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NUTRITIONAL VALUE

of sunflower meal

The nutritional value of sunflower meal has an effect on performance, digestive enzyme activity, organ weight and histological alterations of the intestinal villi of broiler chickens.

Sunflower (*Helianthus annuus*) is an oilseed cultivated worldwide for oil extraction because of its great capability for adaptation to different climate and soil conditions. The by-product rendered by the oil industry, sunflower meal (SFM), is used as an alternative source of protein in animal and poultry nutrition. Its CP content, which ranges from 29 to 45%, depends on the dehulling and oil extraction process, in inverse relation to the fibre content (32 to 14% of the CF).

The use of SFM in broiler diets has been restricted to less than 150g/kg because of its high fibre, low energy, and lysine contents. Several authors have shown that supplementing limiting amino acids and oil to SFM-based diets can increase SFM inclusion levels up to 200 to 350g/kg without affecting broiler performance (Arija *et al.* and Suresh *et al.*).

No adverse effects

No adverse effects are reported from including up to 50 and 120g/kg, respectively, of sunflower seed hulls in broiler diets. Therefore, on the basis of data from the literature, it is possible to incorporate greater concentrations of SFM in broiler diets.



Because many studies have resulted in contradictory conclusions and, to our knowledge, no information is available on the use of SFM on digestive enzyme activities and histological alterations of the intestinal villi of broiler chickens, the current study was designed with the following objectives:

- To determine the ME content of SFM (cultivated in the north of Iran).
- To evaluate the effects of increasing levels of SFM on performance, blood parameters, carcass traits, digestive enzyme activities and histological alterations of the intestinal villi of broiler chickens.

Values for CP and EE were similar to those reported by Zatari and Sell, whereas CF content was higher, probably because of the processing conditions during the extraction procedure. Additionally, hull content, preconditioning, dehulling, cooking and solvent extractions determined the subsequent nutritive value of SFM.

An increasing inclusion rate of SFM decreased the AMEn of the diets. To further assess this trend, the dietary AMEn values were regressed against the inclusion level of SFM by using linear and quadratic models. The linear component was highly significant, whereas the quadratic component was not significant.

AMEn data

Therefore, the energy contribution of SFM to the diets was additive, and the inclusion rate did not alter the use of other dietary ingredients. By using the AMEn values determined for the basal diet and the basal diet containing a given amount of SFM, the AMEn (kcal/kg) of this feed was calculated by the difference.

The AMEn values obtained for diets in the experiment reported here were regressed on the level of SFM in the basal diet to estimate the AMEn content in SFM. The equation derived from fitting a linear model was as follows: $y = 2,957 - 1,735x$; $R^2 = 0,736$ ($P < 0,05$). An estimate

of the AMEn of SFM was obtained by extrapolation from the equation, where 1 000g/kg of SFM in the diet gave a value of 1,219kcal/kg.

The low value of AMEn of SFM in this study may be related to CF content. The cell walls of grains and oilseeds can serve as a physical barrier for digestive enzymes and nutrients contained within the cells, and can either entirely prevent or delay digestion of nutrients in the last part of the duodenum.

Not only the total fibre content, but also the physical and chemical structure of fibrous polysaccharides and their anatomical arrangement within each specific ingredient, can affect the accessibility of enzymes for the digestion of nutrients.

Protein and many other nutrients are "encapsulated" to variable degrees inside fibrous structures, and they remain less available for digestion by the proteases and other endogenous enzymes of the bird. These effects may decrease the AMEn value of seed meals. In our experiment, the CF of the diets increased with an increasing level of SFM. Thus, the AMEn value of the diets decreased. Mandal *et al.* determined values of 1,458, 1,458, and 1,481kcal/kg of AMEn in SFM for cockerels, guinea fowl and quail, respectively.

Growth performance

The FI increased quadratically ($P < 0,01$) with increasing levels of dietary SFM during the grower (22 to 42 days) and finisher (43 to 49 days) periods, as well as overall. In addition, FI tended to increase quadratically ($P = 0,0673$) at the starter phase with the treatments. The BWG responded quadratically ($P < 0,01$) with increasing levels of dietary SFM.

In the grower and finisher phases, FCR improved quadratically with increasing levels of SFM ($P < 0,01$). The improved performance of broilers fed lower levels of SFM compared with the performance of control birds was related to cellulose content of the diet. It has been shown that SFM has 220g/kg of cellulose.

These results are in accordance with the results of Rama Rao *et al.*, who showed that FI was significantly higher in broilers

fed 170 and 340g of SFM/kg of the diet compared with those fed the basal diet, and BWG was significantly higher for chickens fed 340g of SFM/kg of the diet. They also determined that the total replacement of soya bean meal with SFM resulted in similar FI, but a significant decrease in BWG.

The demand for energy and protein for gut maintenance is higher compared with other organs.

This is in agreement with the results of Ibrahim and Zubeir, who reported that a high-fibre (230,5g of CF) SFM could be included at up to 300g/kg of broiler diet with no adverse effects on growth rate or FE. This confirms the findings of Jacob *et al.*, who showed that replacing a portion (80g/kg) of imported soya bean meal in broiler diets with SFM had no significant effect on growth rate or FE.

Zatari and Sell reported that up to 100g/kg of SFM can be used in diets without adversely affecting growth or FCR up to seven weeks of age in broiler chickens. In addition, Elangovan *et al.* showed that BWG, FI, nutrient retention and carcass characteristics of quails did not vary significantly ($P > 0,05$) when SFM was increased in the diets.

Digestive enzyme activity

The activities of neither protease nor α -amylase in chick digesta were significantly affected. In the literature reviewed, no information was found on the determination of digestive enzyme activities of broilers fed SFM. In our experiment, only α -amylase actified by treatments.

Increasing dietary fibre content can increase the production of saliva, gastric juices, hydrochloric acid and pepsin. Graham and Aman noted a similar increase in pancreatic flow, accompanied by a closely related increase in electrolyte production.

Thus, activities of lipases and amylases may increase. The presence of chlorogenic acid (a group of phenolic compounds) in amounts of 10 to 40g/kg in the sunflower kernel could justify the negative effect on the growth of the birds.

In the literature reviewed, information was found on the determination of digestive enzyme activity of broilers fed SFM. In our experiment, the linear decrease ($P = 0,12$) in protease activity may have been caused by the presence of chlorogenic acid because this material has been shown to inhibit the activity of trypsin by 30%.

Organ weight

There were no effects ($P > 0,01$) of increasing levels of SFM on relative weights (g/kg of BW) of the breast and abdominal fat. Similarly, Reddy, Ramesh Kumar and Rama Rao *et al.* reported no effect of feeding SFM on the relative weights of breast and abdominal fat in broilers. Relative weights of the thigh and liver were quadratically ($P < 0,01$) increased and decreased, respectively ($P < 0,01$), as SFM levels increased in the diets.

Likewise, relative weights of the gastrointestinal tract and gizzard were linearly increased ($P < 0,01$) as dietary levels of SFM increased. The higher levels of fibre in the SFM-based diets might be responsible for hypertrophy of these organs, as was evident in previous studies in broilers on high-fibre diets.

Blood parameters

Cholesterol, calcium and protein concentrations did not demonstrate a linear or quadratic response to increasing levels of SFM. However, glucose and phosphorous concentrations linearly increased as the dietary SFM levels increased ($P < 0,05$). Triglyceride and HDL concentrations increased quadratically ($P < 0,01$) with an increasing level of SFM.

In addition, the LDL concentration decreased quadratically as the dietary levels of SFM increased ($P < 0,01$). However, there was no increase in alkaline phosphatase activity, either linear or quadratic, in response to increasing levels of SFM ($P > 0,05$).

Because a higher dietary fibre content is known to reduce dietary fat utilisation by deconjugation of bile salts, which might have reduced fat absorption through the gut, the body fat (liver fat) might have been utilised for the metabolic needs and thereby increased the HDL concentration in serum.

The reduced triglyceride concentration in the serum of broilers fed a higher level of SFM (210g/kg of diet) also supports this hypothesis. A similar trend was observed in the experiments of Rama Rao *et al.*, in which the serum concentrations of LDL and triglycerides decreased in birds receiving high-fibre diets.

Intestinal morphology

A quadratic response was observed for villus heights of the duodenum and jejunum with increasing levels of SFM ($P < 0,01$). Villus height of the ileum did not exhibit a linear or quadratic response. A quadratic response to increasing levels of dietary SFM was observed for crypt depth of the duodenum and jejunum ($P < 0,01$). However, no effect on crypt depth of the ileum, either linear or quadratic, was due to increasing levels of SFM.

A quadratic response to increasing levels of SFM was observed for villus width of the duodenum ($P < 0,01$). With increasing levels of SFM, villus width of the jejunum decreased linearly ($P < 0,05$). The villus height-to-crypt depth ratios of the duodenum and jejunum responded quadratically to increasing levels of SFM ($P < 0,01$).

However, this parameter was not significant for the ileum. In the literature reviewed, no evidence was found of the effect of SFM on the histology of broiler chickens. The structure of the intestinal mucosa can reveal some information on gut health. Stressors that are present in the digesta can lead to relatively rapid changes in the intestinal mucosa because of the close proximity of the intestinal contents to the mucosal surface.

One possible hypothesis about changes in intestinal morphology, such as shorter villi and deeper crypts, has been associated with the presence of toxins. Shortening of the villus decreases the surface area for nutrient absorption. The crypt can be regarded as a villus factory, and a large

crypt indicates fast tissue turnover and a high demand for new tissue.

The demand for energy and protein for gut maintenance is higher compared with other organs. A fast-growing broiler devotes about 12% of the newly synthesised protein to the digestive tract. Any additional tissue turnover will increase nutrient requirements for maintenance and will therefore lower the efficiency of the bird. A shortening of the villus and a large crypt can lead to poor nutrient absorption, increased secretion in the gastrointestinal tract, diarrhoea, reduced disease resistance and lower overall performance.

Renewal of the villus

In the present study, the villus heights of the duodenum and jejunum were quadratically affected as the dietary levels of SFM increased. These results are in accordance with the results for performance. There was an improvement in the performance of broiler chickens fed SFM up to 140g/kg of the diet.

It is possible to incorporate greater concentrations of SFM in broiler diets.

However, the performance parameters of birds fed a high level of SFM in the diet (210g/kg) decreased. The crypt is the area where stem cells divide to permit renewal of the villus – a large crypt indicates fast tissue turnover and a high demand for new tissue.

In previous studies, anti-nutritional factors in SBM, such as trypsin inhibitor (TI) and soya bean globulins, had an adverse effect on the morphology and function of the digestive tract in animals. It is known that TI interfered with the proper functioning of trypsin and chymotrypsin, leading to abnormal intestinal morphology. Zarkadas and Wiseman demonstrated a negative correlation between the TI level in soya bean meal and villus height in weaned piglets.

Additionally, many have suggested that the morphological changes observed

in young animals and poultry are due to transient hypersensitivity to antigenic components of soya bean diets. Antigenic materials in soya bean proteins are associated with villus atrophy, increased crypt cell mitosis and crypt hyperplasia, and thereby cause malabsorption syndrome. Therefore, in our experiment, histological alterations may result from some anti-nutritional factors, such as chlorogenic acid, in SFM.

In addition, changes in small intestinal mucosa may be caused indirectly by the viscous characteristics of non-starch polysaccharides. Malathi and Devegowda determined that SFM contains 110,01, 220,67, 40,92 and 410,34g/kg of pentosan, cellulose, pectin, and non-starch polysaccharides, respectively. Pectin is a non-starch polysaccharide that is not readily digested by the endogenous gut enzymes of broilers.

Sakata demonstrated that an increase in bacterial activity in the gastrointestinal tract was associated with a change in the morphology of the gut wall. They attributed this to the presence of the high level of pectin found in dates.

Conclusions and applications

- The AMEn of local SFM (cultivated in the north of Iran) obtained was 1,219kcal/kg.
- Increasing levels of SFM in the diet quadratically affected FI (in the grower and finisher phases), but BWG (in the starter and grower phases) and FCR (in the grower phase) were linearly affected.
- A quadratic response was observed in the relative weights of the thigh and liver with increasing levels of SFM.
- The triglyceride and HDL concentrations increased and the LDL concentration decreased as the dietary levels of SFM increased.
- Sunflower meal can be used in broiler chick diets at levels up to 140g/kg, and its fibre content had no significant effect on nutrient intake.

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