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ECONOMICAL OLIVE OIL PRODUCTION BY REDUCTION OF POST-HARVEST LOSSES IN OLIVE FRUIT

Muhammad Ashraf Sumrah [a], Syed Hamza Mahfooz [a], Muhammad Jan [a,*], Shoaib Akhtar [b], Muhammad Farhan Khan Pasha [a], Azhar Hussain [a], Muhammad Ramzan Anser [a], Jamil Akhtar [a]

[a] *Centre of Excellence for Olive Research & Training (CEFORT), BARI, Chakwal, Pakistan*
[b] *Department of Agriculture Business and Marketing, Faculty of agriculture sciences and Technology, BZU, Multan, Pakistan*

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ABSTRACT

The higher cost of oil extraction units and their shortage at the district level results in huge economic losses for olive farmers. Olive fruit harvesting and packing method for temporary storage and transportation cause major losses to the growers due to the reduction in the quality of olive oil. Poor economic returns from lower-quality olive oil result in financial losses to the growers. Fruit harvesting and packing method are major sources of fruit losses; hence the studies were designed to standardize commercial fruit harvesting and packing method to minimize the losses. The study was conducted at Buzdar Agricultural Farm, DG Khan. The fruit was packed in plastic bags (Conventional method) and perforated fruit baskets (Non-conventional method) for transportation from the olive orchard to the Oil Mill (Barani Agricultural Research Institute, Chakwal) for extraction of olive oil. Olive oil extraction machine Model (Pieralisi, Italy) and the first cold extraction were used for data collection. Minimum fruit damage of 1.14% was recorded in hand picking, and maximum fruit damage of 10.65% was recorded in stick beating. Maximum fruit rotting of 4.48% was recorded in stick beating, and minimum damage of 1.10% was recorded in the hand picking method. Oil recovery percentage was not affected by harvesting and packing methods; however, oil quality was highly affected by harvesting and packing methods, which resulted in economic returns from produced olive oil. Poor quality oil fetched minimum price as compared with premium quality olive oil, which resulted in financial losses to the grower.

* *Email: mjanleghari@gmail.com*
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INTRODUCTION

According to the international olive council, global oil consumption is about 3.06 million tons in the 2022/23 crop year, the lowest total since 2017/18. Table olive consumption is estimated at 2.7 million t in the 2021/22 crop and more than 2.9 million t in the 2022/23 crop year (International Olive Council, 2023). In the modern olive orchard, harvesting manually is a common harvesting practice (Vossen, 2007; Zion et al., 2011), but manual harvesting requires a huge amount of labour which is costly as a result which reduces the farmer's profitability (Ferguson et al., 2010; Ferguson and Castro, 2014). Trunk shaking and rod beating are the mechanical harvesting technique followed by fruit collection on the ground surface in all experiments, the olives were harvested at a similar stage of physiological maturity, i.e., when most fruit changed color from dark green to light green/straw yellow and the pit separated from the pulp easily (Goldental-Cohen et al., 2019; Zipori et al., 2014).

Olive plants have been planted in different localities of Pakistan. It has been cultivated on 5.00 million acres comprising different topography and mileage from milling stations. Post-harvest management of fruit is a complex, multi-faceted route that fruit takes as it goes from producer to consumer, the packing, transportation, and processing stage of handling cause post-harvest losses. Some factors have more loss than others in every stage of the post-harvest fruit handling process. Fruit losses at the harvesting stage are generally caused by poor handling practices, i.e., harvesting and packing method (Zion et al., 2011; Somavat et al., 2015). The harvesting method of olive fruit is not standardized for the commercial production of olive oil and table products. Fruit harvesting at its peak harvesting time can negatively affect quality. Different harvesting systems, i.e., gentle manual harvesting, manual harvesting using hand-held combs to detach the olives and nets placed under the tree, using two hand-held pneumatic combs with telescopic handles two detach the olives, mechanical harvesting with trunk shaker and straddle machine. The results left no doubt that gentle harvesting caused the least damage, whereas the trunk shaker and straddle machine were the greatest (Jimenez-Jimenez et al., 2013; Debbabi et al., 2020). Mechanical harvesting tended to damage the fruit resulting in lower-quality virgin olive oil (Rufat et al., 2018). Post-harvest losses could be reduced in this situation with greater vigilance on the part of the harvester (Jimenez-Jimenez et al., 2015; Brockamp, 2016). Oil extraction units are away from production points in many areas resulting in poor quality transportation by longer time taking from the orchard to the processing mill. Olive fruit is harvested in different ways, that is, hand picking, stick beating, and mechanical harvesting. The fruit is temporarily stored in the orchard for completion of harvesting operation and transport management from the orchard to the milling station. Conventionally olive fruit

is packed in plastic or jute bag for transportation and storage, resulting in mechanical damage and fruit rotting at large scale. Progressive growers are using perforated fruit baskets for temporary storage and transportation of fruit. Minimum fruit losses have been noted in basket packing as compared with conventional packing systems (Ferguson et al., 2010; Ferguson et al., 2005).

Stick beating for harvesting olive fruit can raise the acidity in the subsequently made olive oil, reducing the quality and the likely hood of consumer consumption. These losses could be reduced by the use of sophisticated harvesting machines and manual picking of fruit (Ferguson and Castro, 2014). Mechanical damage and rotting of fruit could cause a loss the quality and quantity of extracted oil, negatively affecting the ability to nourish consumers and reducing the economic value for producers (Castro-Garcia et al., 2012; Castro-Garcia et al., 2015). Packing olive fruit in bags creates a lethal dose of CO2 and rotting (Somavat et al. 2015). Mechanical harvesting damage the olives and reduced olive oil quality by increasing free fatty acids and peroxide value, decreasing fruitiness, stability, bitterness, and pungency (Rufat et al., 2018). A mechanical operation may cause internal fruit damage leading to a fast reduction in olive oil quality (Erel et al., 2008). Mechanical and harvesting methods showed a drastic effect on the production of olive oil when fruit was picked carefully by hand so that no injurious were inflected, free fatty acid levels were substantially reduced, peroxide was reduced, and total phenol content was increased. Degradation of oil quality related to fruit damage caused during harvesting (Saglam et al., 2014).

The current study was designed to standardize harvesting and packing method for the production of quality olive oil and reduction in post-harvest losses of olive fruit. Harvesting and packing method were triggered to minimize the post-harvest losses of olive fruit in the supply chain of olives.

MATERIAL AND METHODS

The experiment was conducted according to the factorial design of statistical analysis. Six treatments (Stick beating, Vibrator, Combing, Hand picking, conventional and non-conventional packing methods) with four replications were used for the collection of data. The study was conducted at Buzdar Agricultural Farm, DG Khan. The fruit was packed in plastic bags (Conventional method) and perforated fruit baskets (Non-conventional method) for transportation from the olive orchard to the Oil Mill (Barani Agricultural Research Institute, Chakwal) for extraction of olive oil. Fruit transportation was made by mini truck and covered approximately 800 km distance from the production area to the oil mill. 40 kg of fruit was used in each treatment for a recording of experimental data. The Olive oil extraction machine Model (Pieralisi, Italy), having a fruit crushing capacity of 600 Kg/hour, was used for the extraction of olive oil. Only the first cold extraction was used for the collection of experiment data, and the following parameters were studied. All analyses were measured through the methods of Peri (2014).

Mechanical damage Percentage

Randomly selected 01kg fruit was considered as an experimental unit. Mechanically damaged fruits were separated and weighed on an electronic balance. The result was manipulated for the calculation of damaged % by using the formula.

Mechanical damage % = Weight (g) of Damaged Fruits/Total Weight (g) of Fruits x 100

Fruit Rotting %: Rottened fruits from damaged fruits were separated and weighed for calculation of rotting %. The following formula was used to calculate Fruit rotting %:

Fruit Rotting % = Weight (g) of Rottened Fruits/Total Weight (g) of Fruits x 100

Oil Recovery %: The total oil extracted from each treatment was used to calculate the oil recovery % from the olive fruit.

Oil quality (Taste, Color, Aroma, K value, Acidity, and Peroxide): The oil quality of the experimental material was analyzed by sensory and laboratory evaluation tests. Sensory evaluation was made by 05 olive oil expert scientists keeping in view the gender representation in the expert panel. Scores ranged from 1-10 for judgment of quality parameters, i.e., Taste, Flavor, and Aroma. All the panel members ranked the quality parameters individually while sitting in different places without any discussion with each other. The average rank was calculated by counting the score of all panel members for each quality parameter of the studies.

Quality parameters, including acidity, K value, and peroxide values, were determined by CDR Oxitester.

Cost Benefit Analysis of Different Treatments: The cost of olive oil extracted from all treatments mentioned in the studies was calculated according to the wholesale market rate (Rs. /ltr Oil) of olive oil.

Statistical Analysis

Two-way analysis of variance (ANOVA) was performed using a statistical package, Statistix 8.1. A least Significant Difference (LSD) test was done to compare the significance of the difference between the treatments.

RESULTS AND DISCUSSIONS

Data recorded from the studies reflected a clear picture of the impact by harvesting and packing methods of olive fruit. Studied parameters are explained with results received from data analysis.

Fruit Damage Percentage

Maximum olive fruit damage percentage was recorded in stick beating (10.65%), while minimum fruit damage (1.14%) was recorded in the hand-picking method of fruit harvesting. These studies are in conformity with the findings of Famiani et al. (2020) and Rufat et al. (2018).

Fruit Rotting Percentage

Olive fruit rotting % was maximum in the stick beating method with conventional packing methods (6.34%), and minimum fruit rotting (1.10%) was recorded in the hand-picking method of harvesting with non-conventional packing. The results showed that fruit rotting % is greater in conventional packing as compared with non-conventional packing. These results are also in agreement with the findings of Hertog et al. (2008), Burns et al. (2008), and Casanova et al. (2017).

Oil Recovery Percentage

Oil recovery from all treatments showed non-significant results, which means that harvesting and packing methods have a very low impact on the oil recovery % from harvested fruit.

Quality Parameters of Olive Oil Extracted from Different Treatments

The data (Table-4) depicted that fruit harvesting and packing methods have a very prominent impact on the quality of olive oil. Best quality oil was extracted from fruit harvested by hand picking method and packed in non-conventional packing baskets while lower quality oil was received in stick beating harvesting method and non-conventional packing method. This might be due to more oxidation and rotting in damaged fruit packed in conventional packing systems, which increases catabolic activities during temporary storage and transportation. Similar results have been reported by Rufat et al. (2018), Dag et al. (2008), Saglam et al. (2014), Ampatzidis et al. (2009), and Giménez-Martínez and Serrana (2018).

Table 1. Mechanical fruit damage percentage of Olive fruit.

Treatment	Conventional Packing	Non-conventional Packing
Stick Beating	15.87± 1.04	10.65± 1.02
Vibrator	9.92 ± 1.98	7.52± 1.80
Combing	3.41± 0.98	2.64± 0.90
Hand Picking	2.13± 0.04	1.14± 0.14

Table 2. Rotting percentage (%) of Olive Fruit.

Treatment	Conventional Packing	Non-conventional Packing
Stick Beating	6.34 ± 1.53	4.48 ± 1.30
Vibrator	4.37 ± 1.19	2.18 ± 1.70
Combing	3.10 ± 0.86	1.42 ± 0.54
Hand Picking	1.18 ± 0.22	1.10 ± 0.26

Table 3. Oil Content percentage of Olive fruit.

Treatment	Conventional Packing	Non-conventional Packing
Stick Beating	10.11 ± 1.19	10.00 ± 0.98
Vibrator	10.14 ± 1.17	10.13 ± 1.13
Combing	10.16 ± 0.82	10.17 ± 0.79
Hand Picking	10.18 ± 0.59	10.14 ± 0.84

Table 4. Quality parameters of olive oil extracted from different treatments of the experiment.

Conventional Packing					Non-conventional Packing			
Parameters	Stick Beating	Vibrator	Combing	Hand Picking	Stick Beating	Vibrator	Combing	Hand Picking
Color	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green	Light Green
Flavor	04 ± 0.07	06 ± 0.05	06 ± 0.02	07 ± 0.05	05± 0.04	06 ± 0.05	05 ± 0.01	08 ± 0.06
Taste	04 ± 0.03	05± 0.01	07 ± 0.06	08± 0.02	04 ± 0.01	05 ± 0.02	06 ± 0.02	09 ± 0.08
Acidity %	0.08 ± 0.02	0.05± 0.04	0.04± 0.03	0.03± 0.01	2.35 ± 0.09	2.21 ± 0.10	1.89 ± 0.11	0.02± 0.01
K. Value	0.08± 0.04	0.07± 0.01	0.04 ± 0.01	0.05± 0.03	0.06± 0.01	0.05± 0.01	0.06± 0.01	0.06± 0.02
Peroxides	18 ± 0.17	17 ± 0.14	16 ± 0.07	10 ± 0.10	15 ± 0.12	16 ± 0.11	16 ± 0.14	9 ± 0.16

Table 5. Cost benefit analysis of different treatments of the experiments.

	Conventional Fruit Handling Practice						Non-conventional Fruit Handling Practice					
Treatment	Fruit Harvesting Cost (Rs.)	Temporary Storage & Packing Cost (Rs.)	Oil recovery (Liter)	Turn out of Treatment Price/liter (Rs.)	Total Income (Rs.)	Net Income (Rs.)	Fruit Harvesting Cost (Rs.)	Temporary Storage & Packing Cost (Rs.)	Oil recovery %	Turn out of Treatment Price/liter	Total Income	Net Income (Rs.)
Stick Beating	1500	750	10.11	950	9604	7354	1500	750	10.00	1100	11000	8750
Vibrator	2400	1000	10.14	1100	11154	7754	2400	1000	10.13	1350	13675	10275
Combing	2800	850	10.16	1150	11684	8034	2800	850	10.17	1500	15255	11602
Hand Picking	3200	900	10.18	1500	15270	11170	3200	900	10.14	2000	20280	16180

Note: 100 kg fruit of olive variety Manzanilla. The price of oil was calculated according to the wholesale market rate.

Cost Benefit Analysis of Different Treatments

Maximum net profit (Rs. 16180/-) was received from the oil extracted from fruit harvested by hand picking and packed in non-conventional method while minimum net profit (Rs. 7354/-) was received from fruit harvested by stick beating method and packed in conventional method. This difference in financial benefits is due to the premium quality of olive oil extracted from different treatment units. Similar results have been reported by Abayomi et al. (2015), Abdelhamid et al. (2013), and Abenavoli et al. (2016).

CONCLUSIONS

On a global scale, there has been extensive research on many aspects of mechanical harvesting for table olives over the past few decades; no similar research has been done in Pakistan. In

Pakistan's case, no work is already done to calculate post-harvest losses. In the current study, it was observed that hand picking harvesting method is most suitable for picking table olives for the highest return from produced fruit, while the use of a mechanical vibrator is most economical for olive oil production. Stick beating and conventional packing system has lethal effects on the quality of olive oil, resulting in uneconomical returns for the olive orchard. So it was concluded that minimum fruit damage was recorded in hand picking while maximum in stick beating. Maximum fruit rotting was recorded in stick beating and minimum in hand picking method of harvesting. Oil recovery % was not affected by harvesting and packing methods; however, oil quality was highly affected by harvesting and packing methods, which resulted in economic returns from produced olive oil.

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