

## Olive Cake in Livestock Nutrition

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Received on 1/7/2021 and Accepted for Publication on 29/8/2021.

### ABSTRACT

Depending on species and the utilized production system, feed represents the biggest variable cost to livestock producers. For example, feed cost represents 40-50% of the production cost of intensively managed cows and up to 60-70% of the cost of extensively managed sheep and goats. In either case, its proportion is substantial to the profitability of any animal operation. Livestock producers in Jordan face great hardships and challenges related to the environmental impact, animal health, market variability, and, most importantly, feed prices due to the limited feed production stemming from low rainfall. Most of the main feed ingredients in Jordan's livestock sector are imported making them quite expensive. This review discusses the use of alternative feed ingredients (namely olive cake (OC)) in animal nutrition as a means of reducing the cost of feeding and improving returns to producers. Olive oil is one of the healthiest oils available and represents an important part of the Mediterranean diet. The increased demand for olive oil and olive fruits accelerated the increase in planting olive trees to meet these needs. This, in turn, has led to a significant increase in olive residues, such as olive cake (OC). These residues (byproducts) can be a source of pollution if not disposed of properly. The main objective of this review is to focus on the importance of OC in animal nutrition and its impact on the economics of livestock production. Most of the studies we dealt with in this review have shown that incorporating OC (in small substitutions) into the rations of livestock has no adverse effects on animal health and productivity. Thus, utilizing low-cost, agro-industrial by-products, such as OC, can be beneficial from environmental and economic points of view.

**Keywords:** alternative feeds, olive cake, diets cost

### INTRODUCTION

The Hashemite Kingdom of Jordan is celebrating its 100th anniversary. Since its inception, Jordan has given its great attention to the agricultural sector, in general, and the livestock sector, in particular. The livestock sector is considered of special importance in Jordan, as it plays

important roles in economic and social development; it provides employment opportunities in addition to being the livelihood and way of life for residents of the rural and desert communities. This sector also contributes to food security in the Kingdom by providing meat, milk, and table eggs. Earlier on (when Jordan had better rainfall), livestock producers relied on pasture/range as the main source of nutrients, which made raising animals economically feasible and profitable.

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In the last few decades, with the advancement of intensive production systems along with the scarcity of good pastures, the provision of feeds has become the biggest concern for livestock producers.

Climatic changes have resulted in successive years of drought and fluctuations in rainfall which largely contributed to pasture/range scarcity. To overcome pasture limitations, producers relied on different grains and forages to feed animals. This was initially economically feasible, but since most of these feeds were imported, their prices rose to where the cost of feed comprises 70% of the cost of production (Obeidat *et al.*, 2019b). Additionally, this year we have witnessed unprecedented feed prices due to the COVID-19 pandemic (along with other factors) thus compounding the high feed cost problem. Therefore, farmers are seeking non-traditional feed alternatives as a way of reducing their cost of production. Recently, the utilization of plant and agro-industrial by-products contributed to feeding livestock when they replaced grains and protein sources in the ration (Obeidat, 2020).

Interactions exist between the number of animals, the quantity and quality of available and consumed feeds, and animal performance; as the number of animals increases, the number of feeds required increases. Soybean meal, corn, barley, and wheat bran are the major ingredients that supply protein, fiber, and energy to the different classes of animals (Aloueedat *et al.*, 2019). With the increased international demand for these feeds, prices increase portentously and exert pressure on livestock producers. Typically, there are largely seasonal and yearly variations in the quality and quantity of these feed ingredients, which complicates the production process (Obeidat, 2018). Therefore, the need to find other feed resources or by-products is required to meet the shortage in the availability of feeds without affecting the quality of diets that are supplied to the animals (Obeidat, 2017); a good candidate is an olive cake (OC).

The olive cake is considered to be the main by-product of the olive oil production systems (Awawdeh and Obeidat, 2013) and is composed of skin, crushed pulp, stone wall,

kernel, and the remaining oil (Obeidat, 2017). In recent years, the consumption of olive oil has been increasing and, consequently, the need for more olive trees is increasing (International Olive Oil Council, 2021). Olive, and subsequent oil, production is seasonal with about 200 kg of oil and 800 kg of OC being produced per ton of olive fruits (Albuquerque *et al.*, 2004). A large amount of OC accumulates in a short period and utilizing this by-product should alleviate environmental pollution and reduce contamination of the soil and water resources (Weinberg *et al.*, 2008). The increasing demands and the high price of feedstuff creates a challenge for farmers and producers. The use of alternative feeds, such as OC, may reduce the burden of cost on the farmers. Therefore, this review compiles our research and the available literature to provide information to researchers, producers, and stakeholders on the use of olive cake in feeding livestock.

#### **Chemical composition of olive cake**

Introducing unconventional forages, such as OC, when feeding small ruminants requires sufficient research to understand and evaluate the animal's response (palatability, intake, incorporation rate, digestibility, performance, etc.) to agro-industrial by-products. The nutrient content of alternative feeds is one of the most important points that must be understood to evaluate the nutritional value of these by-products. Because of the variable nature of these products, nutrient content (such as dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), ether extract (EE), etc.) must be assessed before adopting alternative feeds as part of the diet. In arid and semi-arid areas, such as Jordan, the use of pasture/range as a source of forages is limited due to the shortage in rainfall and water resources. Therefore, most livestock depends on the use of wheat and barley straw to cover the shortage in fiber sources (Obeidat *et al.*, 2014). However, these ingredients are characterized by not only lower nutritive value and digestibility but also by being cost-ineffective in feeding livestock (Obeidat *et al.*, 2019).

The chemical composition of OC varies according to season, the method of oil extraction, the level of ripeness of the fruit, and the geographical origin of olives (Obeidat, 2017). Olive cake contains about 51% DM, 95% OM, 6.5% CP, 54% NDF, 37% ADF, and 22% EE on DM basis (Awawdeh and Obeidat, 2013). As OC has residual oil, it contains a higher digestible EE component than other fiber sources (Chiofalo *et al.*, 2004). However, the metabolizable energy of OC (1-2 MJ/kg DM) is less than half of that in straw (Abbeddou *et al.*, 2011). The olive cake is classified as low-quality feedstuff (Awawdeh, 2011) due to high cell wall constituents (NDF, lignocellulose (ADF), and lignin (ADL) (Martín García *et al.*, 2003). Another ingredient that makes up 25-30% of the OC composition is the residual water, in addition to the crude fiber that covers about 27-41% of the olive cake composition (Chiofalo *et al.*, 2004). Further, OC contains low amounts of crude protein (ranges between 4.8-10.6 %; (Martín García *et al.*, 2003; Molina-Alcaide and Yáñez-Ruiz, 2008)). The protein content of the olive cake is characterized by low digestibility, which is mainly related to the attachment of 71% of the nitrogen to the rumen cell wall making it unavailable for digestion (Abbeddou *et al.*, 2011). The variations in the chemical composition of the OC make it necessary to be analyzed before using it in animal nutrition. However, the content of nutrients makes the use of these residues have a positive effect in raising livestock.

#### **Dry matter intake and nutrient digestibility**

Olive cake can be used as an alternative feed for ruminants. However, as previously discussed, OC has poor quality (Awawdeh, 2011). Thus, the effect of OC on animals mainly depends on the level of feeding. At lower levels, OC may not exert any effects on the palatability of feed, rendering the intake unchanged. As such, the available literature may yield contradictory results. (Awawdeh and Obeidat, 2013) reported that using sun-dried OC and acid-treated sun-dried OC (up to 10% of the ratio) did not affect intakes of DM, OM, CP, NDF, or ADF of lambs. Similarly, (Abo Omar *et al.*, 2012) reported that 15% inclusion of various types of OC (crude, alkali-treated, or ensiled)

produced no adverse impact on Awassi sheep performance. In a recent study, (Abid *et al.*, 2020) found that treating OC with fibrinolytic enzymes improved DM intake in growing lambs. Several other studies in lambs (Kotsampasi *et al.*, 2017; Obeidat, 2017; Tufarelli *et al.*, 2013), ewes (Abo Omar *et al.*, 2012; Vargas-Bello-Pérez *et al.*, 2013) and dairy cows (Castellani *et al.*, 2017; Neofytou *et al.*, 2020) demonstrated that diets with low levels of OC did not affect nutrient intake. While (Castellani *et al.*, 2017) found no differences in DM intake in dairy cows fed 0.4 kg dried OC, (Cabiddu *et al.*, 2004) reported a decrease in DM intake when dairy ewes were fed OC at 10 and 20% DM. The differences between the two studies can be attributed to species differences, the composition of the diets, and/or the level of OC feeding.

Conventional roughages, like barley hay and straw, can be replaced with OC with proper caution to prevent a reduction in intake. In that context, (Hadjipanayiotou, 1999) found a higher intake of EE, ADF, NDF, and lignin in lactating ewes, Damascus goat, and Friesian cows when replacing conventional roughages with OC silage fed at 0.37, 0.39, and 2.66 kg OC silage on DM basis, respectively; CP intake did not differ by that replacement. As previously mentioned, OC fed at high levels can impact palatability resulting in reduced feed intake. The addition of OC at 32.3% attenuated the voluntary intake of feed by lamb, as the intake was higher among the control group compared to the OC group (Vera *et al.*, 2013). (Aljamal *et al.*, 2021) reported that DM intake decreased when lactating Awassi ewes were fed OC at 25% compared with ewes fed the control diet. Similar results were reported when high levels of OC were fed to ewes (up to 49% of the diet) (Abbeddou *et al.*, 2011; Beken and Sahin, 2011; Cabiddu *et al.*, 2004; Sadeghi *et al.*, 2009). In summary, DM and other nutrient intakes in diets containing OC are variable and depend on the diet composition and the level of the OC inclusion; intake may decrease at higher OC inclusion rates due to palatability issues.

In addition to the discussion above of feed intake, OC tends to have low energy metabolism and digestibility. This stems from the high levels of tannins (1.4% of DM) (Sadeghi *et al.*, 2009), the nearness of proteins in the lignocellulosic compound, the high lignin content, and the high heat level during oil extraction (Sadeghi *et al.*, 2009). High levels of tannins lead to reduced feed intake and lower feed digestibility (Feggeros and Kalaisakes, 1987). Our research has shown that, other than EE, lower nutrient digestibility was observed in diets containing 15% OC feed compared to the control group (Obeidat, 2017). A similar previous study showed that the addition of 10-30% OC was responsible for reducing the digestibility of DM, NDF, and ADF compared to the control diet (Al Jassim *et al.*, 1997). This was proven by a Sacco trial that revealed that organic matter and soluble NDF in the OC group require more time for degradation than any other by-products (Abbeddou *et al.*, 2011). Moreover, during the extraction process, heat exposure may initiate the Maillard reaction between carbohydrates and proteins; hence, the digestibility of CP becomes lower. Also, the availability of nitrogen in the rumen may be decreased, which may negatively affect microbial fermentation (Molina Alcaide *et al.*, 2003).

The inclusion of OC may affect the nutrient digestibility of the ration. In Awassi lambs, the apparent nutrient digestibility in a diet containing 34% OC was low when compared to the control diet. This may be due to the antagonistic effect of OC on other ingredients (Abbeddou *et al.*, 2011). For example, nitrogen balance was lower in Najdi lambs fed diets containing 12% OC (Owaimer *et al.*, 2004). Several other studies reported lower digestibility of DM and fiber segments (NDF and ADF) of the ration when OC was used in the diet (Martín García *et al.*, 2003; Tufarelli *et al.*, 2013; Yáñez-Ruiz and Molina-Alcaide, 2007). In contrast, our research reported that feeding OC did not attenuate the nitrogen intake, or nitrogen loss and retention; it positively affected nitrogen balance in diets containing 15% OC (Obeidat, 2017). We also found no difference in digestibility of DM, OM, CP, and NDF among various OC treatments

(control, sun-dried olive cake, and acid-treated sun-dried olive cake) (Awawdeh and Obeidat, 2013). Reasons for this contradiction can be attributed to the inclusion rate of the OC in the diet, a form of the OC, method of olive oil extraction, and the type of to which the experiment was conducted.

#### **Growth performance and carcass traits**

Another important aspect to be considered upon the addition of OC is animal performance. Much of the variation in animal performance can be attributed to DM intake and feed digestibility. As with previous discussions, literature can be variable depending on feeding rate, species, stage of production, study duration, and other factors. For example, in weaned Pramenka lambs, the administration of 30% OC induced lower final weight, and lower average daily weight gain compared to other groups that were fed either a 15% OC diet or the control diet. The difference in the average daily weight gain was not significant between the 15% OC group and the control group, but it remains higher in the control group (Mioc *et al.*, 2007). In contrast, (Beken and Sahin, 2011) reported no effects on the performance of Awassi lambs fed 20% OC mixed with concentrate compared to those fed control diet alone. Research from our laboratory (Awawdeh and Obeidat, 2013) showed improved weight gain and final body weight in lambs fed up to 10% OC in the diet. Several other studies had similar findings (Abid *et al.*, 2020; Abo Omar and Gavoret, 1995; Belibasakis, 1985; Christodoulou *et al.*, 2008).

(Mioc *et al.*, 2007) investigated the effect of adding OC to the diet of Pramenks lambs on carcass weight. The olive cake is rich in  $\beta$ -carotene (carotenoids and lutein) which increases the yellowness of fat in lamb carcasses (Ghanbari *et al.*, 2012). In terms of carcass yield and dressing percentage, most studies reported no differences when OC was fed at low to moderate rates (Hamdi *et al.*, 2016; Vera *et al.*, 2013). Authors found that adding 15% OC to the diet has not affected the carcass weight but when increasing OC inclusion to 30%, it has shown a negative effect on the carcass weight (Mioc *et al.*, 2007). Olive cake has not shown any effect on commercial dressing percentage or carcass fat

mass (Hamdi *et al.*, 2016). Similarly, OC did not show any effect on chilled carcass weight, dressing percentage, and ultimate pH in Suffolk lambs while using 32.3% OC as DM (Vera *et al.*, 2013). On the other hand, a study on grazing Barbarian lamb reported an increase in hot and cold carcass weight in lambs supplemented with 28% OC compared with controls. Previous studies show that OC can be fed to livestock up to 25% without causing any detrimental effects on nutrient intake, digestibility, and/or growth performance, however, at greater levels it may decrease intake and other performance variables. As previously stated, many factors can cause variations in literature when it comes to OC inclusion into a feeding program.

### **Lactation performance**

One of the most important measures that reflect livestock productivity is milk production, which reflects the animal's ability to convert nutrients into milk. Improving milk production has an economic impact on these animals, which may be either by increasing milk production or by reducing the cost of feeding the animals. Several studies utilizing many livestock breeds and species and various levels of inclusion have shown that OC does not adversely affect milk yield and composition when fed in moderate amounts. This was shown in ewes ((Aljamal *et al.*, 2021); OC at 25% DM; (Vargas-Bello-Pérez *et al.*, 2013); OC at 9.8 and 24.4% DM; (Cabiddu *et al.*, 2004); OC at 10 and 20% DM)), dairy cows ((Chaves *et al.*, 2020); OC at 5, 10 and 15% DM; (Neofytou *et al.*, 2020); ensiled OC at 10% DM; (Castellani *et al.*, 2017); OC fed at 0.4 kg per day; (Belibasakis, 1984); OC at 20 and 40% DM)), lactating camels ((Faye *et al.*, 2013); OC at 3% DM), and in dairy goats ((Keles *et al.*, 2017); OC silage at 10 and 20% DM). Also, (Hadjipanayiotou, 1999) reported that partial replacement of traditional diets (barely hay and straws) with ensiled OC silage did not affect milk yield and fat corrected milk (ewes 6%, goat and cows 4%) of lactating Chios ewes, Damascus goats, and Friesian cows.

Other studies have reported either increased or decreased milk production when OC is included in the diets of lactating animals. (Chiofalo *et al.*, 2004) and (Lanzani *et al.*, 1993)

reported that milk yield increased in lactating ewes fed OC at 20 and 15% DM, respectively. In agreement, (Terramoccia *et al.*, 2013) reported that feeding dried stoned OC at a level of 15.5% DM in the diet of lactating buffaloes improved milk yield whereas it did not affect milk composition. In contrast, (Molina-Alcaide *et al.*, 2010) found an adverse effect on milk yield, protein yield, fat yield, lactose yield and total milk solid in goats fed a diet containing feed block with crude two-stage olive OC at 12 and 10% of dietary DM. Similarly, (Abbeddou *et al.*, 2015) observed a trend toward a decline in milk yield, energy corrected milk, milk fat, and protein of Awassi ewes fed diets containing OC at 30% of dietary DM, while total solids and lactose were not different. A study done by (Abbeddou *et al.*, 2011) showed a negative effect on milk yield of Sarda ewes when feeding olive silage at 250 g or 500 g DM/head/day, while this replacement increased the lactose content when compared to the control group. However, replacing 30% of barley straws with OC in Awassi ewes feed did not affect milk yield, total solid, milk protein, or fat (Abbeddou *et al.*, 2011). Meanwhile, using 20% OC in feed has decreased the casein and protein percentage in milk while the milk yield was increased compared with the control group (Chiofalo *et al.*, 2004). This reduction in both milk casein and protein could be related to the increase in milk volume which may cause dilution of these nutrients in milk. At a 20% inclusion rate, OC was shown not to affect milk lactose or fat content (Chiofalo *et al.*, 2004). The controversial results of including the OC could be related to several reasons, such as the inclusion rate of OC in the diet, substitution as roughage or concentrate or both, form of the OC (ensiled, dried, de-stoned, and partial de-stoned), and the type of ruminant (bovine or ovine) to which the experiment was conducted.

### **Economics of using OC**

Providing the producing animals with a low-cost feed balanced in a way to meet the production needs for growth, gestation, or milk production can be challenging to livestock producers. Therefore, it was necessary to use agro-industrial by-products with acceptable feed value and low cost (such

as OC) to reach the above objective. Many previous studies have shown that the use of unconventional feed ingredients had a positive impact on the cost of feed and, hence, production. Such feeds increased the return over feed cost (RoF) due to their low cost and the level of inclusion in the respective diets (Aljamal *et al.*, 2021; Aloueedat *et al.*, 2019; Hatamleh and Obeidat, 2019; Obeidat, 2020, 2018). The economics of using OC can be identified by the reduction in the cost of feed (compared to a feed not utilizing OC) and the gross returns in animal products, such as meat and milk. This simple calculation can be used to determine whether the use of OC (or other alternative ingredients) is economically feasible or not.

In our lab, various studies showed that the use of many alternative feed ingredients decreased feed cost by 20 and 24% (OC and Atriplex halimus L. at 25% of the dietary DM; (Aljamal *et al.*, 2021)), 11 and 22% (sesame meal at 7.5 and 15% of the dietary DM; (Obeidat *et al.*, 2019a)), 25% (black cumin meal at 15% of the dietary DM; (Obeidat, 2020)), 15% (15% OC of the dietary DM; (Obeidat, 2017)), and 13 and 20% (dried distillers grains with solubles at 20 and 30%

of the dietary DM; (Alshdaifat and Obeidat, 2019). Therefore, any alternative feeds that can lower the ration cost without any adverse effects on animal health and performance can have a positive impact on the RoF.

## Conclusion

This review highlights recent literature and findings from our lab, as well as others, on the use of olive cake as an alternative feed in animal nutrition. Although some studies have reported a positive impact on productive parameters (improved weight gain, milk production, or others), most research shows that olive cake can be incorporated into diets without adverse effects on animal health and production. The fact that olive cake has low nutritive value requires special care when adopting it into the feeding program. Being an agroindustrial byproduct makes feeding olive cake feasible from an environmental and productive points of view.

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## جفت الزيتون في تغذية المواشي

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تاريخ استلام البحث: 2021/7/1 وتاريخ قبوله: 2021/8/29.

### الملخص

اعتمادًا على الأنواع ونظام الإنتاج المستخدم، يمثل العلف أكبر تكلفة متغيرة عند مربّي الثروة الحيوانية، فعلى سبيل المثال، تمثل تكلفة العلف 40-50% من تكلفة الإنتاج للإدارة المكثفة للابقار وقد تصل إلى 60-70% من تكلفة الإنتاج للإدارة المكثفة للاغنام والماعز. في كلتا الحالتين، يعتبر انتاجها جوهرياً لربحية أي عملية حيوانية. يواجه منتجو الثروة الحيوانية في الأردن صعوبات وتحديات كبيرة تتعلق بالتأثير على البيئة وصحة الحيوان وتقلب السوق والأهم من ذلك، أسعار العلف بسبب انتاج الاعلاف المحدود الناجم عن قلة هطول الامطار، لذلك فإن معظم مكونات العلف الرئيسية في قطاع الثروة الحيوانية في الأردن هي مستوردة مما يجعلها باهظة الثمن. تناقش هذه المراجعة استخدام مكونات العلف البديلة (جفت الزيتون) في تغذية الحيوان كوسيلة لتقليل تكلفة التغذية وتحسين العائد على المنتجين. يعتبر زيت الزيتون من أفضل الزيوت المتوفرة صحياً ويمثل جزءاً مهماً في غذاء منطقة البحر الأبيض المتوسط. إن الطلب المتزايد على زيت الزيتون وثمار الزيتون أدى إلى تسريع وتيرة زراعة أشجار الزيتون لتلبية هذه الاحتياجات. وقد أدى هذا بدوره إلى زيادة كبيرة في بقايا الزيتون، مثل جفت الزيتون. هذه المخلفات (المنتجات الثانوية) يمكن أن تكون مصدرًا للتلوث إذا لم يتم التخلص منها بشكل صحيح. إن الهدف الرئيسي من هذه المراجعة هو التركيز حول أهمية جفت الزيتون في تغذية الحيوان وأثره على اقتصاديات الإنتاج الحيواني. أظهرت معظم الدراسات التي تناولناها في هذه المراجعة أن دمج جفت الزيتون (على شكل بدائل صغيرة) في تغذية المواشي ليس لها آثار ضارة على صحة الحيوان وإنتاجيته. وبالتالي، فإن استخدام المنتجات الثانوية الصناعية الزراعية منخفضة التكلفة، مثل جفت الزيتون، يمكن أن يكون مفيداً من وجهة النظر البيئية والاقتصادية.

**الكلمات الدالة:** الأعلاف البديلة، جفت الزيتون، كلفة الأعلاف