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**INTERNATIONAL JOURNAL OF  
 ADVANCED RESEARCH (IJAR)**

Article DOI: 10.21474/IJAR01/5540  
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/5540>



### RESEARCH ARTICLE

#### EFFECT OF DIETARY SUPPLEMENTATION OF THOS (AQUEOUS EXTRACT OF *THONNINGIA SAGUINEA*) ON CARCASS CHARACTERISTICS AND ON SOME PHYSICOCHEMICAL PARAMETERS IN PECTORAL AND THIGH MUSCLES OF ISA BROWN LAYING HENS.

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#### Manuscript Info

##### Manuscript History

Received: 04 August 2017  
 Final Accepted: 06 September 2017  
 Published: October 2017

##### Key words:-

Laying Hen; Thos; Pectoral Muscle;  
 Carcass Characteristics;  
 Physicochemical Parameters.

#### Abstract

Recently, the poultry industry began to face multi-resistant germs against antibiotics. Therefore, the search of new plant molecules to solve the issue of multi-resistant germs in poultry as an alternative to antibiotics is an imperative. THOS, the aqueous extract of the inflorescence of *Thonningia sanguinea* revealed efficient antimicrobial, anti-coccidiosis, anti-salmonellosis and antioxidant activity in laying hens. The present study was conducted to assess the effect of THOS on carcass characteristics and on some physicochemical parameters of laying hens pectoral and thigh muscles. For this purpose, 220 Isa Brown one day aged hens were breed in standard condition till 18 weeks old ( $1113 \pm 90$ g lively mass). Then hens were randomly divided into two (02) groups of 110 hens each. Hens of group II (treated group) received THOS at a rate of 10g/L of water for a week (07 days) while hens of group I (control group) received only water without any additives. At 72 weeks old, six hens were euthanized in each group. Carcass characteristics, post mortem pH, pectoral and thigh meat color, drip loss, cooking loss, moisture, ashes and total mineral rate were evaluated. THOS didn't affect the major carcass characteristics but significantly increased gizzard weight ( $32 \pm 1.14$  vs  $25 \pm 1.6$ g;  $p < 0.01$ ) and reduced abdominal fat weight ( $42 \pm 14$  vs  $65 \pm 15$  g) as compare to control group. pH<sub>pm</sub>; drip loss; cooking loss; moisture and ash were not significantly affected by THOS. In the other hand, THOS significantly reduced the redness (a\*) of *pectoralis major* and minor muscles when compared to control group ( $4.6 \pm 0.08$  vs  $5.2 \pm 0.11$ ;  $p < 0.05$ ). The rate of total mineral of thigh muscle was also significantly enhanced by THOS ( $4.62 \pm 0.12$  vs  $4.16 \pm 0.07$  g/100g;  $p < 0.05$ ). These results reveal that the use of THOS against multi-resistant germs in poultry could also help enhanced poultry meat quality.

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## Introduction:-

Poultry meat has become the second most consumed meat behind pig meat in recent years, with an annual output of 70 million tonnes of which 85% is chicken meat (Huart *et al.*, 2004). Although African population represents 13% of the world population, it produces only 4% of the world annual output. According to Huart *et al.* (2004), this situation is due to the lack of adequate infrastructures, food resources and the lack of commercial organizations capable of regularly supplying markets at competitive prices.

In sub-Saharan Africa, Senegal and Côte d'Ivoire stand out. Indeed, for many years, Ivorian government has set up management structures that have boosted livestock evolution in general and poultry farming in particular. Poultry meat production increased from 9.669 tonnes to 44.451 tonnes from 2001 to 2015, an increase of about 360%. This resulted in a 73% reduction in poultry meat imports from 2.212 tonnes in 2001 to 593 tonnes in 2015 (Anonyme 1, 2016). Nevertheless, the evolution of Ivorian poultry farming, like its sub-region counterparts, is threatened by the appearance of multi-resistant strains due to abusive use of antibiotics used to treat coccidiosis, salmonellosis and avian viruses (Li *et al.*, 2005). Henceforth, research was redirected to plant and spice extracts and essential oils as food additives. These natural substances have proved to be an alternative to solve multi-resistance problem (Christaki *et al.*, 2004).

The aqueous extract of *Thonningia sanguinea* named as THOS, a parasitic plant, is part of these substances. Indeed, THOS has proved effective activity against salmonellosis (M'baïasbé *et al.*, 2002; Ouattara *et al.*, 2005; Ouattara *et al.*, 2007) and avian coccidiosis (Kouakou *et al.*, 2010; Konan *et al.*, 2012). Moreover, the presence of many polyphenols in THOS gives it high antioxidant properties, which allows it to eliminate free radicals accumulating in chicken organisms during their growth (N'guessan *et al.*, 2007). Apart from its antimicrobial properties, THOS improves zootechnical parameters such as laying rate, egg weight and egg shell thickness in laying hens (M'baïasbé *et al.*, 2002; Ouattara *et al.*, 2005; Ouattara *et al.*, 2007). In the regard of these properties, the use of THOS as poultry food additive, would be an alternative for improving productivity of poultry farms. However, it is important to not lose sight of poultry and consumers safety even though the recent study of Yao *et al.*, (2016) who revealed that THOS is well tolerated by hens' organism.

Therefore, the present study was conducted to evaluate the effect of aqueous extract of *Thonningia sanguinea* (THOS) on carcass characteristics and on some physicochemical parameters in pectoral and thigh meat of Isa Brown laying hens.

## Materials and Methods:-

### Materials:-

#### Vegetal material:-

The plant material is composed of *Thonningia sanguinea* (balanophoraceae) inflorescences obtained from Yamoussoukro's region (central Côte d'Ivoire). *Thonningia sanguinea* is a perennial herb plant like. It is also a nonspecific and exclusive parasite of various plants roots. The thickened tubers and rhizomes are commonly sold in local markets for medicinal purposes. *Thonningia sanguinea* present throughout the humid forest zone of Africa. In Côte d'Ivoire, it is found from the coast to Bamoro forest. This plant is available at vendors of medicinal plants at all times but it is abundant in rainy season.

### Animals and experimental procedures:-

This experiment was carried out at the animal laboratory of Veterinary Center of Bingerville. All procedures and animal care were conducted according to the Veterinary Center guidelines and the European Commission recommendations of 18 June 2007 on guidelines for the accommodation and care of animals used for experimental and other scientific purposes.

Two hundred and twenty (220) laying hens were used in this study. 220, one day old (35±3g lively weight) hens were bought from Ivoire Poussins a company of SIPRA group (Ivorian company of Animal Production). These chickens were breed in confinement under standard conditions of breeding in the animal house of Veterinary Center of Bingerville, a part of National Agricultural Development Support Laboratory (LANADA). During breeding period, birds were provided with standard food obtained from Ivograin Bingerville Company (food composition is shown on table 1). At 16 weeks old the chickens (1113 ± 90 g lively weight) were randomly divided into two (02)

groups of 110 chickens each. In addition to the standard diet (table 1), hens of group II (treated group) received THOS at a rate of 10g/L of water for a week (07 days) while the hens of group I (control group) received only water without any additives. Chickens were given food and water ad libitum. At 72 weeks old, 5 to 7 hens were euthanized in each group according to each experiment.

#### Methods:-

##### Preparation of the aqueous extract of *Thonningia sanguinea* (THOS):-

The inflorescences were rid of any impurities by washing, cut into strips and dried in open air away from sunlight. These inflorescences were then pulverized in a blender (IKAMAG-RCT®, Labortechnik, USA). 100g of powder were dissolved in 1 liter of deionized water and homogenized in a blender. The homogenate obtained was drained on a square of fabric and the filtrate was then filtered three times on absorbent cotton and once on whatman filter paper. This second filtrate thus obtained was put to dry in an incubator (45-50 °C) until complete evaporation of the solvent (Zirih et al., 2003). The resulting powder what represent the aqueous extract (THOS) was put in an airtight jar and kept away from moisture till use.

##### Carcass characteristics determination method:-

At 72 weeks old, 6 hens from each group of weight close to the average weight of the group were selected then weighed and euthanized. The chickens were manually plucked with warm water and the carcass weighed before and after evisceration. After this, carcasses were butcher then the *pectoralis major* and minor muscles, thigh muscles, head, legs, wings, liver, heart, gizzard, intestine and abdominal fat were individually weighed. The yield of each organ in relation to the edible carcass weight (eviscerated carcass) was then determined using the following formula:

$$\text{Yield (\%)} = \frac{\text{Organ weight (g)}}{\text{Comestible carcass weight (g)}} \times 100$$

##### Pectoral and thigh muscles color determination method:-

At 72 weeks old, 6 hens from each group were euthanized. *Pectoralis major* and minor muscles, thigh muscle and the liver were remove from carcasses. The color of these samples was then recorded on the inner face using a Minolta reflectance colorimeter CR10 (KONICA MINOLTA INC. JAPAN) according to CIE, (1978) color system ( $L^*$ ,  $a^*$  and  $b^*$ ). Where  $L^*$  represent luminance or surface lightness;  $a^*$  redness; and  $b^*$  yellowness. To accomplish uniformly the determination of meat color, colorimetry was performed on a fixed portion of breast and thigh meat. Each measure was replicated 3 times on each sample and an average of the 3 measurements was calculated.

##### Method of post mortem pH ( $\text{pH}_{\text{pm}}$ ):-

Five hens of 72 weeks old were euthanized. Then, the *pectoralis major* muscles as well as the thigh muscles of each bird were dissected and conserved at 4°C. At different post-mortem times (1h, 24h and 48h), 1g of each sample was collected and grounded with a meat grinder (Moulinex hv2 1300 France). Immediately after grounded, each crushed sample was homogenized in 10 mL of distilled water and the different post mortem pH were determined using a glass electrode pH-meter (Eutech instruments pH 700 Singapour) coupled to a temperature electrode as described by Stewart et al., (1984). Each measure was replicated 3 times on each sample and an average of the 3 measurements was calculated.

##### Method of cooking loss determination:-

Cooking losses were determined according to the method described by Wood et al. (1981) and revised by Honikel (1998). Five samples of breast and thigh meat were packed in hermetic polystyrene bags. The samples have approximately the same weight and the same geometric shape (e.g.  $51.28 \pm 3.2\text{g}$  for thighs muscles;  $45.32 \pm 2.5$  for the major muscles and  $22.35 \pm 1.5\text{g}$  for the minor ones). These samples were then cooked for 15 minutes at 80 °C (temperature corresponding to a core temperature of 75 °C.) in a thermostatically controlled water bath. Then, bags were cooled in water for 45 min and samples were blotted dry with paper towels and reweighed. Cooking losses were the difference of raw weight and cooked weight as shown on the equation below.

$$\text{Cooking loss (\%)} = \frac{\text{Raw sample weight (g)} - \text{cooked sample weight (g)}}{\text{Raw sample weight (g)}} \times 100$$

#### Drip loss determination method:-

Drip losses were determined according to the method described by **Offer *et al.*, (1988)**. Pectoral and thigh muscles were collected from 7 hens euthanized in each group. The sample were immediately weighed and trimmed (for shape and weight uniformity: 100±3g thigh muscle weight; 66±2g pectoral muscle weight). These samples were then packaged in hermetic polystyrene freezer bags containing absorbent paper (paper towels) and stored in tray at 4°C. After 24 hours, the samples were removed from the bags, wiped with absorbent paper and then weighed again. Then the samples were restored again in the previous conditions. This operation was replicated after 48 hours and 72 hours of 4°C storage.

Drip losses were expressed as percentage of the initial weight as described in the equation below:

$$\text{Drip losses (\%)} = \frac{\text{Initial sample weight (g)} - \text{sample weight at T (g)}}{\text{Sample initial weight (g)}} \times 100$$

Where T is post mortem storage time (24h, 48h or 72h)

#### Moisture determination method:-

Pectoral and thigh muscles were riddled of bones and then weighed and dried in a desiccator at 103 °C until a constant mass was obtained. After that, each sample was finely grounded and all the grounded materials obtained were dried again in a desiccator at 103 °C for 35-45 min. After this last drying, the samples were reweighed. The different moisture rates were determined by calculating the variations between the initial and final weight. The results were expressed as a percentage of the raw sample.

#### Total minerals or ashes determination method:-

Total minerals of each sample were determined by calcining dried maters in muffle furnaces at 570 °C for 3 hours in platinum crucibles. It was sometimes necessary to moisten the dried sample once or twice with demineralized water, in order to obtain a whitish ash (**Pinta, 1973**).

#### Statistical analyzes:-

Data Analyzes were carried out using GraphPad Prism software version 5. The comparison of means two (2) by two (2) was made by Mann-Whitney test. The confidence interval is 95%, the average means were significantly different when  $P < 0.05$ .

#### Results:-

##### Effect of dietary supplementation of THOS on carcass characteristics:-

The results of THOS dietary supplementation on carcass characteristics are summarized in table2.

The analysis of the results didn't reveal significant differences not only in hens lively weight, but also in slaughtered and in edible carcass weight between both groups of animals. The average weights of *pectoralis major* and *minor* muscles, thigh muscles, wings, legs, hearts, liver and intestine were also not significantly different. On the other hand, gizzard average weights were significantly greater in THOS supplemented group than in control group (32±1.4g vs 25±1.6g;  $p < 0.01$ ). The same effect was observed in gizzard yield (2.08% vs 1.64%;  $p < 0.05$ ). Head average weights were also significantly higher in THOS supplemented group than in control group (62±2.3g vs

56±1.2g;  $p<0.05$ ). In addition, although there were no significant differences, abdominal fat average weight was very low in THOS supplemented group (42±14g) as compared to control group (65 ± 15).

In sum, the incorporation of THOS into the chicken diet did not significantly affect carcass characteristics, but it has significantly increased head and gizzard average weight and yield. This incorporation also resulted in an important reduction of abdominal fat weight even though this reduction was not significant.

#### **Effect of dietary supplementation of THOS on breast and thigh muscles color:-**

The results of THOS dietary supplementation on carcass characteristics are summarized in table 3.

The liver color was not significantly different between the two groups of the experiment. But dietary supplementation of THOS significantly reduced the redness of *pectoralis major* and *minor* muscles ( $a^*$  4.6±0.08 vs 5.2±0.11;  $p<0.05$  and  $a^*$  4.4±0.08 vs 4.7±0.05;  $p<0.05$  respectively). Dietary supplementation of THOS also increased the yellowness on thigh muscles on the chickens (9.6±0.11 THOS vs 9.0±0.13 control;  $p<0.05$ ).

#### **Effect of dietary supplementation of THOS on post mortem pH ( $pH_{pm}$ ) evolution:-**

The results of THOS dietary supplementation on  $pH_{pm}$  evolution are summarized in table 4.

There was no significant difference in the  $pH_{pm}$  evolution between the two groups of birds. But comparing pH variation (falling rate), a significant difference was observed in the thigh muscle. In fact, the post mortem pH falling rate was significantly greater in THOS supplemented group than in control group (0.30 vs. 0.23;  $p<0.05$  from 1 h to 24 h and 0.31 vs. 0.23;  $p<0.05$  from 1 h to 48 h).

Moreover, regardless of the group and type of muscle considered, there was a significant difference ( $p < 0.01$ ) between the  $pH_{pm}$  1h and 24h and so was the  $pH_{pm}$  1h and 48h. But no significant difference was observed comparing the 24h and 48h  $pH_{pm}$  regardless of the group and the muscle type considered.

#### **Effect of dietary supplementation of THOS on drip loss, cooking loss, moisture, dried matters rate (DMR) and total minerals rate (TMR):-**

The results of THOS dietary supplementation on drip loss, cooking loss, moisture, dried matters and total minerals summarized in table 5

Regardless the muscle type, no significant difference was observed in drip, cooking loss moisture and dried matters (DMR). But despite, the absence of significant difference, THOS supplemented group thigh muscles lost less water compare to control group thigh muscles.

On the other hand, the total mineral rate (TMR) is significantly higher in the thigh muscle of hens treated with THOS compare to control hens (4.62±0.12 g/100g vs 4.16±0.07 g/100g;  $p<0.05$ ).

#### **Discussions:-**

Laying hen is bred in first intention for its eggs but at the end of laying period, the carcass represents an economic gain for the breeder and an important protein source for consumers. Therefore, the finishing weight is a very important carcass evaluation criterion.

In the present study, statistical analysis revealed no significant difference between the finishing weight of THOS treated and untreated 72 weeks old hens (1938±0.02 g THOS vs 1940±0.03g control). These weights are slightly lower than the average standard weights of the Isa Brown hens at 72 weeks of age which is 1990g. Furthermore, carcass/lively weight yield (77.98% control; 79.67 THOS) are higher than those reported by **Guerder et al., (2009)**. These authors obtained carcass/lively weight yields of 60% to 68% in chickens and 74% in turkeys. **Hoffmann et al., (2013)** also obtained low yields ranging from 69.5% to 71% in hybrid chicken. It should be noted that **Guerder et al. (2009)** worked on carcasses with boneless legs. This was not the case in our study where we worked on boned carcasses. This difference would be the cause of the lower yields **Guerder et al. (2009)** obtained.

The significant difference observed in heads average weight of the treated and untreated birds could be due to lack of uniformity during meat cutting. On the other hand, the significant difference in gizzard average weight would be

due to THOS supplementation. In fact, THOS treated hens gizzard average weight is significantly greater ( $P < 0.01$ ) than that of the untreated hens ( $32 \pm 1.4$ g THOS vs  $25 \pm 1.6$ g control). **Bennett et al., (2002)** reported similar effects with the incorporation of whole barley into broilers diet. For these authors, the gizzard weight increase is intended to better crush food and thus increase the digestibility of nutrients. THOS would therefore act as a gizzard stimulus which stimulate the mechanical activity of gizzard resulting in a higher gizzard weight (**Svihus, 2011; Sharma et al., 2017**), allowing better crushing and digestibility of nutrients. This ability of THOS could be the instigator of the low consumption index and the weight gain of hens treated with THOS reported by **Ouattara et al., (2005); Kouakou et al., (2010)** and **Ouattara et al., (2012)**.

There was no significantly difference in abdominal fat weight and yield but THOS supplementation has considerably reduce abdominal fat weight. The abdominal fat yields obtained in our experiment (3.35% control vs 2.17% THOS) are in agreement with those of 2.7% and 3.3% of the live weight reported by **Hamou et al., (2009)** in chickens fed on acorns of green oak. On the other hand, these yields are lower than the rates of 5.31% reported by **Béaza et al., 2009** in "Geline de Touraine" chickens. This ability of THOS to reduce fat accumulation may partly explain the high laying rate in ISA Brown hens treated with THOS reported by **Kouakou et al., (2010)** and **Ouattara et al., (2012)**. In fact, according to **Leclercq et al., 1972** the intensity of fat deposition is partly related to vitellogenesis and therefore to laying so excessive accumulation of fat undermines effectiveness use of food and, in the short term, the ability of layers.

THOS dietary supplementation didn't significantly affect post mortem pH ( $pH_{pm}$ ) values. All  $pH_u$  values obtained in our experiment are within the normal  $pH_u$  range (5.2 to 7.0 and 5.6 to 5.7) reported by **Monin, (1988)** and **DALLE, (2004)** respectively. Thigh muscle  $pH_u$  values ( $5.87 \pm 0.01$  control and  $5.89 \pm 0.01$  THOS) obtained in our study are similar to those reported by **Frizzell et al., (2017)** in 80 and 81 weeks old laying hens ( $5.86 \pm 0.01$  at  $5.73 \pm 0.02$ ). On the other hand, the lower breast muscles  $pH_u$  ( $5.54 \pm 0.01$  and  $5.56 \pm 0.01$ ) obtained in the present experiment could be due to cell variability because, according to (**Monin, 1988**) the  $pH_u$  differs from one muscle to another and within the same carcass.

The thigh muscle  $pH_{pm}$  falling rate was significantly higher in THOS treated group. This difference could be due to ATP hydrolysis acceleration by THOS. According to **Bendal, (1973)**, the falling rate of  $pH_{pm}$  is directly proportional to the hydrolysis activity of ATP. Then, any factor modifying ATPase activity results in a similar change in the falling rate of  $pH_{pm}$ .

There was no significant difference in cooking loss between the two groups of birds studied, regardless of the type of muscles involved. The losses of 35 g/100g (thigh muscle) and  $26 \pm 3.5$  and  $28 \pm 0.19$  g/100g (pectoral muscles) obtained in our experiment are higher than those reported by **De Marchi et al., (2011)**. This difference could be due to genetic variability because **De Marchi et al., (2011)** have worked on different strains from those studied in our experiment.

Water losses of the different muscles studied also revealed no significant difference between the two groups of hens. However, water losses are lower in thigh muscle of THOS treated hens than in control hens. This capacity of water retention by the muscles of hens treated with THOS could be due to the presence of polyphenols (**N'guessan et al., 2007**), particularly to gallic acid contained in THOS. Indeed, **Jung et al. (2010)** and **Lee et al., (2012)** have reported that 1% diet supplementation in gallic acid improves the nutritional quality and water retention capacity of pectoral and thigh muscles of chickens.

Moisture rate obtained in this study ( $73.45 \pm 0.37$  to  $74.04 \pm 0.34$  g/100g of muscle) are similar to those reported by **Rabot (1998)**. This author had found moisture rate of 74.7 g/100g for pectoral muscle and 74.2 g/100g for thigh muscle. Moreover, in our experiment, moisture rate of pectoral muscle (73.45 and 73.55 g/100g) doesn't significantly differed from that of thigh muscle (73.62 and 74.04 g/100g). This observation is occurred in the two groups of hens studied. Indeed, in poultry, the moisture rate varied slightly between thigh and the pectoral muscles whatever the breed (**BRUNEL et al., 2006**).

Unlike the moisture and dried matters (DM) mean rates where no significant difference was observed, thigh muscle total minerals rate (TMR) was significantly higher in THOS treated group. This difference would be due to the reduction in water losses caused by THOS in thigh muscles, which would reduce loss of minerals in the dripping water.

Regarding meat color, breast muscles redness was significantly lesser in THOS treated hens. All the values of the red index ( $a^* = 4.6 \pm 0.08$  for the *pectoralis major* and  $a^* = 4.4 \pm 0.08$  for the *pectoralis minor*) obtained in our study are in agreement with that red index value ( $a^* = 4.54 \pm 0.14$ ) reported by **Chen et al., (2016)** in ISA Brownlayers. The low red color observed in breast muscles of THOS treated hens could be due to the difference in fibers types and the amount of pigments such as myoglobin contained in the muscles. **Froning, (1995)** and **Mancini (2009)** reported that the red color of meat is related to the amount and the state of oxidation of myoglobin and to the pre-mortem and post mortem conditions. But in our case, the effect of THOS would be a decrease in myoglobin level rather than myoglobin oxidation or degradation because THOS contains many polyphenols. The antioxidant activity of polyphenols improves meat quality, stabilizes the red color of the meat by slowing the oxidation of myoglobin (**Krzysztof et al., 2017** and **Salami et al., 2017**). In addition, the significant  $pH_{pm}$  falling rate (0.30) in THOS treated group may also explain the redness loss of breast muscles. In fact, according to **Froning, (1995)** and **Allen et al. (1997)**, a high rate of pH drop tends to make the meat whiter.

### Conclusion:-

The results of the present study show that the use of THOS as Isa Brown laying hens dietary supplementation does not adversely affect the carcass characteristics and the physicochemical parameters of pectoral and thigh muscles. Better, THOS improves gizzard weight and reduces abdominal fat accumulation. This allows hens to value the food consumed. In addition, THOS by its ability to reduce water losses promotes retention of total minerals in chicken muscles. This ability of THOS could improve organoleptic qualities of chicken meat. Finally, THOS reduces pectoral muscles redness. But that isn't a bad outcome when we know that chickens breast muscles are considered as less red meat.

However, other studies should be conducted to elucidate the effect of THOS on pectoral muscles and on organoleptic characteristics of chicken meat in order to better understand the effect of dietary supplementation in THOS on chicken meat quality.

### Acknowledgement:-

The authors would like to give their special thanks and regards to Strategic Support Program for Scientific Research (PASRES) a program of Swiss Centre for Scientific Research Cote d'Ivoire (CSRS), for supporting this experiment by a grant. Authors would also thank the Veterinary Center of LANADA Bingerville for its technical support during the experiment.

**Table 1.** Composition of the basal diet used to feed all hens during the experiment

Ingredients	Starter diet	Grower diet	Laying diet
Metabolisable energy (kcal/kg)	3150	3127.87	2998.49
Crude protein (%)	20.5	18.02	17.01
Crude fat matters (%)	4.08	4.51	3.46
Crude ash (%)	6.14	6.72	13.2
Crude cellulose (%)	4.31	5.05	3.98
Calcium (g/kg)	9.44	10.26	34.91
Phosphorus (g/kg)	6.47	6.36	5.92
Sodium (%)	0.18	NA	NA
Vitamin A (UI/kg)	12500	0	0
Vitamin D3 (UI/kg)	2500	10000	7500
Vitamin E (UI/kg)	2500	10000	7500

NA = not available

**Table 2.** Influence of THOS dietary supplementation on carcass and cut off characteristics of hens

Organs	Control	THOS (10g/L)	P
Lively weight (g) n=6	1940 ± 0.03	1938 ± 0.02	NS
Slaughter carcass (g) n=6	1696 ± 45	1726 ± 46	NS
Edible carcass (g) n=6	1513 ± 36.8	1541 ± 47.3	NS
<i>Pectoralis major</i> (g) n=12	64 ± 2.3	69 ± 2.7	NS
<i>Pectoralis minor</i> (g) n=12	26 ± 0.8	27 ± 1.0	NS
Thigh + drumstick (g) n=12	170 ± 4.7	170 ± 3.9	NS
Wing (g) n=12	73 ± 2.2	69 ± 1.1	NS
leg (g) n=12	24 ± 0.59	25 ± 0.56	NS
Head (g) n=6	56 ± 1.2	62 ± 2.3	S*
Heart (g) n=6	8.7 ± 0.76	8.7 ± 0.49	NS
Liver (g) n=6	36 ± 3.0	38 ± 1.8	NS
Gizzard (g) n=6	25 ± 1.6	32 ± 1.4	S**
Intestine (g) n=6	100 ± 9.4	110 ± 6.7	NS
Abdominal fat (g) n=6	65 ± 15	42 ± 14	NS
yields			
Edible carcass (%) n=6	77.98 ± 1.48	79.67 ± 3.38	NS
<i>Pectoralis major</i> (%) n=12	4.26 ± 0.17	4.48 ± 0.11	NS
<i>Pectoralis minor</i> (%) n=12	1.70 ± 0.05	1.77 ± 0.07	NS
Thigh + drumstick (%) n=12	11.14 ± 0.16	11.13 ± 0.17	NS
Wing (%) n=12	4.78 ± 0.09	4.46 ± 0.08	S*
Leg (%) n=12	1.56 ± 0.03	1.62 ± 0.06	NS
Head (%) n=6	3.73 ± 0.05	4.21 ± 0.15	S*
Heart (%) n=6	0.57 ± 0.04	0.57 ± 0.04	NS
Liver (%) n=6	2.34 ± 0.17	2.49 ± 0.14	NS
Gizzard (%) n=6	1.64 ± 0.10	2.08 ± 0.14	S*
Intestine (%) n=6	6.13 ± 0.46	6.13 ± 0.42	NS
Abdominal fat (%) n=6	4.19 ± 0.91	2.66 ± 0.81	NS

Results are expressed as mean ± standard error of the mean (SEM);

P = statistical probability

NS = no significant difference

S\* = significant difference (p< 0.05)

S\*\* = significant difference (p< 0.01)

THOS (10g/L) = aqueous extract of *Thonningia sanguinea* at the rate of 10 g. l<sup>-1</sup>. The slaughter weight is the weight of the bled and plucked subject

The edible carcass is the carcass riddled of the viscera, the cloaca; the crop; the proventriculus and the bursa of fabricius

The yield of the edible carcass is calculated in relation to the lively weight the yield of the cut of is calculated in relation to the unrefrigerated edible carcass

**Table 3.** Effect of THOS dietary supplementation on hens' pectoral and thigh muscles color

Parameters		Control	THOS (10g/L)	P
<i>Pectoralis major</i> muscle (n=12)	L*	31 ± 0.15	31 ± 0.17	NS
	a*	5.2 ± 0.11	4.6 ± 0.08	S*
	b*	9.3 ± 0.09	9.2 ± 0.08	NS
<i>Pectoralis minor</i> muscle (n=12)	L*	30 ± 0.19	30 ± 0.11	NS
	a*	4.7 ± 0.05	4.4 ± 0.08	S*
	b*	9.4 ± 0.09	9.2 ± 0.08	NS
Thigh muscle (n=12)	L*	29 ± 0.18	29 ± 0.17	NS
	a*	8.3 ± 0.13	8.4 ± 0.12	NS
	b*	9.0 ± 0.13	9.6 ± 0.11	S*
Liver (n=6)	L*	27 ± 0.25	27 ± 0.36	NS
	a*	9.9 ± 0.24	9.4 ± 0.36	NS
	b*	11 ± 0.30	11 ± 0.46	NS

Results are expressed as mean ± standard error of the mean (SEM);

P = statistical probability

NS = no significant difference

S\* = significant difference (p < 0.05)

THOS (10g/L) = aqueous extract of *Thonningia sanguinea* at the rate of 10 g. l<sup>-1</sup>

L\* = luminance or lightness of meat

a\* = red color indicator: (a\* < 0 meat seemed more green; a\* > 0 meat seemed more red)

b\* = yellow color indicator: (b\* < 0 meat seemed more blue; b\* > 0 meat seemed more yellow)

**Table 4.** Influence of THOS dietary supplementation on post mortem pH (pH<sub>pm</sub>)

Parameters			pH <sub>pm</sub>	Control	THOS (10g/L)
Thigh muscle	pH <sub>pm</sub> (n = 5)		pH <sub>I</sub>	6.10 ± 0.07 <sup>a</sup> <sub>c</sub>	6.19 ± 0.07 <sup>a</sup> <sub>c</sub>
			pH <sub>u</sub>	5.87 ± 0.01 <sup>a</sup> <sub>d</sub>	5.89 ± 0.01 <sup>a</sup> <sub>d</sub>
			pH <sub>48</sub>	5.87 ± 0.01 <sup>a</sup> <sub>d</sub>	5.88 ± 0.02 <sup>a</sup> <sub>d</sub>
	ΔpH <sub>pm</sub>		ΔpH <sub>I-24</sub>	0.23 <sup>a</sup> <sub>c</sub>	0.30 <sup>b</sup> <sub>c</sub>
			ΔpH <sub>I-48</sub>	0.23 <sup>a</sup> <sub>c</sub>	0.31 <sup>b</sup> <sub>c</sub>
Pectoral muscle	pH <sub>pm</sub> (n = 5)		pH <sub>I</sub>	5.83 ± 0.01 <sup>a</sup> <sub>c</sub>	5.86 ± 0.06 <sup>a</sup> <sub>c</sub>
			pH <sub>u</sub>	5.54 ± 0.01 <sup>a</sup> <sub>d</sub>	5.56 ± 0.01 <sup>a</sup> <sub>d</sub>
			pH <sub>48</sub>	5.55 ± 0.02 <sup>a</sup> <sub>d</sub>	5.54 ± 0.02 <sup>a</sup> <sub>d</sub>
	ΔpH <sub>pm</sub>		ΔpH <sub>I-24</sub>	0.29 <sup>a</sup> <sub>c</sub>	0.30 <sup>a</sup> <sub>c</sub>
			ΔpH <sub>I-48</sub>	0.28 <sup>a</sup> <sub>c</sub>	0.32 <sup>a</sup> <sub>c</sub>

Results are expressed as mean ± standard error of the mean (SEM);

Means with different superscript letters in the same row (a / b) are significantly different

Means with different subscript letters in contiguous column (c / d) are significantly different

pH<sub>pm</sub> = post mortem pH

pH<sub>I</sub> = 1 heure post mortem pH

pH<sub>u</sub> = ultimate pH (24 hours post mortem)

pH<sub>48</sub> = 48 hours post mortem pH

ΔpH<sub>pm</sub> = post mortem pH variation

ΔpH<sub>I-24</sub> = 1 – 24 hours post mortem pH variation

ΔpH<sub>I-48</sub> = 1 – 48 hours post mortem pH variation

THOS (10g/L) = aqueous extract of *Thonningia sanguinea* at the rate of 10 g. l<sup>-1</sup>

**Table 5.** Effect of THOS dietary supplementation on some physicochemical parameters of pectoral and thigh muscles of hens

Parameters		Tpm (h)	Control	THOS (10g/L)	P
Cooking loss (g/100g ) (n = 7)	Thigh muscle	24	35±1.9	35±1.0	NS
	Pectoral muscle	24	26±3.5	28±0.19	NS
Drip loss (g/100g) (n = 7)	Thigh muscle	24	5.7±3.3	2.3±0.93	NS
		48	9.3±3.6	5.3±1.2	NS
		72	11±3.3	7.6±1.7	NS
	Pectoral muscle	24	5.3±1.5	5.2±0.51	NS
		48	8.5±1.4	8.0±0.71	NS
		72	11±1.4	10±1.1	NS
Moisture (g/100g) (n = 7)	Thigh muscle		73.62 ± 0.37	74.04 ± 0.34	NS
	Pectoral muscle		73.45 ± 0.37	73.55 ± 0.14	NS
DMR (g/100g) (n = 7)	Thigh muscle		26.38 ± 0.37	25.29 ± 0.41	NS
	Pectoral muscle		26.55 ± 0.37	26.46 ± 0.14	NS
TMR (g/100g) (n = 7)	Thigh muscle		4.16 ± 0.07	4.62 ± 0.12	S*
	Pectoral muscle		4.160 ± 0.05	4.22 ± 0.03	NS

Results are expressed as mean ± standard error of the mean (SEM)

Tpm (h) = post mortem time in hour

Drip losses; cooking losses; moisture and dried mater are expressed as percentage (g/100g) of raw meat weight

TMR = total mineral rate; expressed as percentage (g/100g) of dried maters weight

P = statistical probability

NS = no significant difference

S\* = significant difference;  $p < 0.05$

THOS (10g/L) = aqueous extract of *Thonningia sanguinea* at the rate of 10 g. l<sup>-1</sup>

DMR= dried maters rate

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