Effect of Adhesives on the Durability Index of Compacted Olive Cake

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Abstract


Generally, briquettes of plain olive cake, OC, lack durability. This work involved mixing OC at 35% moisture with 1 to 4% of wood adhesive or clay loam and compacting the mixture at a stress of 15 to 45 MPa and dwell time of 5 s. An ASAE standard tumbler was used to determine the briquette durability. The results showed that adhesives had substantial effect and increased the durability index by more than 11 times compared to plain OC. Overall, clay loam was the favorable adhesive and when added at 2% and compacted at 35 MPa produced the best desirable outcome.

Key words: Olive cake, Briquettes, Durability enhancement, Adhesives

Introduction

In Jordan as well as other Mediterranean countries, olive trees are widespread and cover large areas of agricultural land. Every year, huge volume of olive cake, OC, which is the solid by product of squeezing olive fruits for olive oil extraction, is produced and piled on the backyards of olive mills. This huge amount requires practical solutions to the problems associated with OC accumulation particularly the disposal burden and the environmental concern.

Several research efforts were carried out to investigate the potential uses of this abundant resource including utilizing the material as fuel in its loose and compacted forms (Abu-Qudais, 1996; Al-Widyan et al., 2002) and using the material compost as well as its ash as a soil amendment and stabilizer (Al-Widyan et al., 2003; Attom and Al-Sharif, 1998). However, it is known that material volume is of utmost importance when it comes to the utilization of waste biomass particularly storage and transportation costs. Compaction or densification of materi-
als in units of similar shape and size is the most common method of volume reduction. Compaction provides for other advantages especially better mechanical or automatic handling. Consequently, material compaction represents an upgrading process and, therefore, extensive literature exists on studying all aspects of biomass compaction. Bhattacharya et al. (1989) presented an excellent review of literature in this regard.

Biomass compaction has been practiced worldwide for its utilization as animal feed or energy pellets. In all cases, the extra effort of compaction is deemed useless if the units lack durability. That is, if they can’t withstand the rigors of handling and transportation. The most important indicator for evaluating the durability of compacted biomass is the so-called durability index that provides a quantitative numerical value of how good a compaction process is. In biomass compaction, durability is defined as the ability of the compacted unit to resist the changes in its dimension and/or shape, i.e., it measures the ability of the compacted unit to keep its integrity during handling. Al-Widyan et al. (2002) studied the durability of plain OC briquettes. Clearly, any effort to enhance material durability is worthwhile.

This research effort aimed at improving the durability of compacted olive cake by utilizing adhesives that are available and cheap by mixing them in small proportions with olive cake prior to compaction. The study examined the effect of different proportions of adhesives on the cubes durability index.

Materials and Methods

Amounts of as-is olive cake, OC, were gathered in sacks from piles in nearby olive mills and stored under ambient conditions for natural drying as they were spread on the lab floor. Samples of this cake were put to a moisture content of 35% and compacted in a closed-end cylindrical die of 25 mm diameter under different levels of compression pressure (stress) and different percentages of two materials intended as adhesives. The two adhesive materials used were the commercial wood adhesive (Polyvinyl acetate) and clay loam. The 35% moisture content of the batch of OC was obtained by wetting the material with predetermined amounts of water, mixing thoroughly and leaving the sample in a tight container for about 48 hours to assure moisture uniform distribution.

Four levels of maximum pressure (stress), specifically, 15, 25, 35, and 45 MPa, and five levels of adhesive, namely, 0% (the control), 1%, 2%, 3%, and 4% by weight were tested. The dwell time was fixed at 5 s throughout. Material moisture content was determined by oven drying and compaction pressure (stress) was measured by a load cell.

Each briquette weighed 13.5 g of OC that would be manually filled in the die that coped with one sample (batch) at a time. A vertical piston of a hydraulic press was used for axial load application on the loose material. In order to allow air to escape during sample compaction, a small clearance of 0.2 mm between the piston head and
die walls was maintained. The piston would then be slowly pushed against the loose material in the die to a preset value of compaction pressure that was then held for the dwell time of 5 s.

At the end of material compression, the compacted unit had to be removed. Each time, the removable lower cover of the die was replaced with a specially designed open ejection cylinder followed by pushing the unit through by the piston. For each of the two adhesives used, there were 20 different combinations of pressure-% adhesive. For each combination, ten units or more were produced. The briquettes produced were placed in plastic open bags and stored under ambient conditions. The durability index of briquettes in this study was determined by a standard tumbling test set by the ASAE standard S 269.4 (ASAE Standards, 1996). The briquette moisture content during durability tests was about 11% w.b.

Results and Discussion

Figures 1 and 2 show the effect of wood adhesive on the durability of OC briquettes. A glance at Figure 1 indicates that compared to control (0%), significant improvement in durability

![Fig. 1. Effect of wood adhesive on the durability of OC briquettes under different levels of compaction stress](image1)

![Fig. 2. Effect of stress on the durability of OC briquettes under different levels of wood adhesive](image2)
has been achieved at all adhesive and stress levels. It can also be seen from Figure 1 that at any given stress, the 3% adhesive level may be considered optimal since it gave the best results. The durability index, DI, increased roughly from a value of about 25 for the plain OC to about 300 at the 3% adhesive level corresponding to 11 times increase. Figure 2 better shows the influence of compaction stress on durability indicating in general a weak effect of stress on briquette durability for the range tested. However, Figure 2 also shows that at any given adhesive level, durability experienced slow but steady increase with stress until 35 MPa. At the 45 MPa level, the durability declined consistently at all adhesive levels.

The effect of clay loam addition on the durability of OC briquettes is depicted in Figures 3 and 4. In general, Figure 3 readily shows that clay loam addition effected apparent increases in durability at all stress levels. It may also be noticed that the 2% clay loam level resulted in the best durability indices leading roughly to 11-fold increase in briquette durability compared to the control (0%). Figure 4 indicates again that the 35 MPa is the favorite stress level as it resulted in the highest durability indices at almost all clay loam addition levels. The figure further clearly shows by observation
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Fig. 5. All-stress-levels average durability index of compacted OC vs. level of wood adhesive and clay loam

In an attempt to compare between them, the average durability indices for both materials are plotted in Figures 5 and 6. In Figure 5, each point represents the average durability index at each adhesive level under all the four stress levels while each point in Figure 6 represents the average durability index at each stress level for all the adhesive levels. Figure 5 shows that at the 1% and 2% adhesive levels, clay loam was a better adhesive while at the 3% and 4% levels, wood adhesive gave better results. However, since the primary intention of OC densification is to be used for energy or feed and adding adhesive is likely to alter this purpose in unfavorable way, lower addition levels are preferable.

In addition, wood adhesive might impose environmental and health hazards for either purpose. Turning attention to Figure 5 leads to stating that clay loam was superior to wood adhesive throughout the stress range tested. Moreover, both Figures 5 and 6 reaffirm that the best addition levels for clay loam and wood adhesives were 2% and 3%, respectively. Furthermore, the optimum compaction stress for both materials was 35 MPa.

Conclusion

The test results indicate that adding either material leads to substantial boost to briquette durability in excess of 11 times. From the two materials tested, clay loam is a better choice as an adhesive in several aspects and is a superior adhesive as
well. Adding 2% clay loam by weight to loose olive cake and densifying the mixture at 35 MPa gave the best results and made highly durable briquettes.

References


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