The efficacy of using olive cake as a by-product in broiler feeding with or without yeast
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ABSTRACT
The effects of inclusion of olive cake (OC) at 0, 5 and 10% in broiler diets were investigated during 1–28 d of age. Each level of OC was fed with or without yeast (Saccharomyces cerevisiae) at 0.2 and 0.4 g/kg. Thus, the experimental design had a factorial arrangement that included three concentrations of OC by three concentrations of yeast (unsupplemented control, 0.2 and 0.4 g/kg yeast supplementations). Each diet was fed to eight replicates of five male chickens each. Growth performance, European production efficiency index (EPEI), blood lipid constituents, inner body and lymphoid organs were studied. The results indicate that OC can be fed at 5% with yeast supplementation at 0.4 g/kg to broiler chickens during 1–28 d of age, resulting in the best body weight gain (BWG), feed conversion ratio (FCR), and EPEI. Yeast supplementation at 0.2 g/kg to diets containing 0% and 5% OC and at 0.4 g/kg to diets containing 10% OC resulted in the highest survivability rate (100%). In addition, OC in broiler diets up to 10% did not adversely affect carcass traits and inner organs. In conclusion, OC can be safely fed to broiler chickens during 1–28 d of age up to 10%, while reducing the environmental pollution caused by the accumulation of OC after the expansion in the cultivation of olives for oil extraction for human consumption. However, the best productive performance and production index were obtained when 5% OC was supplemented with 0.4 g/kg yeast.

INTRODUCTION
Feeding costs account for about 70% of the total cost of poultry production. In developing countries, feed resources are limited, and the problem became more difficult after the use of grains and oilseeds for biofuel and biodiesel production, respectively. Therefore, it is necessary to find new, non-traditional, low-cost feedstuffs to decrease the overall cost of poultry production (El-Ghamry & Fadel 2004; Molina-Alcaide & Yanez-Ruiz 2008; Al-Harthi et al. 2011). Cultivation of olives in Saudi Arabia has increased in the northern area in Hail, Jouf and Tabouk due to several health benefits of olives (Amici et al. 1991). The residues after oil extraction are estimated to be 30–40% of olive seeds (Nefzaoui 1993). These residues are a rich source of oil 6.8% (Amici et al. 1991; Sadeghi et al. 2009). In addition, utilisation of olive by-products in animal nutrition can enrich animal products with unsaturated fatty acids and improve animal product quality (Molina-Alcaide & Yanez-Ruiz 2008; Abd El-Samee & Hashish 2011).

In the literature, olive cake (OC) was added at 5–10% to broiler diets without adverse effects on growth performance, carcass characteristics, inner body organs and blood hematology (Rupić et al. 1999a, 1999b; Abo-Omar 2000; Rabayaa 2000; Abo-Omar 2005; Zangeneh & Torki 2011). However, a higher level of OC negatively affects nutrient digestibility (Abo-Omar 2000). OC cell walls consist of non-starch polysaccharides (NSP) that contain xyloglucan and xylan–xyloglucan complexes (Gil-Serrano & Tejero-Mateo 1988; Coimbra et al. 1995) and glucuronoxylans with xylose/glucose at the ratio 7:1 (Domingues 2002). The performance of poultry and pigs is adversely affected by the presence of dietary NSP (Gil-Serrano & Tejero-Mateo 1988; Coimbra et al. 1995).

For several decades, yeasts have been used to improve feed utilisation by farm animals, and they have played an important role since the ban on using antibiotics as growth promoters in animal feed in the European Union in 2006. Yeast is a rich source of protein, fat, vitamin B and enzymes such as cellulase.
Materials and methods

**Diet, design and birds**

This study was carried out in the Hada Al-Sham Research Station, at the College of Meteorology, Environment and Arid Land Agriculture of King Abdulaziz University, Jeddah, KSA. OC, the residual material after oil extraction by screw press, including pulp and stones, was transported from Al-Jouf area to the Hada Al-Sham Research Station. Then, it was distributed on the floor of a big room (10 x 5 m), which has 4 big fans, 2 on each side, for pulling warm air from the outside (environment temperature was about 45°C) and pushing it back outside as a ventilation cycle, with air-speed 60,000 m³/h. The OC was continuously stirred until completely dried. Then, it was crushed to a dry powder, sieved in a special capacity in order to reach the appropriate size (e.g. ~0.5 mm for feeding), and then stored in bags until used in diet formulation. Experimental diets, formulated to be isocaloric and isonitrogenous, met the nutrient requirements for broiler chickens suggested by the National Research Council (NRC 1994). The composition of diets that used during 1–8 d of age is shown in Table 1. The OC was included at 0, 5 and 10%, and the diets were also supplemented with yeast at 0, 0.2 and 0.4 g/kg. This resulted in a factorial experimental design, e.g. 3 (OC concentrations) x 3 (yeast levels 0, 0.2 and 0.4 g/kg), nine treatments. Thus, 360, 1-d-old males Ross broiler chickens were distributed randomly among 9 treatments (40 chickens/treatment) and eight replicates (five chickens/replicate). *Saccharomyces cerevisiae* is a product bought from Alzahraa company – Alexandria – Egypt, which containing 8,000,000,000 cfu active per g, and its recommended concentration is 150–300 g/ton feed. The aim of using these two ratios (5 and 10%) and no higher is attributed to the high content of fibre in olive cake (14.12%, data not shown), and also to the weak digestive tract of broilers, especially at the early stage of 1–28 d old (Sklan & Noy 2003; Thomsen et al. 2008). Another reason is that this study is the first one to investigate this by-product in Saudi Arabia, where no previous data have been available for such ratios.

**Husbandry of chickens**

The department committee that mentors animal rights, welfare and minimal stress according to King Abdulaziz

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| Ingredients, g/kg | Olive cake concentration, % |
|------------------|-----------------------------|
|                  | 0   | 5   | 10  |
| Maize            | 550.5 | 477.5 | 404.5 |
| Soybean meal, 48% CP | 373.0 | 380 | 387.0 |
| Dried olive cake³ | 0.0 | 50.0 | 100 |
| Dical phosphate  | 19.0 | 8.5 | 18.5 |
| Limestone        | 12.5 | 11.56 | 11.0 |
| Sodium chloride, % | 3.0 | 3.0 | 3.0 |
| Vitamin + mineral premix⁴ | 1.0 | 1.0 | 1.0 |
| α-methionine     | 2.5 | 2.6 | 2.8 |
| L-Lysine         | 2.0 | 2.0 | 2.2 |
| Soybean meal oil | 36.5 | 53.75 | 70.0 |
| Total            | 1000 | 1000 | 1000 |

³Chemical composition of sundried olive cake (AOAC 1990) showed 52% CP, 0.79% Ca and 0.90% total phosphorus, of which about 0.35% was considered available based on the assumption by NRC (1994), 0.03% methionine, 0.15% methionine and cysteine, 0.03% lysine and 6.7 MJ/kg ME.

⁴Vit + Min mix provides per kilogram of the diet: vit. A 1700 U, vit. E 13 U, vit. K1 mg, vit. D 250 IU, riboflavin 4 mg, pantothenic acid 12 mg, niacin 40 mg, choline 1.500 mg, vit. B12 0.02 mg, Pyridoxine 4 mg, thiamin 2 mg, folacin 1 mg, biotin 0.2 mg. Trace minerals (mg/kg of diet): Mn 70, 1.04, Zn 50, Fe 90, Cu 10 and Se 0.2 mg.

Calculated values.

Analysed values.
University animal rights and ethics regulations approved all the procedures. Chicks were distributed in floor pens (1 × 1 m) furnished with wood shavings as a padding material under similar managerial and hygienic conditions. Feed and water were provided ad libitum throughout the experimental period (1–28 d). Vaccinations and a medical program were performed under the supervision of a veterinarian. The brooding temperature was 33, 29, 26 and 23°C during the 1st, 2nd, 3rd and 4th weeks of age with 45% RH. The chickens were illuminated with a 23:1 light-dark cycle.

**Data collection**

The broiler chickens were weighed at 1 and 28 d of age, and BWG, feed intake, and feed conversion ratio (FCR) were calculated for the period of 1–28 d of age. The FCR was calculated as the amount of feed intake divided by BWG. Survival rate (%) was calculated by the number of live chickens at the end of the experiment divided by the number of chickens at the beginning of the experiment. The European production efficiency index (EPEI) was calculated according to the Hubbard Broiler Management Guide (1999).

At 28 d of age, eight chickens per treatment, as 1 from each replicate, were randomly chosen and slaughtered for the assessment of carcass characteristics, inner body organs and lymphoid organs (spleen and bursa of Fabricius) ratios to live body weight.

Also at 28 d of age, another group of eight chickens per treatment, as 1 from each replicate, were used to collect blood samples (5 ml) from the brachial vein into heparinised tubes. Plasma was collected after blood centrifugation at 1500 g for 20 min. Blood plasma lipid profiles were determined using commercial diagnostic kits as follows: triglycerides (Fossati & Prencipe 1982), total cholesterol (Watson 1960), low-density lipoprotein (LDL) (Wieland & Seidel 1983) and high-density lipoprotein (HDL) (Lopez-Virella et al. 1977). Plasma very-low-density lipoprotein (VLDL) was calculated according to Friedewald et al. (1972), VLDL, total cholesterol-HDL-LDL.

**Statistical analysis**

Data were analyzed with the GLM procedure of SAS® (SAS 2003) using two-way factorial analyses according to the 2-factors randomised complete block design of the experiment (3 × 3). Before analysis, all percentages were subjected to logarithmic transformation (log 10x + 1) to normalise the data distribution. Differences between means were tested using the Student–Newman–Keuls test at p 0.05 (SAS 2003). Interactions only were presented and, in case of significance, discussed.

**Results and discussion**

**Growth, survival rate, feed intake, feed conversion ratio and European production efficiency index**

The results in Tables 2 and 3 show data for the growth, survival rate, feed intake, FCR and EPEI of the broiler chickens during 1–28 d of age. A lack of significant differences in initial body weight was noticed among various treatments, which confirmed the random distribution of the chicks among the treatments.

It was found that the BWG during 1–28 d of age, final body weight at 28 d, feed intake, FCR and EPEI of the broiler chickens were not significantly affected by the OC level or yeast addition in the broiler feed. The results indicate that OC had no negative effect on growth, feed intake and FCR, and hence yeast did not boost them. This finding may be due to using isocaloric and isonitrogenous diets. These results are consistent with previous studies (Abo-Omar 2000; Rabayaa 2000; Abo-Omar 2005), which showed that OC can be fed to broiler chickens up to 10% without detrimental effects on growth, feed intake, feed conversion ratio and European production efficiency index.

**Table 2.** Effects of different concentrations of olive cake and/or yeast concentrations on the body weight gain, final body weight and survival rate of broiler chickens during the period from 1 to 28 d of age.

| Treatments          | Initial BW, g | BWG 1 to 28 d of age, g | Final BW 28 d of age, g | Survival rate 1 to 28 d of age, % |
|---------------------|---------------|-------------------------|-------------------------|----------------------------------|
| Control             | 45            | 1070                    | 1115                    | 88.9b                            |
| Control with yeast 0.2 g/kg | 46            | 1042                    | 1088                    | 100.0a                           |
| Control with yeast 0.4 g/kg | 45            | 1100                    | 1145                    | 95.6*                            |
| 5 OC                | 47            | 1105                    | 1152                    | 97.8*                            |
| 5 OC with yeast 0.2 g/kg | 48            | 1134                    | 1182                    | 100.0a                           |
| 5 OC with yeast 0.4 g/kg | 47            | 1166                    | 1213                    | 95.6*                            |
| 10 OC               | 45            | 1088                    | 1133                    | 95.6*                            |
| 10 OC with yeast 0.2 g/kg | 46            | 1106                    | 1152                    | 95.6*                            |
| 10 OC with yeast 0.4 g/kg | 48            | 1078                    | 1126                    | 100.0a                           |
| SE                  | 1.87          | 19.47                   | 22.22                   | 1.59                             |
| Interaction         | 0.35          | 0.265                   | 0.237                   | 0.009                            |

Mean values within a column not sharing similar superscripts are significantly different (p < 0.05). SE: standard error.
Table 3. Effects of different concentrations of olive cake and/or yeast concentrations on feed intake, feed conversion ratio, and European production efficiency index of broiler chickens during 1 to 28 d of age.

| Treatments                  | Feed intake 1 to 28 d of age, g | Feed conversion ratio 1 to 28 d of age | European production efficiency index |
|-----------------------------|---------------------------------|----------------------------------------|-------------------------------------|
| Control                     | 1514                            | 1.42                                   | 268.7                               |
| Control with Yeast 0.2 g/kg | 1477                            | 1.42                                   | 286.8                               |
| Control with Yeast 0.4 g/kg | 1600                            | 1.45                                   | 278.5                               |
| 5 OC                        | 1607                            | 1.45                                   | 295.5                               |
| 5 OC with yeast 0.2 g/kg    | 1587                            | 1.40                                   | 322.0                               |
| 5 OC with yeast 0.4 g/kg    | 1544                            | 1.32                                   | 357.5                               |
| 10 OC                       | 1547                            | 1.42                                   | 299.8                               |
| 10 OC with yeast 0.2 g/kg   | 1593                            | 1.44                                   | 281.5                               |
| 10 OC with yeast 0.4 g/kg   | 1531                            | 1.42                                   | 282.2                               |
| SE                          | 35.05                           | 0.029                                  | 18.34                               |
| Interaction                 | 0.136                           | 0.201                                  | 0.254                               |

SE: standard error.

intake and FCR. Moreover, the results of Rupi ć et al. (1992) and El Hachemi et al. (2007) showed that OC can be included in broiler chickens’ feed up to 15% without adverse effects on feed consumption and feed utilisation. However, Al-Shanti (2003) reported that OC at 10% in broiler diets significantly improved FCR.

Also, the lack of a significant effect of yeast when added to OC diets means that the inclusion of OC in broiler feeds did not adversely affect the availability of other nutrients, and thus similar performances were achieved. These results are consistent with those reported in the literature that the effect of yeast depends on the dietary nutrient profile and the presence of a suitable substrate (Stavric & Kornegay 1995; Onifade 1998).

It is well known that yeast has been used successfully to improve the utilisation of diets containing agro-industry by-products (Yaşi ć et al. 2008; Warmadewi et al. 2009). On the other hand, the addition of probiotics to chickens’ feeds improved feed conversion rate (Jagdish & Sen 1993; Alvarez et al. 1994; Hamid et al. 1994; Silva et al. 2000; Ahmad 2006). However, other researchers could not find a positive effect (Samanta & Biswas 1997; Gohain & Sapcota 1998; Panda et al. 2000; Ergun et al. 2000). These differences in performance response among the different experiments might be attributed to the dietary composition and nutrient profile, age and strain of chickens, the type, form and dose of yeast, and environmental conditions. However, this inconsistency in published results encourages further research to determine when the utilisation of yeast can be obtained and, also, to maximise the utilisation of the yeast in poultry feed.

The results indicated that OC or yeast addition at 5 and 10% and 0.2 and 0.4 g/kg, respectively, increased the survival rate compared to the control group (OC-free diet and no yeast addition). These results are consistent with those reported by Karaoglu and Durdag (2005), Chumpawadee et al. (2008) and Hassan et al. (2012). In the literature, it was reported that yeast improves gut ecology, which helps the growth of beneficial organisms, and, therefore, improves digestion (as a result of the presence of cellulase and phytase). This, in turn, improves feed utilisation, health status and immunity of animal due to the presence of MOS, β-glucans and chitin (Warmadewi et al. 2009). Additionally, antioxidant enzymes such as superoxide dismutase, catalase, peroxidase and glutathione were found and reported to improve the animals’ defence system (Zhang et al. 2005; Hassan et al. 2012; Aluwong et al. 2013). However, Hassan et al. (2012) and Attia et al. (2013) clarified that yeast had a positive effect on immunity and thus enhanced the animals’ defense against disease.

It is worth noting that the addition of OC also helped to keep the survival rate high. This could be explained by the valuable nutrients found in OC, such as polyphenols, essential amino acids, essential fatty acids and important elements (data not shown). Also, the difference in ingredient composition such as soybean meal oil (e.g. 37, 54 and 70 g/kg in OC-free diet, 5% and 10% OC diets, respectively) is an important factor, where the increase in soybean oil intake induced an increase in essential fatty acids (linolenic, linoleic and oleic). The role of previous nutrient components on health status was previously evident (Wang et al. 2000; Wenk 2003). The synergetic effect of OC and soybean oil could not be ignored.

Dressing percentage and internal organs

The results shown in Table 4 indicate the effect of OC level and yeast additions on carcass trait and inner body organ ratios to a live body weight. It was observed that the application of neither OC nor yeast could affect these values, with the exception of intestinal ratio.

Yeast supplementation at 0.4 g/kg feed to 5% OC significantly decreased the intestinal ratio compared with those fed on 10% OC and had same yeast addition. Also, the addition of 0.4 g/kg to the OC-free diet and 5% OC diet led to a significant decrease in the relative weight of the intestines compared to their respective controls. It is difficult to explain the reason for these findings. However, these adaptive changes in the intestines ratios due to the use of yeast with specific OC level or to the concentration of yeast supplemented might reveal a decrease in energy.
consumption by the gut and an increase in nutrients availability (repatriating) for different purposes, such as growth and/or immune function (Attia et al. 2014).

The current findings are consistent with the results of several studies (El-Ghamry 2004; El-Ghamry & Fadel 2004; Abdel-Azeem et al. 2005; Karaoglu & Durdag 2005; Hosseini et al. 2006; Momtazan et al. 2011). These studies concluded that the effect of probiotics and baker’s yeast was not significant on the hot and cold weights of the carcass, dressing, carcass parts and abdominal fat. They also concluded that the addition of yeast had no significant effect on dressing percentage, breast, liver, heart, spleen, proventriculus, gizzard, and abdominal fat and the percentages of dry matter, protein, fat and ash of the meat.

In other studies, the addition of yeast to broiler chickens led to a significant increase in the absolute weight of the carcasses, while the absolute and relative weights of the preventriculus, gizzard, liver and pancreas and the length of the duodenum, jejunum, ileum and ceca were not significantly affected (Pelicano et al. 2004). The previous authors added that, proportion of the breast, leg, wings, abdominal fat, pH of breast meat and leg, cooking loss and shearing force were not significantly affected, too. These different responses to yeast supplementation could be due to the type and level of yeast, feed type and composition, length of feeding period, and age and strain of chicken (Attia et al. 2013).

The findings in this study suggest the safe use of OC up to 10% without yeast addition during 1–28 d of age, where no negative effects were recorded on dressing and the relative weights of the internal organs.

**Lymphoid organs**

Table 5 shows the data of immune organ ratios (spleen and bursa) to live body weight. Neither increasing the OC level nor the addition of yeast had an effect on the previous observations. According to the results published by Zangeneh and Torki (2011), OC up to 9% in laying hens’ diets did not significantly affect the white blood cells and their types. Also, yeast addition did not cause a significant increase in Fabricius bursa, pancreas and carcass traits (Yalcinkaya et al. 2008; Hassan et al. 2012). Moreover, Agawane and Lonkar (2004) and Strompfova et al. (2005) demonstrated that probiotics supplementation did not affect the different types of white blood cells in broiler chickens.

**Blood lipid components**

The results presented in Table 6 show the influence of OC level and yeast addition on plasma lipid components (total lipids, triglycerides, cholesterol, HDL [beneficial], LDL [harmful], HDL/LDL ratio and VLDL). There was a significant effect of the interaction among treatments of OC and yeast on all previous observations, except HDL.

The results of the interaction indicated that when the control group (OC-free diet without yeast addition) was compared with groups fed on 5 and 10% OC

| Treatments          | Dressing, % | Abdominal fat, % | Liver, % | Heart, % | Pancreas, % | Gizzard, % | Intestines, % | Caecum, % |
|---------------------|-------------|------------------|----------|-----------|-------------|------------|---------------|-----------|
| Control             | 68.08       | 0.356            | 2.20     | 0.618     | 0.300       | 1.77       | 4.24          | 0.572     |
| Control with yeast  | 70.70       | 0.402            | 2.10     | 0.658     | 0.286       | 1.74       | 3.83          | 0.640     |
| Control with yeast  | 69.66       | 0.330            | 2.06     | 0.606     | 0.350       | 1.70       | 3.60          | 0.540     |
| 5 OC                | 70.28       | 0.542            | 2.11     | 0.764     | 0.314       | 1.79       | 4.20          | 0.498     |
| 5 OC with yeast     | 70.28       | 0.542            | 2.11     | 0.764     | 0.314       | 1.79       | 4.20          | 0.498     |
| 5 OC with yeast     | 69.66       | 0.330            | 2.06     | 0.606     | 0.350       | 1.70       | 3.83          | 0.640     |
| 10 OC               | 69.76       | 0.390            | 2.32     | 0.718     | 0.300       | 1.84       | 3.54          | 0.474     |
| 10 OC with yeast    | 69.78       | 0.510            | 2.25     | 0.702     | 0.320       | 2.11       | 3.83          | 0.648     |
| 10 OC with yeast    | 70.80       | 0.556            | 2.39     | 0.618     | 0.308       | 2.16       | 3.64          | 0.698     |
| SE                  | 0.742       | 0.087            | 0.060    | 0.034     | 0.018       | 0.076      | 0.164         | 0.039     |
| Interaction         | 0.292       | 0.892            | 0.087    | 0.602     | 0.668       | 0.847      | 0.028         | 0.821     |

Mean values within a column not sharing similar superscripts are significantly different (p < 0.05). SE: standard error.

| Treatments          | Spleen, % | Bursa, % |
|---------------------|-----------|----------|
| Control             | 0.098     | 0.202    |
| Control with yeast  | 0.090     | 0.228    |
| Control with yeast  | 0.106     | 0.118    |
| Control with yeast  | 0.098     | 0.174    |
| 5 OC                | 0.106     | 0.202    |
| 5 OC with yeast     | 0.260     | 0.178    |
| 10 OC               | 0.096     | 0.246    |
| 10 OC with yeast    | 0.118     | 0.266    |
| 10 OC with yeast    | 0.086     | 0.232    |
| SE                  | 0.033     | 0.021    |
| Interaction         | 0.150     | 0.383    |

SE: standard error.

### Table 5. Effects of different concentrations of olive cake and/or yeast concentrations on immune organs ratio of broiler chickens raised during the period from 1 to 28 d of age.
Table 6. Effects of different concentrations of olive cake and/or yeast concentrations on blood lipid constituents of broiler chickens raised during the period from 1 to 28 d of age.

| Treatments                        | Total lipids, mg/dl | Triglyceride, mg/dl | Cholesterol, mg/dl | HDL, mg/dl | LDL, mg/dl | HDL/LDL ratio | VLDL, mg/dl |
|-----------------------------------|---------------------|---------------------|--------------------|------------|------------|---------------|-------------|
| Control                           | 525^e               | 168^a               | 192^a              | 33.38      | 82.25^a    | 0.406^a       | 76.75^e     |
| Control with yeast 0.2 g/kg       | 350^d               | 173^a               | 195^a              | 32.63      | 81.75^b    | 0.406^a       | 81.00^c     |
| Control with yeast 0.4 g/kg       | 400^cd              | 174^bc              | 195^a              | 35.13      | 78.63^a    | 0.44^ck       | 81.63^e     |
| 5 OC                              | 338^d               | 177^a               | 199^d              | 34.50      | 78.75^e    | 0.438^bc      | 85.63^bd    |
| 5 OC with yeast 0.2 g/kg          | 400^cd              | 175^a               | 207^a              | 36.13      | 80.38^ac   | 0.449^bc      | 90.00^ab    |
| 5 OC with yeast 0.4 g/kg          | 475^abc             | 174^bc              | 202^ac             | 35.88      | 79.50^bc   | 0.452^abc     | 86.25^bc    |
| 10 OC                             | 450^bc              | 174^bc              | 202^ac             | 35.50      | 81.25^a    | 0.47^c        | 84.75^cd    |
| 10 OC with yeast 0.2 g/kg         | 438^bc              | 172^a               | 206^ab             | 36.63      | 76.63^a    | 0.478^c       | 92.38^e     |
| 10 OC with yeast 0.4 g/kg         | 438^bc              | 172^a               | 197^a              | 35.38      | 76.00^a    | 0.466^ab      | 85.25^bd    |
| SE                                | 2.23                | 0.961               | 1.63               | 0.728      | 0.724      | 0.009         | 1.76        |
| Interaction                       | 0.0001              | 0.0002              | 0.021              | 0.110      | 0.0002     | 0.001         | 0.030       |

Mean values within a column not sharing similar superscripts are significantly different (p < 0.05). SE: standard error; HDL: high-density lipoprotein; LDL: low-density lipoprotein; VLDL: very-low-density lipoprotein.

Results found in this study, have also demonstrated that the effects of yeast on different components of plasma lipids depend on OC concentration. It was found that the addition of yeast at 0.2 and 0.4 g/kg to the OC-free diet significantly decreased the plasma total lipids concentration compared with the unsupplemented control, but increased plasma triglycerides. Also, using 0.4 g/kg yeast with OC-free diet induced a reduction in LDL and boosting in HDL/LDL ratio.

However, the addition of yeast at 0.4 g/kg to the diet containing 5% OC induced a significant increase in plasma total lipids compared with the other concentrations of yeast, while supplementation of yeast at 0.2 g/kg to the diet containing 5% OC significantly increased plasma cholesterol compared with the other groups. On the other hand, yeast supplementation to the 5% OC diet did not significantly affect plasma LDL, the HDL/LDL ratio and VLDL.

The effect of yeast concentration on the different components of the plasma lipid of broilers fed a 10% OC diet demonstrated that, yeast at 0.2 and 0.4 g/kg did not significantly affect the plasma total lipids and triglycerides, but yeast at 0.4 g/kg significantly decreased plasma cholesterol compared with the other levels of yeast. Moreover, yeast supplementation at 0.2 and 0.4 g/kg significantly decreased plasma LDL compared with the respective controls, while it increased the HDL/LDL ratio. On the other hand, yeast supplementation at 0.2 g/kg significantly increased the plasma VLDL of birds fed the 10% OC diet compared with the other groups fed the OC diet.

In general, these results indicate the beneficial influence of yeast on plasma blood lipid components, but this depends on OC concentrations. The current findings are consistent, to some extent, with the results of Tolla et al. (2004a, 2004b), who showed that the addition of lactobacillus, pediococcus, Lacto Sacc and Yea Sacc under natural conditions and heat stress conditions decreased cholesterol and plasma total lipid. Abdel-Azeem et al. (2005) also found that probiotics (Lacto sacc and Yea sac) led to a significant decrease in cholesterol and plasma total lipid. Baker’s yeast at 1 and 1.5% reduced triglycerides and cholesterol in the

without yeast addition, a significant reduction was noted in plasma total lipids. The decrease was 35.6% with 5% OC and 14.3% with 10% OC. Additionally, 5% OC diet significantly decreased plasma LDL by 4.3, when compared with the OC-free diet. On the other hand, a contrary trend was shown in triglycerides and cholesterol, as they were significantly increased with 5 and 10% OC diets when compared with the OC-free diet. Also, the 5% OC diet induced a significant decrease in plasma triglycerides compared to the 10% OC diet; however, this difference was not significant in plasma cholesterol. The HDL/LDL ratio and VLDL were significantly increased, similarly, with feeding 5 and 10% OC diets compared with the unsupplemented control. The decrease in plasma total lipids at 5% OC compared with the OC-free diet coincided with a significant decrease in plasma LDL and an increase in HDL/LDL at both concentrations of OC.

Studies on the effects of OC on biochemical blood components of broilers are rare, but they generally support the positive effects of OC on reducing total lipids and increasing the HDL/LDL ratio due to OC’s unsaturated and polyunsaturated fatty acids (El Hachemi et al. 2007; Dal Bosco et al. 2012). However, Al-Shanti (2003) and Abd El-Samee and Hashish (2011) declared that the inclusion of OC at 10% in broiler chickens’ feeds significantly reduced the concentrations of blood cholesterol and triglycerides. Further, Zangeneh and Torki (2011) reported that OC as an independent variable up to 9% in laying hens’ diets had no significant influence on serum glucose, cholesterol, triglycerides, HDL, LDL and thyroid hormones.

Observations
Conclusions

According to the findings in this study, it can be concluded that OC is a valuable ingredient and might be included in broiler diets at up to 10% without yeast supplementation. Furthermore, these findings support the idea of using agricultural by-products, which can lead to a reduction in the feeding cost and increase economic returns while decreasing environmental pollution. However, further studies are required to investigate the possibility of using higher ratios of OC or OC mixed with another by-product in poultry diets. These studies can be associated with suitable additives at different concentrations that might help to increase the utilisation of OC, or at least keep performance equal to the control.

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Disclosure statement

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