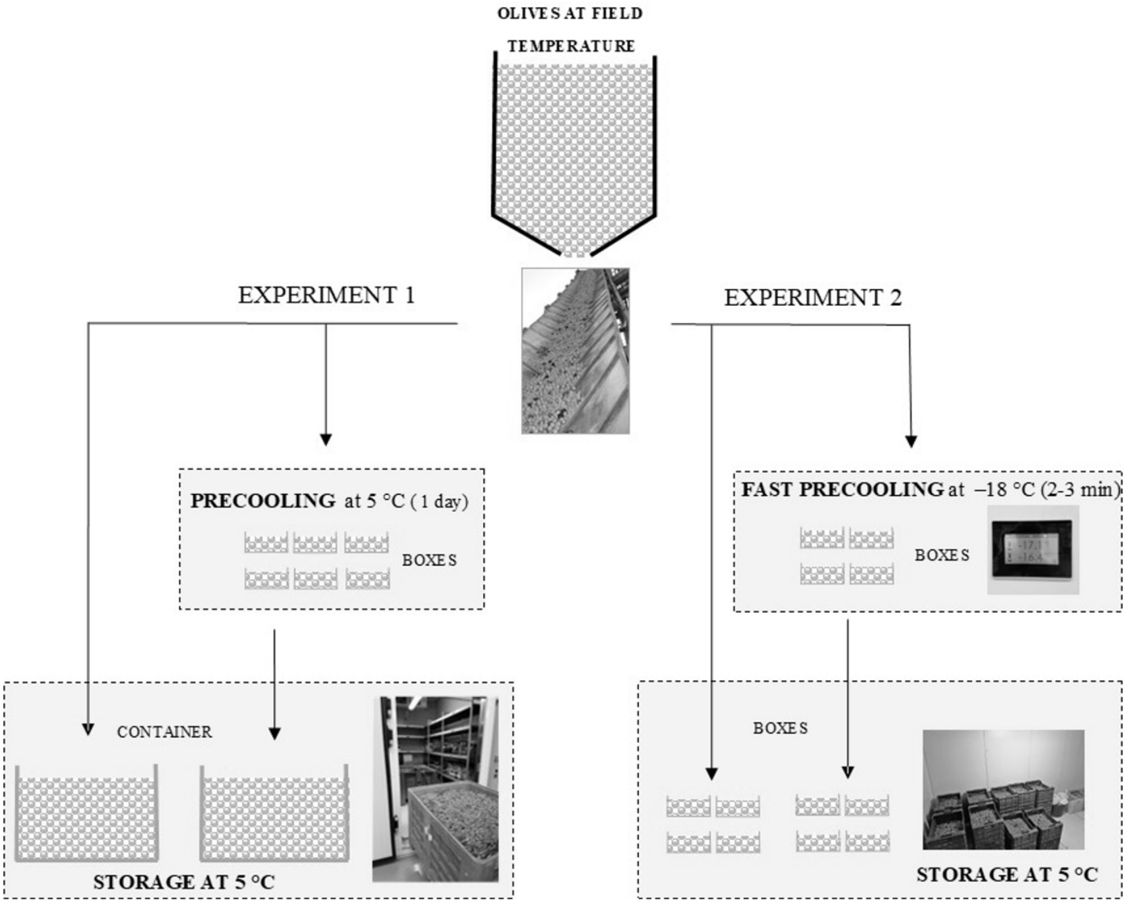

FIGURE 1. Schematic representation of experiment 1 and 2 with their different treatments.

shakers in the 'Del Cetino' plantation in Bollullos del Condado (Huelva, Spain) during the second week of October, 2018. The fruit was healthy and presented optimal ripening characteristics (color index between 1.5 and 2.0). The fruit was collected in perforated plastic boxes (30 x 50 x 40 cm), able to contain a maximum of 20 kg. 50 boxes were recollected, and on the same day transported to the experimental mill of the Instituto de la Grasa (CSIC) in Sevilla in approximately one hour. Upon arrival, the olives were mechanically cleaned of leaves and small twigs but not washed at the outdoor facilities of the experimental mill. The batch of cleaned but dry olives provided the necessary amount of fruit for the two experiments. Minor bruises were produced during the cleaning treatment and passage onto various conveyor belts. The cooling installations were situated within the Research Center and comprised two cooling refrigeration rooms set at 5 °C (± 1 °C), and one freezing room at -18 °C (± 1 °C).

2.2. Trials

2.2.1. Experiment 1

The goal of the experiment was to evaluate the effects of a pre-cooling treatment on the internal temperature of olive containers and the quality of the subsequently extracted oil over 14 days (Figure 1).

Two vented bulk bin containers (100 x 120 x 80 cm; volume of 670 L) were used, each with a capacity of 380 kg olives. One container was filled with fruit at field temperature (FT) immediately after the cleaning procedure. The second container was filled the next day after the olives underwent a preliminary treatment (PC). This treatment consisted of bringing the temperature of the olives to 5 °C by storing the fruit in half-filled boxes (± 10 kg) in a cooling room up to the next day. After controlling that the temperature of the fruit attained 5 °C, the container was filled with the pre-cooled olives.

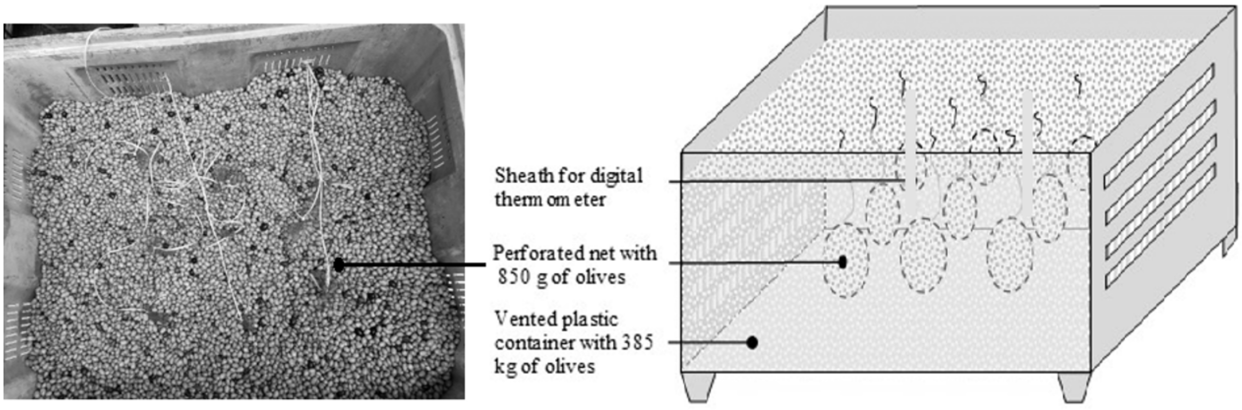

FIGURE 2. Schematic representation of experiments 1 and 2 with their different treatments.

To facilitate the withdrawal of similar samples of olives at a future moment in time, nine plastic nets, each filled with 850 g of olives, were buried within the fruit in each container, evenly distributed, halfway up the height and at the same distance from each other (3 x 3 units) (Figure 2). Every net had a long drawstring attached to facilitate its location and pulling out when needed. To enable the measurement of the internal temperature in each of the containers, two hollow tubes were used as a sheath and situated along the middle ax, at 1/3 of each of the smaller sides.

The cooling room at 5 °C (± 1 °C) was accommodated to store the two containers side by side. One container filled with olive fruit with a field temperature of 18 °C was placed inside once the nets and sheaths were in place. The next day, a second container, filled with pre-cooled fruit at 5 °C was brought inside (Figure 1).

The temperature was measured with a digital thermometer (precision of 0.1 °C) with a wired probe that was glided into the sheaths. The measurement took place every 24 hours, twice, for 14 days.

On day 0, three samples of 750 g of olives were taken from the FT container and the boxes in the pre-cooling treatment, both before entering the cooling room. On days 4, 8, and 14, three nets of olives were pulled out of each container and used to extract oil. Olive oil was physically extracted following the Abencor method as described below, nitrogenized, and stored at -18 °C until analysis.

2.2.2. Experiment 2

The goal of the experiment was to evaluate the effect of a fast-cooling procedure before the cool storage of olives on the quality of the extracted oil (Figure 1).

Two ventilated plastic boxes, each filled with 10 kg olives were placed in a cooling room at 5 °C (+/- 1°C) to attain the same temperature at a slow rate (SR). Four boxes, each filled with 5 kg olives were placed in a freezer room at -18 °C for the time necessary for the fruit to attain a temperature of 5 °C. This cooling process at a fast rate (FR) was continuously monitored with an IR thermometer. The desired temperature was attained after 3 minutes and then the 4 boxes were brought immediately to the cooling room at 5 °C, where the content of 2 boxes was brought together into one.

On days 0, 4, 8, and 14, three olive samples of 750 g were taken from both the SR and the FR-boxes. 100 olives from each sample were visually examined for the presence of ‘chilling injuries’. Virgin olive oil from each of the samples was extracted following the Abencor method, nitrogenized, and stored at -18 °C until analysis.

2.3. Extraction method and sample conservation

The oil was extracted following the procedures for extraction with an Abencor installation (Martinez *et al.*, 1975). Individual samples of 750 g olives were crushed in a hammer mill. 600 g of the resulted paste was weighted in a stainless-steel casserole pot and malaxated in the thermoblender for 30 min at 30 °C. Centrifugation was performed at 1372 G for 1 min. The liquid obtained was placed in a graduated 500-mL test tube for separating the aqueous phase from the lipids. The olive oil was taken using a Pasteur pipette, filtered with filter paper, and placed in an amber glass bottle of 125 ml, filled with nitrogen, and frozen at -18 °C until further examination.

2.4. Physicochemical analysis

The physicochemical analysis consisted of the measurement of the following parameters: Titratable acidity (Free Fatty Acid, FFA), peroxide index (PI) value, and the extinction coefficients at 232 and 270 nm (K232 and K270). The analysis followed the guidelines of the official analytical methods (EEC, 1991). The selected parameters are a crucial part of the internationally established quality standards for olive oil and essential for evaluating the quality of the extracted oils (Conte *et al.*, 2020).

2.5. Statistical analysis

A statistical data analysis of temperature data and physicochemical parameters for both experiments was performed using PASW Statistics 18.0 (SPSS). The effects of 2 treatments at each storage time (ST) were determined by one-way ANOVA.

2.6. Implementation strategy

It was agreed and planned that the outcome of the experiments would be used to adjust the actual working and storage procedures at the farm as far as the results would lead to expect an amelioration of the logistics without jeopardizing the quality of fruit.

3. RESULTS

3.1. Effect of pre-cooling (experiment 1)

The evolution of the internal temperature of both containers was characterized by the profile shown in Figure 3. In the container with the olive fruit at a field temperature (FT), the mean internal temperature descended towards 10 °C during the first week, after which a more stabilized period set in with temperatures that oscillated between 8.8 and 9.5 °C up to the end of the measurement. Within the first week, a more pronounced cooling was observed during the first two days in which the temperature descended from 18 °C to 13°C. The evolution of the temperature in the container with pre-cooled fruit (PC) followed an inverse trajectory. On day 1, the measurements confirmed that the desired internal temperature of 5 °C was present once the container was filled with the fruit. From day 2, a slow but uninterrupted temperature rise set in, amounting to 7.6 °C on day 14. As this rise was almost linear, no flattening the curve tendencies were observable between day 2 and day 14.

In both treatments (FT and PC), none of the examined parameters attained a level that would lead to losing the quality level ‘Extra Virgen Olive Oil (EVOO)’ (Table 1). For the measured acidity, indicating straightforwardly the degree of oil deterioration, the values stayed far below the established maximum level of 0.8% FFA (expressed as oleic acid). Neverthe-

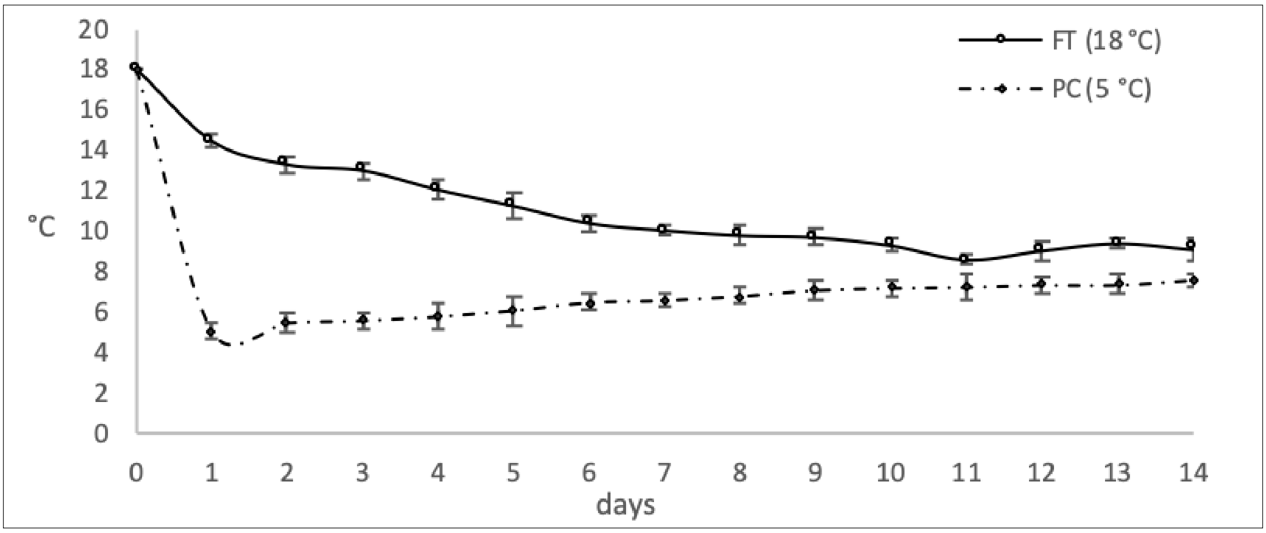

Figure 3. Evolution of the temperature over 14 days within two perforated containers, each filled with 375 kg olives, and placed in the cooling room at 5 °C. FT refers to the fruit with an initial temperature of 18 °C (field temperature); PC refers to fruit brought to 5 °C in small perforated boxes before their transfer to the container (pre-cooled). Each value is the mean of two measurements. Vertical bars express Standard Deviation.

Table 1. Physicochemical parameters of oil extracted from olives stored up to 14 days in perforated plastic bulk containers after applying a pre-cooling treatment before storage (PC) and at field temperature (FT).

Cooling Method (CM)	Storage Time (ST) (days)	FFA (% oleic acid)	PI (meq O_2/kg oil)	K_{232}	K_{270}
FT	0	0.15 ± 0.00 b‡	6.83 ± 0.85	1.69 ± 0.13	0.17 ± 0.01
	4	0.14 ± 0.00 b	7.26 ± 1.56	1.75 ± 0.24	0.16 ± 0.01
	8	0.15 ± 0.01 b	6.66 ± 0.66	1.71 ± 0.05	0.16 ± 0.01
	14	0.18 ± 0.01 a	9.21 ± 1.30	1.92 ± 0.26	0.16 ± 0.01
PC†	0	0.15 ± 0.00	6.83 ± 0.85	1.69 ± 0.13	0.17 ± 0.01
	4	0.13 ± 0.01	7.92 ± 1.16	1.76 ± 0.15	0.15 ± 0.01
	8	0.15 ± 0.01	7.12 ± 0.89	1.77 ± 0.12	0.15 ± 0.01
	14	0.14 ± 0.00	7.90 ± 1.76	1.73 ± 0.05	0.16 ± 0.01
CM		0.011*	0.926	0.617	0.144
ST		0.006**	0.076	0.520	0.005**
CM × ST		0.011*	0.493	0.571	0.826

† The pre-cooling treatment consisted of keeping 10 kg of olives in boxes at 5 °C overnight to guarantee that the fruit attainted an internal temperature of 5 °C before filling the plastic container with 375 kg. The container without treatment was filled with olives at a field temperature of 18 °C (FT). The storage temperature was 5 °C.

‡ In each variable, the values of different treatments followed by different letters are significantly different according to the Tuckey test ($P < 0.05$). The absence of letters means no significant effect due to treatment according to one-way ANOVA ($P < 0.05$). Each value is the mean ± SD of 3 replicates. Significant levels of the factors CM, ST and CM × ST * $p < 0.05$, ** $p < 0.01$.

less, there was a significant difference between both treatments as well as a significant effect of storage time. The significant effect of the interaction between the cooling method (CM) and the storage time (ST) underlined that the effects of applying a pre-cooling treatment increased with storage time. This effect was more prominent in the container filled with fruit at field temperature (FT), where a significant increase was detected at 14 days of storage compared to the other storage times. The olives that underwent a pre-cooling treatment in small boxes (PC), did not experience a significant increase in the acidity level after 14 days of storage compared to the previous ones. The PI values as well as those obtained for K232 and K270 were not influenced in a significant way, either by the CM or the ST.

3.2. Effect of rapid cooling treatment (experiment 2)

Visual examination of triplicate samples of 100 olives at each of the different storage times did not show damages that could be attributed to 'chilling injuries' in any of the treatment tested (data not shown).

Subjecting the olives to a rapid cooling at -18 °C for a short time to obtain the desired temperature of 5 °C did not lead to an overall worsening of the examined physicochemical quality parameters (Table 2). No significant differences were observable in the acidity or the K232 and K270. Only the measured PI showed an effect on the speed of cooling (SC). On the other hand, the effect of the ST was significant in all the variables. At punctual storage times, there was a significant difference between the two obtained values. This was the case on day 0 concerning the K270 and, for the level of FFA, on day 4. These slightly deviated results do not influence the overall appreciation of the results.

Finally, it is worth mentioning that the visible bruises that were caused during the cleaning procedure did not produce any problematic rise in any of the examined parameters.

3.3. Implementation

The obtained results were promising for the integration of a pre-cooling procedure as a valuable intermediate step before storage in bins. The filling level of the boxes used during harvesting was reduced to 2/3 to maximize the evacuation of the field heat within each box during the pre-cooling treatment. The filled boxes were transferred to the

Table 2. Physicochemical parameters of oil extracted from olives stored at 5 °C for up to 14 days after being subjected to rapid pre-cooling at -18 °C (FC) compared to room cooling at 5 °C (SC).

Storage time (ST) (days)	**Speed of cooling (SC)**	**FFA (% oleic acid)**	**PI (meq O_2/kg oil)**	**K_{232}**	**K_{270}**
0	SC	0.14 ± 0.01	11.97 ± 0.29	1.88 ± 0.20	0.21 ± 0.01 a†
	FC	0.13 ± 0.01	9.87 ± 1.49	1.89 ± 0.02	0.19 ± 0.01 b
4	SC	0.14 ± 0.00 a	14.83 ± 0.45	1.69 ± 0.06	0.19 ± 0.01
	FC	0.12 ± 0.00 b	13.05 ± 1.87	1.82 ± 0.07	0.19 ± 0.01
8	SC	0.14 ± 0.01	13.89 ± 1.30	1.76 ± 0.07	0.19 ± 0.00
	FC	0.14 ± 0.01	11.21 ± 1.49	1.82 ± 0.07	0.18 ± 0.00
14	SC	0.15 ± 0.00	9.90 ± 1.82	1.70 ± 0.07	0.19 ± 0.01
	FC	0.15± 0.01	10.20 ± 0.68	1.70 ± 0.12	0.20 ± 0.01
ST		0.032*	0.000***	0.034	0.009**
SC		0.162	0.010**	0.245	0.051
ST × SC		0.271	0.257	0.661	0.011*

† In each variable, the values for different treatments followed by different letters are significantly different according to the Tuckey test ($P < 0.05$). The absence of letters means no significant effect due to treatment according to one-way ANOVA ($P < 0.05$). Each value is the mean ± SD of 3 replicates. Significant levels of the factors ST, SC and ST × SC * $p < 0.05$, ** $p < 0.01$; *** $p < 0.001$.

cooling room on a very regular basis and whenever 20 boxes were filled. The boxes were placed on pallets and pilled with sufficient space to optimize the airflow between them. The temperature was set at 5 °C (± 1 °C). The next morning, the cooled olives in these boxes were transferred to the presented bins. The emptied boxes were reused during the following picking day.

This procedure was carried out in the harvesting campaigns of 2018 and 2019. Bins were filled and stored within the cooling room. Several of them were stacked on top of each other to make the best use of space. The temperature of the olives in the containers was monitored with a digital thermometer as well as an IR thermometer. The first filled bins were stored for up to 7 days, as the picking had to be postponed for several days due to bad weather. The internal temperature climbed to 7 °C on the day of transport to the mill. Minor problems arose during storage as the capacity of the existing cooling installation was not designed to store such an amount of fruit. The fact that the olives came in in small batches made it possible to remove the field heat over the time of a day and night, although the formation of ice on the slats of the evaporator was inevitable and needed to be removed daily by blowing warm air over it.

The physicochemical characteristics of the obtained oils were analyzed and revealed a high-quality profile for both years (Table 3). The organoleptic quality was not tested by an official sensory panel,

Table 3. Physicochemical parameters of the bottled AOVE extracted from olives (c.v. Picual) in the experimental olive mill of the Instituto de la Grasa during the recollection campaigns of 2018 and 2019. The recollected fruit was picked with a Manual Inverted Umbrella and stored at 5 °C with full implementation of the described pre-cooling treatment. Analysis report issued by the Physical-Chemical Laboratory of the Instituto de la Grasa (CSIC).

Harvesting				**FFA (% oleic acid)**	**PI (meq O_2/kg oil)**	**K232**	**K270**	**Delta K**
Year	Amount of bins	kg	Max. storage (days)					
2018	10	3.583	7†	0.13	6.6	1.65	0.16	< 0.01
2019	13	4.721	5	0.11	5.7	1.75	0.17	< 0.01

† The picking was postponed for three days due to bad weather.

but the obtained prizes in various international competitions (New York International Olive Oil Contest 2018: Gold; 2019: Silver; Japanese Olive Oil Contest 2019: Gold; Premio Mezquita de Córdoba 2018: Gold; 2019: Gold) convincingly illustrated their exceptional quality over both years.

4. DISCUSSION

The evolution of the internal temperature showed that instead of a continuous increase in temperature up to even 25 °C, as was reported by García *et al.* (1994) and García and Yousfi (2006), a steady decrease was observed. Some parameters such as the degree of maturity, the degree of damage due to harvesting, and the cooling conditions in which they were kept, come to the fore as possible factors to explain these differences (data not shown). Proper control of the internal temperature was obtained, even without a pre-cooling treatment, and with even better results when the storage of a bulk container started with pre-cooled olives.

Experiment 1 demonstrated that the internal temperature did not rise by more than a few degrees over 2 weeks. As the environment stayed constant at 5 °C, the parameters for the convection stayed the same as well as those for the heat conduction dynamics within the container. It can thus be hypothesized that the excess of energy was generated by the fruit itself. The initial temperature of 5 °C inhibited the respiration of the fruit to a large extent, although it could not impede that over 14 days the heat generated by the respiration exceeded the heat that dissipated from the container by way of transmission or by radiation. In this respect, the results support the assumption of Redding *et al.* (2016) that respiratory heat does have a significant contribution when the (pre)-cooling process is extended.

The vulnerability of olives for chilling injuries is well known and well documented (Kader, 1985). The development of these injuries takes place over an extended storage time and at temperatures below 5 °C. The results of this experiment showed that exposing the olives to a room temperature as low as –18 °C for less than 3 minutes did not cause injuries to the fruit or deterioration to the oil subsequently extracted. The required cooling time of 3 minutes was in line with the observations published by Plasquy *et al.* (2021), who documented the cooling rate of 6 varieties, including the Picual c.v. used in this experiment.

A detailed comparison with the data as published by Garcia *et al.* (1994) was complicated as neither the intactness nor the state of ripening of the fruit was reported. However, the fact that the FT samples did not present excessive acidity levels indicated that additional factors must have exerted a detrimental effect on the fruit and consequently on the quality level of the extracted oil. It must be pointed out that the field temperature of 18 °C is rather low compared the daytime temperatures that can be experienced at the start of the harvesting campaign. Dealing with fruit at temperatures above 25 °C is far from unusual and do caution that more research is needed to document the evolution of the temperature of stored olives in containers.

The respiration rate of fruit increases at higher temperatures and as a consequence so does the respiration heat (Becker *et al.*, 1996). The results of Garcia *et al.* (1994) illustrated that once a given threshold temperature is reached, room cooling, even at 5 °C, becomes insufficient to lower the heat load. This experiment showed that this limit must be above 18 °C. However, further empirical research and modeling are needed to determine at what temperature storage in 400-kg containers becomes critical if not impossible.

Pre-cooling is since long recognized as critical in guaranteeing the quality of fresh fruit and vegetables. Removing the field heat does lead to a drastic reduction in the respiration rate and hence a decline in the deterioration as well (Brosnan and Sun, 2001). The implementation of the experiment illustrated that this technique can be successfully realized at a small scale to optimize cold storage. To what extent the proposed solution can be introduced on a larger scale will depend on the creativity to adapt existing systems to the specific conditions of the olive harvest. The obtained results showed that it is worthwhile to undertake such an endeavor.

5. CONCLUSIONS

The results indicated that olives of the 'Picual' variety, stored in containers of 400 kg at an initial temperature of 18 °C, can be kept at 5 °C for 14 days without significant signs of deterioration. Applying a pre-cooling treatment by bringing the fruit temperature to 5 °C before their storage in these containers resulted in a lower internal temperature during the storage time. The slight increase in temperature over time indicated that the respiration of the fruit substantially contributed to the internal heat production, although without provoking substantial deteriorations. Pre-cooling the olives in a fast way did not cause 'chilling injuries' nor did it affect the quality parameters of the extracted oil. The pre-cooling treatment offered a workable and affordable solution for the producer and could be successfully implemented as an integral part of the recollection process on the farm. Both experiments raised the expectation that the storage of olives in bin containers be further examined to clarify the vulnerability of the different cultivars and the impact of greater temperature gradients. At the same time, it seems recommendable to explore the possibilities of a fast pre-cooling process in greater depth and at the level of the farm to obtain the desired temperature before olive storage in container bins in a more efficient way.

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