Substitution of plant protein for fish meal in the diet of laying ducks

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ABSTRACT

Fish meal is a good source of protein feed that can be used to get a high production yield even though it has a comparatively higher price. Plant protein has been found to substitute for fish meal without any adverse effect on production as well as helping to reduce feed cost. Moreover, it is not necessary for a level more than 5% fish meal in the diet of laying ducks. One type of plant protein is soybean meal, considered one of the most valuable sources of vegetable protein and whose amino acid composition is comparable to that of milk protein. In a soybean meal, the first limiting amino acid is methionine. Soybean meal can substitute for fish meal in laying ducks' diet but supplementation of methionine and lysine is recommended. Since sesame meal is rich in methionine and arginine, 50% of soybean meal can be replaced by sesame meal without adverse effects. Leucaena leaf meal is also a valuable source of protein (26%) and carotenoids but it also has a toxic amino acid (mimosine). However, soaking leucaena leaf meal in water can remove the toxic amino acid and can be used, together with added methionine and lysine, as 10% of the diet for laying ducks.

Key words: fish meal, laying duck, leucaena leaf meal, sesame meal, soybean meal.

INTRODUCTION

Ducks were first domesticated in Asia but are now distributed all over the world with large variations in their shape, size, feather color and markings due to the domestication process which has generally caused most domesticated ducks to lose their ability to fly. Another consequence of duck domestication is almost a complete elimination of brooding and nesting behavior in most egg laying strains. Since brooding results in the cessation of laying, artificial pressure for the selection of higher egg producers is certainly against this trait.

Runner and Khaki Campbell duck breeds are classified as egg laying breeds. Many of ducks belonging to these breeds can lay more than 300 eggs a year and are very keen in searching and devouring slugs and insects, which they forage all day long. Normally, ducks lay eggs early in the morning during 04.00 and 06.00 hours. The size of duck eggs is normally bigger than that of chickens with an average weight of 65–80 g whereas that of chickens is 45–60 g. The albumen and yolk ratio is somewhat different between the two species; at 52.6:35.4 in duck eggs and 55.8:31.9 in chicken eggs. The moisture content of the edible part is 70.4% in duck eggs and 73.7% in chicken eggs. This shows that duck eggs have more highly concentrate nutrients than chicken eggs. The nutrient contents on a dry matter basis of the edible part are 44.9 and 49.1% protein, 49.6 and 43.7% fat, 2.4 and 3.4% carbohydrate, 3.7 and 3.8% ash and 6.45 and 6.12 kcal GE/g in duck and chicken eggs, respectively (Singh 1981).

The main region of duck domestication is generally believed to be South-east Asia (Zeuner 1963). FAO (2001) reported that there were 887 million ducks in the world in 2000, among which 782 millions (88%) were domesticated in Asia. It was reported that China is the biggest duck producing country in the world.
with about 612 million ducks at present and followed by Europe, Africa, North and Central Americas and Oceania, producing about 65, 17, 16, 7 and 1 million ducks, respectively.

ENERGY AND PROTEIN REQUIREMENTS OF LAYING DUCK

Siregar and Farrell (1980) noted that the nutrient requirements of ducks are generally based on that of chickens but these two species are quite different in their growth rate, body structure, digestive physiology and basal heat production. Unlike chickens, the crop of ducks is not developed and the proventriculus is not fusiform but cylindrical in shape (Das et al. 1965). The size and peristalsis of intestines of duck and chicken are also different (Leeson et al. 1982). Pisharody and Nair (1975) reported that the mucous membrane enzymes in the duck’s digestive tract showed higher activity than those of chicken. In addition, the digestibility of crude protein (CP) and crude fat were higher but that of crude fiber was lower in ducks when compared with chickens (Mohamed et al. 1984). The digestibility and feed efficiency of chickens ceased when diets at 160% of their voluntary intake were force fed (Teeter & Smith 1985). Ducks have been observed to utilize diets at 200–250% of their voluntary intake because of enlarged crop and gizzard (Zhou & Isshiki 1994).

Reddy et al. (1980) reported the energy requirement of Khaki Campbell to be 2.80 Mcal of metabolizable energy (ME)/kg diet while Pan et al. (1981) indicated that a ME of 2.6–2.8 Mcal/kg diet did not show any significant effect on the egg production of Tsaiya laying ducks. The National Agricultural Council, Japan (1984) recommended a diet of 2.7 Mcal ME/kg with 16% protein.

The protein requirement of laying birds is the sum for their maintenance and egg formation (Bondi 1987). Gonzalez (1981) reported that the egg production efficiency of Khaki Campbell was dependent on the protein content in their diet. Pan et al. (1981) found that the egg production of Tsaiya layers given a 19% protein diet was significantly higher than those fed a 15% protein diet. Reddy et al. (1981) reported that the feed conversion of Khaki Campbell layers was better under a 19% protein diet than under a 17% protein diet. Tan et al. (1988) reported that the daily requirement of CP for Putain laying ducks was 16–18% while Thongwittaya and Tasaki (1992a) recommended that the CP level for egg production in crossbred laying ducks was 16.0%, and the ME/CP ratio should be 170/1.

As protein sources, fish meal and soybean meal are the most common ingredients while sesame meal and leucaena leaf meal are sources of vegetable protein. On the other hand, groundnut meal is not recommended for ducks due to its frequent infestation with aflatoxin, to which ducks are very sensitive.

UTILIZATION OF FISH MEAL

Fish meal is an excellent protein source for poultry feeding since it contains adequate quantities of all essential amino acids required, particularly lysine and methionine (Scott et al. 1982) and it is also a good source of unidentified factors (Bondi 1987). The International Fishmeal and Fish Oil Organisation (2006) reported that fish meal provides a concentrated source of high quality protein and a fat rich in long-chain omega-3 fatty acids, docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). The benefits of feeding fish meal to layers include higher productivity, better disease resistance, the reduced use of coccidiostat, and improved fertility and nutritional value of eggs for people due to the deposition of DHA and EPA. Wakeling et al. (1980) suggested that egg tainting was due to overloading of hens with dietary trimethylamine. North (1978) concluded that oil from fish carried a definite fishy taste and odor, which were noticeable in poultry eggs when hens’ diet contained more than 8–10% fish meal. Fish meal in the feed sometimes induced gizzard erosion or ulceration in chickens (Janssen 1971). Similarly, Ito et al. (1985) reported that fish meal containing gizzerosine at more than 20 mg/kg induced a severe gizzard erosion in chicks. The high cost of fish meal may also restrict its use (Rose & Michie 1984). Thongwittaya and Tasaki (1992b) concluded that it was not necessary to increase the fish meal level for laying ducks was not necessary to more than 5% (Table 1).

In Table 2, the chemical and essential amino acid compositions of fish meal are indicated together with those of soybean meal, sesame meal and leucaena leaf meal with and without soaking in water.

Utilization of soybean meal

Soybean meal is a major protein component in livestock feeds. Soybean meal has been estimated to make up more than 90% of the oilseed meals consumed in poultry feeds (Wilcox 1987). The nitrogenous
constituents of the seed include some inhibitory and toxic factors such as trypsin inhibitors which block the activity of a digestive enzyme, trypsin. As this factor is destroyed by heating, too high or too prolonged heat could destroy essential amino acids. Raw soybean also contains urease, an enzyme that releases ammonia from urea. Properly produced soybean meal is an excellent feed for all classes of animal with no restraints on its use. Soybean meal extracted with trichloroethylene is, however, toxic to some animals and should not be used for feeding (Gohl 1981). Methionine is the first limiting amino acid of soybean meal when fed to poultry, hence, synthetic methionine is often added to their diet (Wilcox 1987). Yuan (1989) suggested that soybean meal supplemented with synthetic amino acids can replace fish meal as a main protein source of the diet for duckling and broilers production (Okan & Ogun 1988). Leeson et al. (1988) reported that diets containing 30% soybean meal of laying hens had no effect on their performance but there was an indication of reduced egg production. Vodolazhchenko & Vedyakina (1988) reported that replacing 70% of feed of animal origin with soybean meal supplemented with 25–50 mg/t of vitamin B12 and 4 g/t of riboflavin increased egg production and egg hatchability and decreased the cost of feed. Thongwittaya (1996) concluded that laying ducks could produce eggs almost normally on a diet based on soybean meal (21.0% diet) with no added fish meal, but supplements of small amounts of methionine and lysine would be recommended for higher egg production (Table 3).

### Utilization of sesame meal

Sesame meal is frequently used as a principle protein source. The advantage of sesame meal as animal feed is its high methionine content while lysine seems to be its first limiting amino acid (Smith & Scott 1965). Lease (1972) reported that sesame meal contained phytic acid while Abrams (1966) demonstrated it contained a high oxalate content. Thus, the amount of zinc and calcium supplements in the diet should be increased, depending on the level of sesame meal. It should also be noted that sesame meal tends to

<table>
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<tr>
<th>Performance</th>
<th>Fish meal level (%)</th>
<th>SEM</th>
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<tr>
<td></td>
<td>5.0</td>
<td>6.5</td>
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<tr>
<td>Egg production (%)</td>
<td>37.6</td>
<td>39.7</td>
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<tr>
<td>Egg weight (g)</td>
<td>57.7</td>
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<td>Feed intake (g/day)</td>
<td>145</td>
<td>144</td>
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<td>Feed conversion ratio</td>
<td>7.0</td>
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<table>
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<tr>
<th>Composition</th>
<th>Fish meal†</th>
<th>Soybean meal†</th>
<th>Sesame meal†</th>
<th>Leacaena leaf meal‡</th>
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<tbody>
<tr>
<td>Dry matter</td>
<td>92.10</td>
<td>88.20</td>
<td>90.00</td>
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<td>Metabolizable energy (Mcal/kg)</td>
<td>2.82</td>
<td>2.23</td>
<td>2.21</td>
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<tr>
<td>Protein</td>
<td>60.05</td>
<td>44.00</td>
<td>41.00</td>
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<tr>
<td>Fat</td>
<td>9.40</td>
<td>0.800</td>
<td>6.50</td>
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<td>Fiber</td>
<td>0.70</td>
<td>7.00</td>
<td>7.00</td>
<td>15.33</td>
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<tr>
<td>Arginine</td>
<td>3.68</td>
<td>3.14</td>
<td>4.68</td>
<td>1.25</td>
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<tr>
<td>Cystine</td>
<td>0.57</td>
<td>0.66</td>
<td>0.78</td>
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<td>Glycine</td>
<td>4.46</td>
<td>1.90</td>
<td>2.04</td>
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<td>Histidine</td>
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<td>1.17</td>
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<td>1.96</td>
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<tr>
<td>Leucine</td>
<td>4.16</td>
<td>3.39</td>
<td>2.68</td>
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<tr>
<td>Lysine</td>
<td>4.51</td>
<td>2.69</td>
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<td>Methionine</td>
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<td>0.62</td>
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<td>Threonine</td>
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<td>Tryptophan</td>
<td>0.49</td>
<td>0.74</td>
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<tr>
<td>Tyrosine</td>
<td>1.80</td>
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<td>Valine</td>
<td>2.77</td>
<td>2.07</td>
<td>1.91</td>
<td>0.79</td>
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</table>

†NRC (1994), ‡Sriwatanavorachai (1989).
become rancid if stored incorrectly (Gohl 1981). In addition, Hassan (1974) reported that even only 5% sesame meal in the diet may decrease egg production. Cheva-Isarakul and Tangtaweewipat (1993) reported that imported sesame meal could substitute for 50% of soybean meal in the diet of laying hens without any adverse effects on egg production performance, while local sesame meal showed an adverse effect, even at a level of 15–20%. Thongwittaya (1996) reported that about 50% of soybean meal (10.50% diet) can be replaced with sesame meal to equalize the productive performance of a soybean meal diet (Table 4).

Utilization of leucaena leaf meal

Leucaena (Leucaena leucocephala) is a kind of leguminous tree that is commonly called ipil-ipil, koa haole, white popinac, lead tree, wild tamarind, cow tamarind or shack-shack. Its leaves and seeds contain mimosine, a toxic amino acid; however, the addition of iron salts may decrease its toxicity as well as soaking the leaves in water. In addition, the leaves should not be fed to breeding animals as they may affect reproduction. When included in poultry diets, production usually decreases and it takes longer for birds to reach sexual maturity although a small inclusion (5%) of dried ipil-ipil seems to increase the hatchability of eggs (Gohl 1981). Schulke et al. (1982) reported that even after leucaena leaf meal was soaked with water for 0, 6, 12, 18 and 24 h, it still contained mimosine at 2.06, 1.06, 0.73, 0.41 and 0.38%, respectively. Panja (1983) subjected fresh leucaena leaves to one of the following procedures; sun-drying for 11 h, steam-boiling or immersion in 0.2% ferrous sulfate solution for 1 h, and concluded that each procedure was significantly effective in reducing the mimosine content, particularly the immersion in ferrous sulfate, which was found to be most effective and with a reduction rate of up to 90%, while the other methods showed a 40–32% reduction rate. Sriwatanavorachai (1989) reported that soaking leucaena leaves in water decreased their mimosine content from 3.089 to 0.068%, while Chacon et al. (1988) suggested that leucaena leaf meal should not be used in poultry diets at higher levels than 5% because of its toxicity. Thongwittaya (1996) concluded that including 10% soaked and unsoaked leucaena leaf meal without fish meal showed an adverse effect on the performance of laying ducks. Supplements of methionine and lysine would be effective in order to improve the performance of laying ducks when 10% of leucaena leaf meal was used in the diet. However, the leaf meal must be soaked with water before formulation and the inclusion level of the leucaena leaf meal should not be higher than 10%.

REFERENCES


Gonzalez DA. 1981. Egg production by ducks (Khaki Campbell).


Wakeling DE, Fenwick GR, Pearson AW. 1980. Fish meal and egg taint. Veterinary Record 107, 431.


