ABSTRACT

In this experiment, 240 Cobb-500® broilers reared from 1 to 49 days, and distributed according to a completely experimental randomized design with four treatments of four replicates each in order to evaluate the effect of the dietary inclusion of 0, 33, 66 or 100 g/kg of squash seed meal (SSM) (Cucurbita moschata) on the performance, carcass yield, serum lipid profile and sensory meat quality of broilers. Significant differences (p<0.05) were detected in performance, carcass weight, weight and breast yield, and leg weight. The best results were obtained with 33 and 66 g/kg as compared to the control diet and 100 g SSM/kg. Abdominal fat decreased with the inclusion of 66 and 100 g SSM/kg, but the sensory quality of breast and thighs was not affected by the inclusion of SSM. The serum levels of total cholesterol, very low density (VLDL) and low density (LDL) lipoproteins, triglycerides, glucose and atherogenic index decreased with the inclusion of 100 g/kg of SSM, except for high density lipoproteins (HDL), which increased. The inclusion of 0, 33, 66 and 100 g/kg of SSM in broiler diets, partially replacing soybean meal and vegetable oil, improved live performance and edible portions yield. In addition, abdominal fat and serum levels of harmful lipids were reduced, whereas serum levels of beneficial lipids increased. There was no effect on meat sensory quality.

INTRODUCTION

Squash pulp is consumed in Cuba since pre-Colombian times; however, seed are not used as human food or animal feed, and consequently, thousands of tons of seeds, containing 940 g/kg dry matter and significant amounts of proteins, amino acids, unsaturated lipids, phytosterols, squalene, dietary fiber, and minerals, are wasted. Squash seeds produce 225 to 248 kg crude protein/hectare and 240 to 255 kg ether extract/hectare, which could potentially be used for poultry feeding (Martínez et al., 2008; Martínez, 2009). Squash seed meal is rich in proteins, but its inclusion in diets for monogastric animals have shown poor results (Bressani & Arroyave, 1963; Rossainz et al., 1976; Manjarrez et al., 1976; Bernal et al., 1977). However, literature search has not retrieved sufficient information on the use of full-fat squash seeds in poultry diets, particularly in broiler diets.

Hrdinka et al. (1996) and Ayerza et al. (2002), using oil seeds such as linseed and chia, observed better performance, reduced levels of harmful lipids and better meat quality in broilers. It should be mentioned that the chemical composition of feeds strongly influences blood levels of triacylglycerides, total cholesterol, phospholipids and low- and high-density lipoproteins (LDL and HDL, respectively) in poultry (Murata et al., 2003 e Martínez et al., 2010).
The aim of this study was to evaluate the effect of squash seed meal (SSM) (*Cucurbita moschata*) on broiler performance, sensory meat quality, and blood lipid profile.

**MATERIALS AND METHODS**

**Location**

The experiments were carried out at the Poultry Experimental Unit of the Center of Biological and Agricultural Sciences of the University of Guadalajara (Unidad Experimental Avícola del Centro Universitario de Ciencias Biológicas and Agronómicas (CUCBA) de la Universidad de Guadalajara), Mexico, N 20.67°, W 103.34°. An average relative humidity of 70 %, and average minimum and maximum temperatures of 16.9 °C and 27.9 °C, respectively, were recorded using a hygro-thermometer placed inside the experimental house.

**Squash seeds**

Six samples of whole squash seeds of different lots of the variety Tapatía, moschata species, stored for 12 months, were collected, ground, and mixed. Their chemical composition was analyzed by Martínez (2009).

**Birds and diets**

A total number of 240 one-day-old female Cobb-500® chicks were reared until 49 days of age. Birds were distributed, according to a completely randomized experimental design, into four treatments with four replicates each.

Treatments consisted of diets containing 0, 33, 66 or 100 g squash seed meal (SSM) /kg feed. The experimental diets (Tables 1-2) were formulated to contain equal protein and energy levels and to supply the requirements recommended in the Cobb-500® manual (2007). The inclusion of SSM was made at the expense of vegetable oil and soybean meal. A four-phase feeding program was used: starter 0-10 days, grower 11-22 days, development 23-42 days and finisher 43-49 days.

**Experimental conditions**

Each replicate consisted of a pen with deep corn stover litter and 12 birds/m². Feed and water were offered *ad libitum*, in tube feeders and nipple drinker, respectively. Brooding lamps were used up to 10 days, after which a lighting program of 23 hours of light was applied. Birds were vaccinated in the hatchery against fowl pox, infectious bronchitis, Newcastle disease and infectious bursal disease. No medication was added to the feed, nor were therapeutic drugs used during the experimental period.

**Performance parameters**

All birds were weighed in the beginning and end of the experiment (49 days). Feed intake (g/bird/day) was measured daily during the experimental period and calculated as the difference between the amount of feed offered and of feed residue. Feed conversion ratio was calculated as the amount of feed intake to gain one kg body weight. Viability was determined as the difference between the initial number of birds and recorded mortality.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Squash seed meal levels (g/kg)</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>33</td>
<td>66</td>
</tr>
<tr>
<td>Ground corn</td>
<td>575.40</td>
<td>564.60</td>
<td>567.40</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>347.00</td>
<td>328.90</td>
<td>300.00</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>30.00</td>
<td>26.00</td>
<td>19.50</td>
</tr>
<tr>
<td>SSM</td>
<td>0.00</td>
<td>33.00</td>
<td>66.00</td>
</tr>
<tr>
<td>Salt</td>
<td>2.50</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>L-lysine</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>DL-methionine</td>
<td>2.00</td>
<td>2.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>19.80</td>
<td>19.80</td>
<td>19.80</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>11.50</td>
<td>11.40</td>
<td>11.00</td>
</tr>
<tr>
<td>Choline</td>
<td>0.40</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Premix³</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

1 - Each kg contains: vitamin A, 13,500 IU; vitamin D3, 3,375 IU; vitamin E, 34 mg; B2, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; Cu, 2,000 mg; folic acid, 1.13 mg; vitamin B12, 34 µg; Mn, 72 mg; Zn, 48 mg.

2 - Each kg contains: vitamin A, 13,500 IU; vitamin D3, 3,375 IU; vitamin E, 34 mg; B2, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; Cu, 2,000 mg; folic acid, 1.13 mg; vitamin B12, 34 µg; Mn, 72 mg; Zn, 48 mg.

3 - Each kg contains: vitamin A, 13,500 IU; vitamin D3, 3,375 IU; vitamin E, 34 mg; B2, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; Cu, 2,000 mg; folic acid, 1.13 mg; vitamin B12, 34 µg; Mn, 72 mg; Zn, 48 mg.
Table 2 - Ingredients and nutritional composition of the development (23-42 days) and finisher (43-49 days) diets on as-fed basis.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Phase 3</th>
<th>Phase 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Squash seed meal levels (g/kg)</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Ground corn</td>
<td>619.30</td>
<td>615.30</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>286.00</td>
<td>263.00</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>50.00</td>
<td>44.50</td>
</tr>
<tr>
<td>SSM</td>
<td>0.00</td>
<td>33.00</td>
</tr>
<tr>
<td>Salt</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>L-lysine</td>
<td>1.20</td>
<td>1.20</td>
</tr>
<tr>
<td>DL-methionine</td>
<td>2.40</td>
<td>2.30</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>17.00</td>
<td>17.00</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>11.20</td>
<td>10.80</td>
</tr>
<tr>
<td>Choline</td>
<td>0.40</td>
<td>0.40</td>
</tr>
<tr>
<td>Premix1</td>
<td>10.00</td>
<td>10.00</td>
</tr>
</tbody>
</table>

Nutritional levels (g/kg)

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>0</th>
<th>33</th>
<th>66</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolizable energy (MJ/kg)</td>
<td>13.29</td>
<td>13.29</td>
<td>13.29</td>
<td>13.29</td>
</tr>
<tr>
<td>Crude protein</td>
<td>180.00</td>
<td>180.00</td>
<td>180.00</td>
<td>180.00</td>
</tr>
<tr>
<td>Calcium</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
<td>9.00</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>4.50</td>
<td>4.50</td>
<td>4.50</td>
<td>4.50</td>
</tr>
<tr>
<td>Methionine+cystine</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
<td>8.20</td>
</tr>
<tr>
<td>Lysine</td>
<td>10.50</td>
<td>10.50</td>
<td>10.50</td>
<td>10.50</td>
</tr>
<tr>
<td>Ether extract</td>
<td>24.00</td>
<td>35.00</td>
<td>46.00</td>
<td>58.00</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>34.00</td>
<td>34.00</td>
<td>41.00</td>
<td>45.00</td>
</tr>
</tbody>
</table>

1 - Each kg contains: vitamin A, 13,500 IU; vitamin D3, 3,375 IU; vitamin E, 34 mg; B6, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; Cu, 2,000 mg; folic acid, 1.13 mg; vitamin B12, 34 µg; Mn, 72 mg; Zn, 48 mg.

Analysis of blood lipids

When broilers were slaughtered on day 49, 10 ml of blood were collected from the jugular vein of 10 birds per treatment. Blood samples were kept for one hour in 20-ml tubes, and were then centrifuged (Eppendorf centrifuge) at 10,000 rpm and 20 °C for 25 min. Sera were stored at -20 °C until analyses in the laboratory.

Triglyceride, total lipid, total cholesterol, high-density lipoprotein (HDL), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL) and glucose serum levels were determined by enzymatic colorimetric methods, using kits and an ultraviolet spectrophotometer (Humalyzer 2000). The atherogenic index was calculated according to the ratio reported by Salma et al. (2007): IA=LDL/HDL. All analyses were conducted in quintuplicate.

Data were submitted to one-way analysis of variance (Anova) according to a completely randomized experimental design. The test of Duncan (1955) was used to compare means, using the SPSS version 17.0 statistical package.

RESULTS AND DISCUSSION

Table 3 shows that viability was not influenced by the inclusion of SSM in the feed. Live weight, cumulative feed intake and cumulative feed conversion ratio were significantly different (p<0.05), with birds fed 33 and 66 g SSM/kg presenting better results as compared to those fed the control and 100 g SSM/kg diets.

Viability results (Table 3) show the lack of detrimental effects of the squash seed used in the present experiment in birds. Bressani and Arroyave (1963) & Rossainz et al. (1976) included 200 g/kg squash seed meal in broiler diets and observed 90 % morbidity due to thiamine deficiency. This may be related to the excessive temperature (200 °C) used for the mechanic extraction of fat from squash seeds (Murkovic et al., 2004), considering that thiamine is the water-soluble

Edible cuts and total viscera weight and yield and sensory quality of breast and leg meat

Ten birds per treatment were sacrificed by bleeding of the jugular vein after four hours of feed fasting (water was offered ad libitum).

Carcass and viscera weights were determined by weighing the birds before slaughter, after which carcass, total viscera, liver, breast, leg, and abdominal fat pad were weighed. Leg and breast samples were kept frozen at -20 °C.

Breast and leg sensory quality was determined by a panel of 15 tasters selected from Centro Universitario de Ciencias Biológicas y Agronómicas, Universidad de Guadalajara, Mexico. Meat samples were thawed, and cooked in water with no salt for 30 minutes at 80 °C (Ruiz et al., 2001). Panel members were selected according to the following criteria: healthy, non-smokers, did not have the habit of consuming coffee and/or alcoholic beverages, mean and women between 25 and 55 years.

The sensory quality parameters surveyed were: aroma (normal or abnormal), flavor (normal or abnormal), tenderness (normal, tough, very tough, very soft), color (normal, pale or intense).
vitamin that is most destroyed by processing (up to 50%) (McCourt et al., 2006). In the present experiments, no signs of thiamine deficiency were detected, as also found by Martínez et al. (2010), who used similar inclusion levels in layer diets.

The performance results obtained with the diet containing 100 g SSM/kg were as to those produced with the control diet, but were inferior as compared to the 33 and 66 g SSM/kg inclusion levels, which may have been due to the supply of 44 to 48 g/kg CF in that diet (Tables 1 and 2). Ayerza et al. (2002) reported that, when using linseed and dietary crude fiber levels higher than 50 g/kg, broiler performance was poor. It must be mentioned that chia seeds contain higher CF levels than SSM, Tapatía variety (221.0 g/kg and 162.4 g/kg, respectively) (Martínez, 2009).

According to Savón et al. (2007), there is a high correlation (R²=0.75) between dietary neutral detergent fiber (NDF) content and the volume they occupy in the gastrointestinal tract, which may trigger satiety signs in poultry, reducing their voluntary feed intake. In addition, Smith & Sales, (1996) stress that the efficiency of fiber utilization in broilers is related to intestinal transit time (12 to 24 horas), which is higher than in other poultry species. Squash seeds (Tapatía var.) contain 362.00 g NDF/kg (Martínez, 2009), and this may explain the poorer performance of broilers fed 10 % SSM relative to those fed 33 and 66 g SSM/kg diet.

The better performance obtained with the inclusion of 33 and 66 g SSM/kg feed as compared to control diet may be due to the flavor enhancement promoted by unsaturated fats. Rosebrough et al. (1999) and Crespo & Esteve-García (2002) showed that, when unsaturated fat levels were increased in broiler diets, feed intake and final body weight was higher than that obtained with the control treatment. Mateos & Sell (1980) and Latshaw (2008) demonstrated a linear increase in broiler daily gain with increasing dietary fat inclusion levels. Mateos et al. (1995) mentioned that fats improve diet palatability as they reduce dust formation and hide undesirable flavors. The results of the present study showed that SSM acts as a natural growth promoter in broilers when added up to 66 g/kg of feed.

The broilers fed 33 and 66 g SSM/kg of feed presented higher ME, CP, lysine, methionine+cystine, Ca and P intakes (Table 4) relative to the control group and those fed 100 g SSM/kg. The diets containing 66 and 100 g SSM/kg promoted higher ether extract and crude fiber intakes.

Crude fiber intake increased in the broilers fed 66 and 100 g SSM/kg due to the higher supply of this component in these diets (Tables 1 and 2). In this sense, Savón et al. (2007) demonstrated higher CF intake when fiber-rich feedstuffs were added to poultry feeds; however, high CF levels reduce energy intake, and consequently impair performance. The CF content of the diets containing 100 g SSM/kg reduced broiler compensatory growth.

Higher ether extract intake, particularly of unsaturated fats, promotes better broiler performance, as shown by the broilers fed 33 and 66 g SSM/kg in the present experiment. López-Ferrer et al. (2001a) reported higher weight gain and final body weight in broilers consuming diets with high ether extract levels.

The lysine intake of the broilers fed SSM in the present study was similar as to that reported by Ayerza et al. (2002) when including 10% chia seed in broiler diets. Martín et al. (2002) observed higher lysine and methionine+cystine intake in the pre-starter phase when increasing CP (25 %), lysine (1.46 %) and methionine+cystine (1.08 %) levels of broiler diets. However, Corzo et al. (2002) did not determine significant differences (p<0.05) in lysine intake when dietary lysine levels was increased from 0.75 to 1.15 % in broiler diets.

### Table 3 - Live performance of Cobb-500 broilers fed different SSM levels

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Squash seed meal level (g/kg)</th>
<th>SE± Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live weight (g)</td>
<td>95.00</td>
<td>95.00</td>
</tr>
<tr>
<td>Cumulative feed intake (g/bird)</td>
<td>4837.00</td>
<td>4971.00</td>
</tr>
<tr>
<td>Cumulative feed gain</td>
<td>2.13a</td>
<td>2.10b</td>
</tr>
<tr>
<td>Live weight (g)</td>
<td>2268.00b</td>
<td>2366.00a</td>
</tr>
</tbody>
</table>

* Means followed by different letters in each row as significantly different at p<0.05 (Duncan, 1955). **p<0.01. ***p<0.001.

### Table 4 - Average ME and nutrient intake of Cobb-500 broilers fed different SSM levels (1-49 days)

<table>
<thead>
<tr>
<th>Average intake</th>
<th>Squash seed meal levels (g/kg)</th>
<th>SE± Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME (MJ/bird/day)</td>
<td>1.30b</td>
<td>1.34a</td>
</tr>
<tr>
<td>CP (g/bird/day)</td>
<td>17.86b</td>
<td>18.36a</td>
</tr>
<tr>
<td>Lysine (g/bird/day)</td>
<td>1.04b</td>
<td>1.07a</td>
</tr>
<tr>
<td>Methionine+cystine (g/bird/day)</td>
<td>0.81b</td>
<td>0.83a</td>
</tr>
<tr>
<td>Calcium (g/bird/day)</td>
<td>0.90b</td>
<td>0.93a</td>
</tr>
<tr>
<td>Available phosphorus (g/bird/day)</td>
<td>0.45b</td>
<td>0.46a</td>
</tr>
<tr>
<td>Ether extract (g/bird/day)</td>
<td>3.45d</td>
<td>3.85c</td>
</tr>
<tr>
<td>Crude fiber (g/bird/day)</td>
<td>3.36d</td>
<td>3.85c</td>
</tr>
</tbody>
</table>

* Means followed by different letters in each row as significantly different at p<0.05 (Duncan, 1955). **p<0.01. ***p<0.001.
Table 5 - Weight and yield of edible parts and total viscera of Cobb-500 broilers fed different SSM levels (1-49 days).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Squash seed meal levels (g/kg)</th>
<th>SE± Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Final live weight (g)</td>
<td>2277.00b</td>
<td>2376.00a</td>
</tr>
<tr>
<td>Carcass weight (g)</td>
<td>1634.00b</td>
<td>1722.00a</td>
</tr>
<tr>
<td>Carcass yield (%)</td>
<td>71.77</td>
<td>72.38</td>
</tr>
<tr>
<td>Breast weight (g)</td>
<td>388.00b</td>
<td>422.00a</td>
</tr>
<tr>
<td>Breast yield (%)</td>
<td>23.73b</td>
<td>24.56a</td>
</tr>
<tr>
<td>Leg weight (g)</td>
<td>511.00b</td>
<td>544.00a</td>
</tr>
<tr>
<td>Leg yield (%)</td>
<td>31.77</td>
<td>31.76</td>
</tr>
<tr>
<td>Abdominal fat weight (g)</td>
<td>35.20</td>
<td>35.60a</td>
</tr>
<tr>
<td>Abdominal fat yield (%)</td>
<td>2.15a</td>
<td>2.06a</td>
</tr>
<tr>
<td>Total viscera weight (g)</td>
<td>188.00</td>
<td>189.00</td>
</tr>
<tr>
<td>Total viscera yield (%)</td>
<td>8.27a</td>
<td>7.96b</td>
</tr>
<tr>
<td>Liver weight (g)</td>
<td>52.00</td>
<td>52.00</td>
</tr>
<tr>
<td>Liver yield (%)</td>
<td>2.28</td>
<td>1.85</td>
</tr>
</tbody>
</table>

a,b Means followed by different letters in each row as significantly different at p<0.05 (Duncan, 1955) ***p<0.001. Carcass is considered here with no viscera, head, or feet. Breast, leg, and abdominal fat yields are expressed as carcass percentage. Total viscera and liver yield are expressed as final weight percentage.

Carcass and leg yields, total viscera weight, and liver weight and yield were not influenced (p<0.05) by the treatments (Table 5). Final body weight, carcass weight, breast weight and yield, leg weight, and total viscera yield were significantly higher (p<0.05) in birds fed 33 and 66 g SSM/kg as compared to those fed the control diet and that containing 100 g SSM/kg, whereas abdominal fat weight and yield were reduced in the treatments with 66 and 100 g SSM/kg inclusion relative to the control and the 33 g SSM/kg treatments.

The increase in breast weight of the broilers fed with 33 and 66 g SSM/kg may be explained by their higher lysine intake. Berri et al. (2008) observed similar increase in breast weight when dietary lysine level (0.3 %) and lysine intake were increased.

Vieira et al. (2004) detected an increase in breast yield and reduction of abdominal fat yield when the methionine+cystine to lysine ratio was reduced in 0.77% in the diet of finisher Cobb-500® broilers, similarly to the findings of the present study.

It is also possible that the SSM content of unsaturated fats in the feed indirectly resulted in higher lysine intake, and consequently, higher breast yield. López-Ferrer et al. (2001a) and López-Ferrer et al. (2001b), using linseed oil and fish oil rich in polyunsaturated fatty acids, obtained breast and leg yield responses similar to the findings of the present study.

Despite the higher supply of ether extract in the diets containing 66 and 100 g SSM/kg, the abdominal fat yields were lower as compared to the other treatments (Tables 1 and 2). According to Crespo & Estevez-Garcia (2003), abdominal fat increase is directly proportional to the reduction in the serum levels of very low-density lipoproteins (VLDL). The diets with 66 and 100 g SSM/kg reduced serum VLDL relative to the control diet (Table 7).

Liver weight and yield (Table 5) were not affected by the inclusion of SSM as a feedstuff with hypcholesterolemic effects. In this sense, Razani et al. (2001) mention that blood cholesterol reduction stimulates the liver to compensate it by increasing the synthesis of cholesterol 7-hydroxylase, which, if excessive, may cause liver hypertrophy. This results shows that SSM is may efficiently stabilize serum lipids (Table 7), with no gross changes in the liver of Cobb-500® broilers.

Panel members did not detect any differences in the sensory quality of the breast and thighs (Table 6) of broilers fed or not SSM.

These results are consistent with the reports of Ayerza et al. (2002) when including 100 g/kg chia seeds in broiler diets. On the other hand, Taga et al. (1984) and Shukla et al. (1996), when feeding linseed and fish oil to broilers, detected unpleasant flavor.

Table 6 - Sensory quality of breasts and muscles of Cobb-500® broilers fed different SSM levels (1-49 days).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Squash seed meal levels (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Aroma</td>
<td>Breast Thighs</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
</tr>
<tr>
<td>Abnormal</td>
<td>0</td>
</tr>
<tr>
<td>Flavor</td>
<td>Breast Thighs</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
</tr>
<tr>
<td>Abnormal</td>
<td>0</td>
</tr>
<tr>
<td>Tenderness</td>
<td>Breast Thighs</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
</tr>
<tr>
<td>Abnormal</td>
<td>0</td>
</tr>
<tr>
<td>Color</td>
<td>Breast Thighs</td>
</tr>
<tr>
<td>Normal</td>
<td>15</td>
</tr>
<tr>
<td>Pale</td>
<td>0</td>
</tr>
<tr>
<td>Intense</td>
<td>0</td>
</tr>
</tbody>
</table>

The values represent the opinion of the different panelists (15) that participated in the sensory evaluation.
in the meat of these birds. Squash seeds present high concentrations of polyunsaturated fatty acids (Martínez, 2009), particularly of linoleic acid. According to Shukla & Perkins (1998), linoleic and α-linolenic acids are the most resistant to oxidation among the polyunsaturated fatty acids, but are more susceptible as compared to saturated and monounsaturated fatty acids. The high susceptibility of linseed and fish oil as compared to saturated and monounsaturated fatty acids, but are more susceptible acids are the most resistant to oxidation among the Shukla & Perkins (1998), linoleic and □ (Martínez, 2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According toMartínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According to Martínez (2009), particularly of linoleic acid. According toTable 7 shows that detrimental lipid levels in the serum were reduced when SSM was included in the feed. Triglycerides and total cholesterol levels were significantly lower (p<0.05) with the inclusion of 100 g SSM/kg relative to the control diet. VLDL, LDL, glucose and atherogenic index were lower in broilers fed the control diet as compared to the diets with 66 and 100 g SSM/kg inclusion, while HDL levels were higher with the 100 SSM g/kg diet relative to the control.

The high contents of octadecaenoic, linoleic, and oleic fatty acids and of phytosterols, squalene, and the low levels of α-linoleic acid in the SSM, tapatía variety (Martínez, 2009), reduced the levels of detrimental lipids in the evaluated broilers. Triacylglycerides were reduced in 7.43 mg/dL in the birds fed 100 g SSM/kg relative to those offered the control diet. Viveros et al. (2009) mentioned that oleic fatty acid a reduction of triacylglycerides post-feeding, with an increase of the activity of the enzyme lipoprotein lipase (LPL) in the muscle. SSM may have reduced triacylglyceride levels due to its high oleic acid content (8616 mg/100 g), which is much higher than in conventional oil seeds (Martínez, 2009). In addition, the linoleic level determined in squash seeds (15027 mg/100 g) suppresses the synthesis of fatty acids and triacylglycerides in the liver, thereby limiting the synthesis of VLDL (McNamara, 1995). When 100 g SSM/kg were included in the feed, a VLDL was reduced in 2.28 mg/dL relative to the basal diet. This effect was also observed by Crespo & Esteve-García et al. (2003), who compared the dietary inclusion of linseed, olive and sunflower oils and tallow, and detected a reduction in VLDL levels of 5, 3 and 2 mg/dL, respectively, relative to the control, while tallow increased VLDL levels in 15 mg/dL.

SSM linoleic acid content (15027 mg/100 g) reduced LDL levels in 24.72 mg/dL, possibly by increasing liver expression of LDL receptors and, consequently, their take-up by the liver (Mustad et al., 1996). Palou et al. (2005) and Martínez et al. (2010) also mention that the liver takes up cholesterol for the synthesis of bile salts, also reducing LDL blood levels, resulting in a favorable change in the serum LDL to HDL ratio.

The squash seed, tapatía variety, contains 293 mg phytosterols/100 g (Martínez, 2009), which is higher compared with soybean and olive oil and with ground corn and soybean meal. De Jong et al. (2003) mentioned that plant sterols stimulate the excretion of bile acids, promoting lipid digestion. Armstrong & Carey (1987) also suggest that part of cholesterol is precipitated in the intestines, and therefore, it is not absorbed or less absorbed in the presence of plant sterols. This results demonstrates the efficacy of the SSM phytosterols in the reduction of total cholesterol in the blood of broilers and layers, according to Martínez et al. (2010).

The 6.74 mg/dL increase in HDL in the serum of broilers may be associated with the increase in essential and omega-9 fatty acids, together with a decrease of low-density lipoproteins (Navab, 2001). This was also observed in layers (Martínez, 2009). According to Von Eckardstein et al. (2001), the enzyme lecithin-cholesterol acyltransferase catalyzes the formation of cholesterol esters in HDL from free cholesterol and lecithin, and the liver uptakes the esterified cholesterol by the action of an antioxidant receptor, showing the efficacy of HDL in the reduction of blood cholesterol.

The atherogenic index decreased with SSM inclusion in the diet, as previously reported by Martínez et al. (2010) in layers fed up to 100 g SSM/kg, which is associated to a reduction in detrimental lipid levels and increase in beneficial lipids. It must be mentioned that layers and broilers present different lipid profiles. Salma et al. (2007) reported lower values for layers, as opposed to Murwani & Bayuardhi (2007), who did not find significant differences (p<0.05) between these birds. However, Martínez et al. (2010) observed higher values in

### Table 7 - Serum lipid profile and glucose levels of Cobb-500 broilers fed different SSM levels (1-49 days).

<table>
<thead>
<tr>
<th>Parameters (mg/dL)</th>
<th>Squash seed meal levels (g/kg)</th>
<th>SE±</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>VLDL 10.25a 9.06ab 8.30bc 7.42c 0.47*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triglycerides 47.30a 43.02ab 41.96ab 39.87b 1.794*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total cholesterol 132.58a 126.38a 120.30ab 109.42b 4.65***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDL 98.04a 90.44ab 87.34b 73.32c 3.28***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL 45.70a 47.14b 50.60ab 52.44a 1.64***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atherogenic index 2.17a 1.92ab 1.72b 1.40c 0.096***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glucose 183a 182a 163b 158b 5.46***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Means followed by different letters in each row as significantly different at p<0.05 (Duncan, 1955) **p<0.05, *** p<0.001.
layers, as well as Peebles et al. (1997), who mentioned that higher lipid blood levels are required during egg production for fat deposition in the yolk and energy maintenance requirements, which are related to blood estrogen levels.

Serum glucose levels decreased in 20 and 25 mg/dL with the inclusion of 66 and 100 g SSM/kg diet. Pál et al. (2002) observed the same effect in layers when comparing squash seeds (rich in omega 6) with fish oil (rich omega 3), demonstrating that diets with omega 6 reduce blood glucose in poultry. In addition, the unsaturated fats supplied with the inclusion of SSM reduced digesta passage rate, resulting in slow intestinal release and maintenance of dietary glucose, with consequent lower blood insulin levels (Bird et al., 1994), thereby suggesting a direct effect of glucose and added fats.

**CONCLUSIONS**

The inclusion of 0, 33, 66 and 100 g SSM/kg in broilers diets in partial replacement of soybean meal and vegetable oil improved the performance and increased edible carcass parts, while abdominal fat in the carcass was reduced. Blood levels of detrimental blood lipids were reduced and of beneficial levels were increased. Meat sensory quality was not affected.

**REFERENCES**


Marjarréz B, Enrique F, Ávila E, Shimada S. Sustitución de la pasta de soya por pasta de semilla de calabaza en razas para abasto. Resúmenes de la 13ª Reunión Anual del Instituto Nacional de Investigaciones Pecuarias; 1976 mayo 4-7, México, DF.


Martínez Y. Caracterización química de la Harina de Semilla de Calabaza y su empleo de la alimentación de gallinas ponedoras y pollos de ceba [Tesis]. La Habana (CU): Instituto de Ciencia Animal; 2009.


Effect of Squash Seed Meal (Cucurbita Moschata) on Broiler Performance, Sensory Meat Quality, and Blood Lipid Profile

Aguilar YM, Yero OM, Navarro MIV, Hurtado CAB, López JAC, Mejía LBG


