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Digestibility and Metabolic Utilization and Nutritional Value of *Leucaena leucocephala* (Lam.) Leaves Meal Incorporated in the Diets of Indigenous Senegal Chickens

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Abstract: In the prospect of the *Leuceana leucocephala* leaves meal using as a protein ingredient source for indigenous Senegal chickens diets, a study was carried out to determine their nutrient utilization and nutritional value when incorporated at various levels in the diets. Twenty adult indigenous chickens with an average body weight of 1.22 kg were conducted in metabolic cages and allocated in four groups of five birds each. The groups were corresponded to four dietary treatments (LL_0, LL_7, LL_{14} and LL_{21}) containing respectively 0, 7, 14 and 21% of *Leuceana* leaves meal. During the trial, birds were weighed at the beginning and at the end. Feed offered and refused, collected fresh excreta were weighed daily and the droppings were oven-dried at 60°C and ground per bird for six days. The ingredients and experimental diets used and collected excreta were subjected to chemical analyses. Results showed that the *Leuceana* leaves were relatively rich in protein (24.9% DM), ether extract (6.4% DM), crude fiber (14.2% DM) and Neutral detergent fiber (22.4% DM). It contained respectively 43.1% and 11.4% DM of nitrogen free extract and ash, particularly calcium (1.8%) and potassium (1.1% DM) and 2573.8 kcal/kg DM of metabolizable energy. The results of the trial showed that the inclusion of *L. leucocephala* leaves meal in the diet at 21% level, has no significant adverse effect on feed intake, average daily weight gain, feed conversion ratio and nutrients utilization (except ether extract) of adult indigenous Senegal chickens. It has significantly ($p<0.05$) improved the crude protein and metabolizable energy utilization in birds fed the 7% level inclusion diet (LL_7).

Key words: Leuceana leaves, digestibility and metabolic utilization, nutritional value, indigenous chickens

INTRODUCTION

Despite the remarkable growth recorded in the industrial poultry farming in the recent years in some West African countries (Burkina Faso, Ghana, Mali, Nigeria, Senegal), consumption of poultry products is still highly dependent on imports causing huge outflow of foreign exchange for most countries of this region (FAO, 2009). The traditional poultry farming although very little concerned by the development projects (states paying more attention to the industrial poultry) remains the most widespread. It constitutes an important pillar of food support and socio-economic development in West Africa where it's practiced by almost all farmers, including women and children of rural families (Bebay, 2006; Traoré, 2006). The numbers of poultry in 2004 were estimated at 31.937 millions heads in Burkina Faso, 27.15 millions in Mali and 27.868 millions heads in Senegal with an average of 75-85% of traditional or indigenous chickens (Alders, 2005; Bebay, 2006; Pousga, 2007). Thus, in order to contribute effectively to poverty alleviation, animal protein availabilities and food security improvement, it is necessary and essential to improve and promote the indigenous or local chickens' production.

However, the indigenous chickens farming are confronted to various constraints in which food is a major challenge. In addition to the lack of dietary supplement, village chickens faced quantitative and qualitative food shortage particularly in poor agricultural or household residues environment (Pousga, 2007; Sonaiya and Swan, 2004; Hofman, 2000; Bonfoh *et al*., 1997). Moreover, because of the increasingly cost of

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common protein ingredients (groundnut cake, soybean or fish meal) traditional stockholders often have little access to such resources compared to industrial farmers.

Several studies carried out, have reported that leguminous leaves such as *Leuceana leucocephala* are important food resources which are relatively rich in crude protein (25-44%) and in essential amino acids, minerals, carotenoids and vitamins (Aletor and Omodara, 1994; Ekpenyong, 1986; Akbar and Gupta, 1985; D'Mello and Fraser, 1981; D'Mello and Thomas, 1978). Although the presence of mimosine, an important toxic factor has often been mentioned as the handicap of the intensive use of *Leuceana* leaves (D'Mello, 1992, 1982; Semenye, 1990), they have been used for a long-time in both ruminants (Jones, 1979; Jones and Megarrity, 1983; Pamo *et al*., 2005) and monogastrics (Atawodi *et al*., 2008; Hussain *et al*., 1991; D'Mello and Acamovic, 1989, 1982; Ter Meulen *et al*., 1984; D'Mello and Talpin, 1978) with various performance results depending on their incorporation level and their nutritional value. But, despite the abundance and availability of this resource in Senegal, any study has been carried out on its nutritional value and use in poultry feeding, especially in indigenous Senegal chickens. Then, the use of *Leuceana* leaves meal in the diets of chickens as protein ingredient source might go through a good knowledge of their nutritional value and inclusion limit level. The purpose of this study was to investigate the digestibility and metabolic utilization and nutritional value of *Leuceana leucocephala* leaves meal incorporated at different levels in the diets of adult indigenous Senegal chickens.

MATERIALS AND METHODS

Vegetable material and experimental diets formulation: The *Leuceana* leaves used for this study were mainly collected in the region of Thies, 70 km from Dakar, particularly in the High National Agricultural School of Thiès (ENSAT) and the fields located in its environs. Branches bearing leaves were cut and transported to the ENSAT where they were displayed evenly under a semi-open shed for 2 days. The branches and twigs were then removed and the leaflets of the leaves were retrieved. They were sun-dried during 2-3 days until they become soft crispy while still retaining the greenish coloration. Indeed, drying was able to reduce or eliminate the potential labile toxic factors (mimosine, lectin) present in the leaves (Wee and Wang, 1987; Tangendjaja *et al*., 1984; D'Mello and Fraser, 1981). These sun-dried leaves were then processed into meal using a grinder mesh of 4 mm in diameter. The leaf meal was packaged in bags of 40 kg and stored until use. The other ingredients (yellow maize, white sorghum, millet, wheat bran, groundnut cake and fish meal) were bought at the markets of Dakar and Thiès. Samples of the various ingredients including *Leuceana* leaves meal were subjected to proximate analyses before being used in the formulation of experimental diets.

Based on the analysis results of the different ingredients, four iso-nutrients calculated growing chickens diets (LL_0, LL_7, LL_{14} and LL_{21}) were formulated to contain respectively 0, 7, 14 and 21% of *L. leucocephala* leaves meal in a partial substitution to groundnut cake. The diet (LL_0) was the control. So as to detoxify the mimosine, main anti-nutritional factors, the diets based on *Leuceana* leaves (LL_7, LL_{14} and LL_{21}) were supplemented with ferrous sulphate at 30 g/kg of leaves meal (D'Mello and Acamovic, 1982; Ross and Springhall, 1963). The ingredients composition and calculated nutritive value of the experimental diets are presented in Table 1.

Birds, experimental design and data collection: The experiment was undertaken in the Application Centre for Breeding Technical of ENSAT during the first two weeks of December 2009. Twenty adult indigenous chickens with an average body weight of 1.22 kg were raised in individual metabolic cages for digestive and metabolic nutrients utilization studies. They were allocated into four treatments groups consisting of five birds each (2 cocks and 3 hens). The treatment groups were corresponded to the four previous dietary treatments (LL_0, LL_7, LL_{14} and LL_{21}). Each metabolic cage was equipped with two compartments for distribution of food and water. The cages were screened in their upper and earlier, but tight on the lateral and posterior part. They were open by their top while the lower part was equipped with triple compartments which allow separately the excreta, water and refused feed collection.

Experiment was conducted in two phases (Table 2). During the first phase named pre-experimental, birds received an anti-stress (coliteravet[ND]), 1 g/L in the drinking water and were adapted to their new environment and to feed. It lasted for five days during which the diet usually distributed has been gradually replaced by the experimental diets. It had enabled to determine the amount of food that could be offered to chickens during the second phase.

In the experimental phase, the four diets (LL_0, LL_7, LL_{14} and LL_{21}) were distributed respectively to each of the corresponding four treatment groups of chickens. They were weighed early in the morning and served two times a day. The water was provided *ad libitum*. This second phase lasted for seven days out of which 6 were used for the collection and measurement of droppings.

During the trial, birds were weighed at the beginning and at the end of the experimental phase. The feed intake (feed offered-feed refused), collected fresh excreta per bird were weighed daily. The collected droppings were kept individually, oven-dried at 60°C and also weighed. At the end of the experiment, the 6-day collected excreta per bird were pooled, mixed, ground and stored respectively for chemical analyses.

Table 1: Ingredients composition and calculated nutrients value of experimental diets

	Dietary treatments			
Ingredients	LL_0	LL_7	LL_{14}	LL_{21}
Yellow maize (%)	24.30	24.47	26.90	26.00
White sorghum (%)	16.40	16.00	8.00	0.00
Millet (%)	13.50	13.00	16.51	24.00
Wheat bran (%)	16.50	14.50	12.10	8.71
Groundnut cake (%)	23.00	18.40	16.00	13.40
Leuceana leaves meal (%)	0.00	7.00	14.00	21.00
Fish meal (%)	2.20	3.00	3.00	3.50
Dicalcium Phosphate (%)	1.09	0.40	0.50	0.50
Food chalk (%)	0.48	0.65	0.25	0.00
Lysine (%)	0.23	0.17	0.12	0.06
Méthionine (%)	0.00	0.00	0.00	0.00
Macrovitamix (CMV) (%)	2.00	2.00	2.00	2.00
Ferrous Sulfate (%)	0.00	0.21	0.42	0.63
Liptol[1] (%)	0.15	0.10	0.10	0.10
Fintox[2] (%)	0.15	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated nutrients value				
Dry matter, DM (%)	90.98	91.06	91.09	91.19
Crude protein, CP (% DM)	20.90	20.40	20.32	20.32
Ether extract, EE (% DM)	6.90	6.53	6.51	6.51
Crude fiber, CF (% DM)	4.83	5.29	5.81	6.18
Total Ash (% DM)	6.62	6.73	6.87	7.20
Lysine (% DM)	0.93	0.93	0.93	0.94
Méthionine (% DM)	0.43	0.43	0.44	0.45
Metabolizable energy, ME (Kcal/kg DM)	3085.47	3050.40	3042.42	3047.33
ME/Protein ratio (kcal/g)	14.76	14.95	14.97	15.00
Calcium, Ca (% DM)	1.05	1.05	1.05	1.08
Phosphorus, P (% DM)	0.75	0.68	0.67	0.67
Sodium, Na (% DM)	0.08	0.08	0.08	0.09
Potassium, K (% DM)	0.57	0.58	0.62	0.65

LL_0: Control diet (0% of *Leuceana leucocephala* leaves meal); LL_7: Diet containing 7% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{14}: Diet containing 14% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{21}: Diet containing 21% of *L. leucocephala* leaves meal in substitution of groundnut cake. CMV (mineral and vitamin complex, macrovitamixND): Contain per kg 1400 mg of Manganese, 1200 mg of Zinc, 1400 mg of ferrous, 20 mg Copper, 8 mg ode, 2 mg cobalt, 2.8 mg selenium, 250000 UI vitamin A, 50000 UI vitamin D, 50 mg, 100 mg, 480 mg, 195 mg, 55 mg, 0.6 mg, 290 mg, 50 mg, 175 mg of vitamins B_1, B_2, B_3, B_5, B_6, B_{12}, E, K_3 and C respectively, 27 mg of folic acid, 0.6 mg of biotin and 0.6% of cholin.

[1]Liptol: antifungal and antibacterial preservative; [2]Fintox: preservative absorbing mycotoxins.

Table 2: Experimental design of feed distribution to indigenous Senegal chickens and fresh excreta collection

Groups/dietary treatments	Pre-experimental phase (5 days)					Experimental Phase (7 days)						
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	D_{11}	D_{12}
I (n = 5)/LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0	LL_0
II (n = 5)/LL_7	LL_0	50% LL_0 50% LL_7	25% LL_0 75% LL_7	LL_7	LL_7	LL_7	LL_7	LL_7	LL_7	LL_7	LL_7	LL_7
III (n = 5)/LL_{14}	LL_0	50% LL_0 50% LL_7	50% LL_0 50% LL_{14}	25% LL_0 75% LL_{14}	LL_{14}	LL_{14}	LL_{14}	LL_{14}	LL_{14}	LL_{14}	LL_{14}	LL_{14}
IV (n = 5)/LL_{21}	LL_0	LL_7	25% LL_0 75% LL_{14}	LL_{14}	25% LL_{14} 75% LL_{21}	LL_{21}	LL_{21}	LL_{21}	LL_{21}	LL_{21}	LL_{21}	LL_{21}
Fresh excreta collection	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes

LL_0: Control diet (0% of *Leuceana leucocephala* leaves meal); LL_7: Diet containing 7% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{14}: Diet containing 14% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{21}: Diet containing 21% of *L. leucocephala* leaves meal in substitution of groundnut cake

Proximate analyses of ingredients, experimental diets and collected excreta: Chemical analyses were focused on samples of the ingredients, experimental diets and collected excreta. They were carried out in the laboratory of food and animal nutrition of Dakar's Inter-states School of Sciences and Veterinary Medicine (EISMV) and the laboratory of animal nutrition of ENSAT during the periods from February to September 2009 for ingredients and December 2009 to January 2010 for experimental diets and collected excreta. The analyses concerned the determination of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF), Neutral Detergent Fiber (NDF), total ash and minerals.

The DM and total ash of different samples were obtained according to standard methods of the French Association for Standardization, AFNOR (1977). The CP content was based on the Kjeldahl method (N * 6.25) and that of EE was determined by reflux extraction method for 6 h with diethyl ether or petroleum ether using the Soxhlex apparatus described by the same standard. The CF determination was carried out following AFNOR (1993) standard based on the Weende's method, while this of the NDF was based on the method of Van Soest and Wine (1967).

The calcium, sodium and potassium were measured according to the photometric absorption method of AFNOR (1984) and the total phosphorus determination was done using the spectrophotometric method at 430 nm as described by AFNOR (1980). All analyses were performed in duplicates and parameters were calculated based on dry matter.

The Metabolizable Energy (ME) was calculated respectively according to the regression equations of Conan and Lessire cited by Carre and Rozo (1990) for maize, millet, white sorghum, wheat bran and groundnut cake, of Bourdon *et al.* (1984) for fish meal and of Sibbald *et al.* (1980) cited by Leclercq *et al.* (1984) for *Leuceana* leaves meal, experimental diets and collected excreta.

Apparent coefficients of nutrients utilization determination and statistical analyses: The data collected were entered into the Microsoft Excel table and performances of birds (average daily weight gain, daily feed intake, food conversion ratio, daily feces excreted) were calculated. The Apparent Coefficients of Nutrients Utilization (ACNU) including these of DM and ME were determined according to the following formula:

$$ACNU\ (\%) = [(NI - NE) \div NI] * 100$$

Where, NI represented the nutrient intake and NE the nutrient excreted.

The data collected were subjected to Analysis of Variance (ANOVA) at 5% level using the Statistical Package for Social Science (SPSS) logician. When significant dietary treatments effects were detected from ANOVA analysis, means were compared using Tukey's test of the same logician.

RESULTS

Proximate composition of *Leuceana leucocephala* leaves meal, other ingredients, experimental diets and collected excreta: Chemical composition and calculated metabolizable energy content of *Leuceana leucocephala* leaves meal and other common ingredients used are shown in Table 3. From this, it appears that leuceana leaves were relatively rich in crude protein (24.9% DM) and ether extract (6.4% DM) compared to yellow maize, white sorghum, millet and wheat bran, in crude fiber (14.2% DM) and NDF (22.4% DM) compared to groundnut cake, yellow maize, white

Table 3: Chemical composition and Metabolizable Energy (ME) content of *Leuceana leucocephala* leaves meal and other common ingredients used in experimental diets formulation

Composition	*L. leucocephala* (leaves meal)[1]	Groundnut cake[1]	Yellow maize[1]	White Sorghum[1]	Millet[1]	Fish meal[1]	Wheat bran[1]	DCP	Food chalk	CMV
DM (%)	92.4±0.2	91.1±0.2	89.3±0.2	91.1±0.1	90.8±0.1	94.9±0.1	90.7±0.1	99.5	99.5	99.0
CP (% DM)	24.9±0.8	48.1±0.6	9.9±0.3	10.2±0.4	10.1±0.1	54.9±0.6	16.9±0.3	-	-	9.2
EE (% DM)	6.4±0.5	16.9±0.4	4.0±0.1	2.8±0.0	4.9±0.3	9.2±0.4	4.5±0.2	-	-	-
CF (% DM)	14.2±0.5	5.3±0.5	2.9±0.4	2.1±0.3	2.3±0.6	0.0	13.7±0.3	-	-	-
NDF (% DM)	22.4±0.9	14.6±0.7	9.8±0.5	10.3±0.7	10.1±0.6	0.0	46.9±0.9	-	-	-
NFE (% DM)	43.1±1.6	22.9±0.2	81.9±0.2	82.8±0.6	80.7±0.9	3.6±0.7	59.6±0.5	-	-	-
Ash (% DM)	11.4±0.3	6.8±0.1	1.3±0.1	2.0±0.4	2.1±0.1	32.4±0.3	5.4±0.2	-	-	-
Ca (% DM)	1.8±0.1	0.1±0.0	0.0	0.0	0.0	1.4±0.1	0.1±0.0	28	37.9	25
P (% DM)	0.2±0.0	0.4±0.0	0.3±0.0	0.2±0.0	0.3±0.0	5.2±0.1	1.0±0.0	13	-	4.9
Na (% DM)	0.0	0.0	0.0	0.0	0.0	0.6±0.0	0.0	-	-	3.3
K (% DM)	1.1±0.0	1.0±0.0	0.4±0.0	0.3±0.1	0.4±0.0	0.4±0.0	1.0±0.1	-	-	-
ME (kcal/kg DM)	2573.8±52.5[2]	3769.9±34.8[3]	3449.6±46.3[4]	3235.0±0.0[5]	3521.3±66.2[4]	2760.6±27.8[6]	1845.2±32.4[7]	-	-	-

DM: Dry Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; NDF: Neutral Detergent Fiber; NFE: Nitrogen Free Extract; ME: Metabolizable Energy; DCP: Dicalcium Phosphate; CMV (mineral and vitamin complex, macrovitamix[ND]): contain per kg 1400 mg of Manganese, 1200 mg of Zinc, 1400 mg of ferrous, 20 mg Copper, 8 mg ode, 2 mg cobalt, 2.8 mg selenium, 250000 UI vitamin A, 50000 UI vitamin D, 50 mg, 100 mg, 480 mg, 195 mg, 55 mg, 0.6 mg, 290 mg, 50 mg, 175 mg of vitamins B_1, B_2, B_3, B_5, B_6, B_{12}, E, K_3 and C respectively, 27 mg of folic acid, 0.6 mg of biotin and 0.6% of cholin.

[1]Results obtained from 5 samples chemical analyses;

[2]ME = 3951 + 54,4*EE - 40,8*Ash - 88,7*CF, in [Leclercq *et al.*,1984];

[3]ME = 3985 + 47,02*EE - 53,07*Ash - 44,62*NDF, in [Carre and Rozo, 1990; Carre and Brillouet,1989];

[4]ME = 3780 - 114*CF, in [Carre and Rozo, 1990];

[5]ME = 3871 - 397*Tannin, (Tannin = 1,6) in [Carre and Rozo,1990];

[6]ME = 39,5*CP + 64,5*EE, in [Bourdon *et al.*, 1984]; [7]ME = 3887 - 52 * Ash - 37,5*NDF in [Carre and Rozo, 1990]

Table 4: Chemical composition and Metabolizable Energy (ME) content of experimental diets and collected excreta

Dietary treatments and excreta	Ratio ME/CP	DM (%)	Chemical composition (% DM) OM	CP	EE	CF	NFE	Ash	ME (kcal/kg DM)
LL_0	17.97	91.24	93.25	20.98	6.94	3.17	62.14	6.75	3771.51
LL_7	18.55	91.33	93.05	20.24	7.08	3.35	62.37	6.95	3755.71
LL_{14}	17.18	91.43	92.51	20.87	6.66	4.74	60.23	7.48	3587.43
LL_{21}	17.20	90.50	92.36	20.33	6.67	5.69	59.66	7.63	3497.05
Excreta from LL_0	-	19.74	84.62	38.29	2.81^a	10.81^a	32.69	15.37	2517.62
Excreta from LL_7	-	13.44	83.15	34.43	3.78^b	13.73^{ab}	31.20	16.84	2252.02
Excreta from LL_{14}	-	12.05	84.69	37.01	4.04^b	13.14^{ab}	28.70	15.30	2380.96
Excreta from LL_{21}	-	20.17	84.88	36.37	4.27^b	15.54^b	30.77	15.11	2189.01

[a,b]Means within column with different superscripts are significantly different at 5% level ($p<0.05$).

DM: Dry Matter; OM: Organic Matter; CP: Crude Protein; EE: Ether Extract; CF: Crude Fiber; NFE: Nitrogen Free Extract; ME: Metabolizable Energy; LL_0: Control diet (0% of *Leuceana leucocephala* leaves meal); LL_7: Diet containing 7% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{14}: Diet containing 14% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{21}: Diet containing 21% of *L. leucocephala* leaves meal in substitution of groundnut cake

sorghum and millet, in ash (11.37% DM), particularly in calcium (1.8% DM) and potassium (1.1% DM) compared to the main contents of other ingredients used. Their nitrogen free extract content (43.1% DM) was higher than these of groundnut cake and fish meal, but low compared to yellow maize, white sorghum, millet and wheat bran. The *Leuceana* leaves contained a low metabolizable energy (2573.8 kcal/kg DM) compared to other ingredients except the wheat bran (1845.2 kcal/kg DM). The groundnut cake and fish meal had respectively the more amounts of crude protein (48.1% DM and 54.9% DM) and ether extract contents (16.9% DM and 9.2% DM). They also had respectively the high content of metabolizable energy (3769.9 kcal/kg DM) and phosphorus (5.2% DM) compared to other ingredients used.

The results of chemical analyses performed on experimental diets and collected excreta per treatment are reported in Table 4. The experimental diets were globally iso-nutrients and isonitrogenous, but their energy value decreased with the rate of *Leuceana* leaves meal inclusion. The control diet (LL_0) was the most energetic and the diet LL_{21} was the least energetic. Indeed, the diets based on *Leuceana* leaves meal (particularly LL_{14} and LL_{21}), were richer in crude fiber and ash than the control diet, which led to the reduction of their metabolizable energy with the gradual increase of the inclusion level of *Leuceana* leaves in the ration. Concerning the collected excreta, their ether extract and crude fiber content were significantly ($p<0.05$) increased with the rate of *Leuceana* leaves inclusion in the diet. The higher content obtained for EE and CF in droppings of the birds fed diets based on *Leuceana* leaves may reflect a low retention of those nutrients by birds. For other nutrients in droppings, including energy and dry matter, no significant ($p>0.05$) difference was observed between the different dietary treatments. However, the collected excreta from the birds in LL_{14} treatment contained the lowest rate of dry matter (12.05%), while in fresh matter it represented the highest amount of droppings (Table 5). This low rate of dry matter in excreta of birds fed with LL_{14}, was mainly due to diarrhea cases recorded during the experiment in this treatment. But these were not pathological or linked to dietary treatment because they were not observed in birds with other treatments and disappeared later without any medical intervention. These diarrhea cases were probably due to a stress condition because they have mainly concerned the hens which started laying during the trial.

Effects of different dietary treatments on growth performances and nutrients utilization of adult indigenous Senegal chickens: The impacts of *Leuceana leucocephala* leaves meal inclusion in the diets on growth performances and nutrients utilization of indigenous Senegal chickens are presented in Table 5. Except the birds fed LL_{14} diet which had the lowest average daily weight gain, ADWG (9.14 g/d) and daily feed intake, DFI (47.57 g/bird), in other diets containing *Leuceana* leaves (LL_7 and LL_{21}), the ADWG and DFI of birds were higher than that in the control diet (9.89 g/d and 62.10 g/bird). The lowest feed conversion ratio, FCR (5.63) was obtained with birds fed the LL_{21} diet, while the highest (11.55) was in LL_{14} dietary treatment. Unlike the fecal dry matter excretion, the highest amount of fresh excreta (124.93 g/bird) was recorded in birds fed the LL_{14} and the lowest (89.68 g/bird) in birds with LL_{21} ration. But, for these different parameters, any significant ($p>0.05$) difference was not revealed between dietary treatments. Moreover, any mortality was not observed among the chickens fed the control and the *Leuceana* based diets. The high amount of fresh excreta, the low ADWG and DFI obtained in the LL_{14} dietary treatment can be explained by the diarrhea cases observed in some birds during the experiment. Indeed, this diarrhea has caused a loss weight that could have contributed to the increasing of the FCR in chickens with this treatment.

Table 5: Effects of dietary treatments on indigenous Senegal chickens performances and nutrients utilization

Parameters	Dietary treatments					
	LL_0	LL_7	LL_{14}	LL_{21}	SEM	P
Initial body weight of bird (kg)	1.22±0.06	1.20±0.07	1.20±0.04	1.29±0.01	0.02	0.619
Final body weight of bird (kg)	1.28±0.16	1.28±0.15	1.26±0.09	1.36±0.04	0.03	0.562
Average daily weight gain (g/day)	9.89±3.98	13.09±7.07	9.14±7.44	12.26±3.17	1.23	0.663
Daily feed intake (g DM/bird)	62.10±13.93	68.00±16.52	47.57±4.71	66.70±18.57	3.49	0.140
Feed conversion ratio (g feed/g gain)	6.60±1.14	6.13±2.25	11.56±12.45	5.63±1.62	1.42	0.453
Fresh daily excreta (g/bird)	116.33±110.7	97.44±16.16	124.94±37.90	89.68±27.40	12.8	0.781
Daily excreta (g DM/bird)	15.55±2.42	13.00±2.41	12.83±3.57	16.98±4.76	0.81	0.200
Apparent coefficient of nutrient utilization						
Dry matter (%)	72.25±1.92	78.86±1.63	70.12±9.53	71.90±2.86	1.30	0.074
Organic matter (%)	74.82±1.74	81.11±1.46	72.65±8.72	74.17±2.63	1.21	0.054
Crude protein (%)	$49.35±3.50^{ab}$	$64.04±2.80^{b}$	$47.01±16.90^{a}$	$49.73±5.11^{ab}$	2.42	0.036
Ether extract (%)	$88.74±0.78^{a}$	$88.70±0.87^{a}$	$81.86±5.78^{b}$	$81.98±1.83^{b}$	1.00	0.002
Crude fiber (%)	5.67±6.47	13.36±6.70	17.40±26.26	23.35±7.80	3.31	0.304
Nitrogen free extract (%)	85.18±1.02	88.80±0.86	84.22±5.03	85.90±1.43	0.67	0.083
Total ash (%)	36.77±4.38	48.75±3.96	38.87±19.50	44.38±5.66	2.42	0.304
Metabolizable energy (%)	$81.47±1.28^{ab}$	$87.32±0.98^{b}$	$80.17±6.32^{a}$	$82.41±1.8^{ab}$	0.93	0.022

^{a,b}Means within rows with different superscripts are significantly different at 5% level (p<0.05).

LL_0: Control diet (0% of *Leuceana leucocephala* leaves meal); LL_7: Diet containing 7% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{14}: Diet containing 14% of *L. leucocephala* leaves meal in substitution of groundnut cake; LL_{21}: Diet containing 21% of *L. leucocephala* leaves meal in substitution of groundnut cake

Concerning the nutrients utilization, the Apparent Coefficient of Nutrients Utilization (ACNU) of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), total ash, Ether Extract (EE), Nitrogen Free Extract (NFE) and Metabolizable Energy (ME) are globally higher in chickens fed the LL_7 diet than in other dietary treatments. The best ACNU was recorded in chickens fed with LL_7 diet, except that of the CF which was obtained with LL_{21} dietary treatment. The ACNU of Crude Fiber (CF) and ash increased with the *Leuceana* leaf meal incorporation, while the ACNU of other nutrients including DM was reduced in LL_{14} dietary treatment. Except the CF and ash for which the ACNU was lower in birds with the control diet, the dietary treatment LL_{14} had recorded the lowest ACNU for other nutrients. The inclusion of *Leuceana* leaves meal at 7% level in the diet, significantly (p<0.05) improved the digestibility and metabolic utilization of crude protein, ether extract and metabolizable energy. However, apart from the EE for which the reduction of ACNU was significant, inclusion of *Leuceana* leaves meal up to 21% in the diet had not shown overall any adverse effect on digestibility and metabolic nutrients utilization with diets containing leaves meal compared to the control.

DISCUSSION

The chemical composition of *Leuceana* leaves are globally in agreement with those obtained by most of the authors (Dhar *et al.*, 2007; Reyes and Fermin, 2003; Aletor and Omodara, 1994; Ekpenyong, 1986; Akbar and Gupta, 1985) who had worked on these leaves. However, the crude protein content was higher than those (21.3% and 23% DM) obtained respectively by Hussain *et al.* (1991) and Onibi *et al.* (2008) and was inferior to those (28-29% DM) reported by Munguti *et al.* (2006), Farinu *et al.* (1992) and D'Mello and Fraser (1981). Total ash content and metabolizable energy are relatively higher than those obtained by most of these authors. Moreover, the crude fiber content obtained was quite high, but still remains below that (15-19% DM) of Akbar and Gupta (1985), Aletor and Omodara (1994) and Munguti *et al.* (2006). These variations can be explained not only by age but also the type of leaves. According to Akbar and Gupta (1985), young leaves and leaflets are rich in crude protein, while mature leaves are in crude fiber, as well as leaflets with the presence of residual veins or twigs. In comparison to the chemical composition of other leaves of plants such as *Gliricidia sepium* (Ige *et al.*, 2006; Odunsi *et al.*, 2002), *Centrosoma pubescens* (Nworgu and Fasogbon, 2007), *Manihot esculenta* (Iheukwumere *et al.*, 2008) and *Azolla pinnata* (Alalade and Iyayi, 2006; Basak *et al.*, 2002; Becerra *et al.*, 1995), *Leuceana* leaves contained similar levels of crude protein and crude fiber but, were richer in ether extract and minerals, particularly in calcium and potassium. It also contained more EE and energy than *Cassia tora* leaves which were well supplied with CF and ash, calcium, potassium and phosphorus (Ayssiwede *et al.*, 2010.; Mbaiguinam *et al.*, 2005; Ranjhan *et al.*, 1971). However, nutrients and energy content of *Leuceana* leaves are lower than those of *Moringa oleifera* leaves (Kakengi *et al.*, 2007; Foidl *et al.*, 2001; Fuglie, 1999; Makkar and Becker, 1997 and 1996). Concerning common ingredients, the results obtained with maize, white sorghum and millet were in line with those of the chemical composition tables of Bourdon *et al.* (1984) and Sauvant *et al.* (2004). The Metabolizable Energy (ME) calculated for wheat bran (1845.2 kcal/kg

DM) was similar to those obtained by Boudouma (2007) and Sibbald (1976), but still relatively higher than that of Sauvant *et al.* (2004) and Bourdon *et al.* (1984). This high ME of wheat bran was likely due to the presence of flour, but also to its high levels of CP content (16.9% DM) and nitrogen-free extract (59.6% DM) compared to the value of Bourdon *et al.* (1984) and Sauvant *et al.* (2004). The relatively high ME of groundnut cake used might be explained by its high EE content, 16.9% DM. However, the low ME of fish meal could be due to its high total ash (32.4% DM) and low CP content (54.9% DM) compared to those of the ingredients composition tables (Bourdon *et al.*, 1984; Sauvant *et al.*, 2004). Even if the *Leuceana* leaves meal contained more calcium (1.80% DM) than fish meal (1.4% DM), this latter was particularly distinguished by its very high total phosphorus content (5.2% DM).

The results on growth performances are consistent with those obtained by D'Mello and Acamovic (1982) and Springhall and Ross (1965) who had demonstrated the improvement of ADWG, DFI and FCR by incorporating 15-20% of *Leuceana* leaf meal treated with ferrous sulphate in the laying hens diet. Similar results were also obtained by Ayssiwede *et al.* (2010.) and Hussain *et al.* (1991) respectively at 15% level of *L. leucocephala* and *Cassia tora* leaves meal in broilers and indigenous Senegal chickens diets and by Tendonkeng *et al.* (2008) and Kakengi *et al.* (2007) with 6-20% level of *Moringa oleifera* leaves meal inclusion respectively in laying and broilers poultry diets. However, our results are in disagreement with those of Atawodi *et al.* (2008), Bhatnagar *et al.* (1996), D'Mello *et al.* (1987), Satyanarayana *et al.* (1987) and Ter Meulen *et al.* (1984) who with 20-30% level of *Leuceana* leaves meal in the diet, have obtained a significant decrease in ADWG and DFI and a high FCR in broiler or laying chickens. The controversy could arise from the fact that these authors have not treated *Leuceana* leaves with additive sulphate of iron to complex mimosine, the main toxic factor of *L. leucocephala* as doing D'Mello and Acamovic (1982) or Springhall and Ross (1965). Furthermore, the present results are also in contrasting with those recorded by Iheukwumere *et al.* (2008), Onibi *et al.* (2008) and Ravindran *et al.* (1986) with 15-20% level of cassava (*M. esculenta*) or *Leuceana* leaves meal, Odunsi *et al.* (2002) and Osei *et al.* (1990) with 5-25% of *G. sepium* leaf meal and Gupta *et al.* (1970) with 10% of *C. tora* leaf meal in the diets, who had obtained a significant deterioration in chickens growth performances.

In terms of nutrients utilization, the lowest apparent coefficient of nutrients utilization (ACNU) obtained in LL_{14} dietary treatment can be explained by diarrhea cases observed in this group. On a physiological point of view, diarrhea caused an acceleration of intestinal transit which leads to the reduction of nutrients utilization, including protein when the level of crude fiber was too high in the diet (Tangendjaja *et al.*, 1990). The protein retention coefficient at 21% level of leuceana leaves is similar to that obtained (48.82%) by Farinu *et al.* (1992), with 40% level of these leaves in the diet of rats. Our results are also in line, but better than those of Ayssiwede *et al.* (2010) and Gupta *et al.* (1970), using respectively 15% and 10% of *Cassia tora* leaves meal in the diet of chickens. Ayssiwede *et al.* (2010) were obtained at the rates of 5% and 10% leaves meal incorporation respectively, 53.04% and 47.80% for protein retention, 81.41% and 78.22% for energy utilization, while Gupta *et al.* (1970) found at these rates, the ACNU of 37.1% and 40.1% for protein and 60.72% and 63.41% for the energy. Iheukwumere *et al.* (2008) have also recorded similar results by including up to 15% of cassava (*Manihot esculenta*) leaves meal in the broiler finisher diet, but they have obtained the highest ACNU with the control diet except the ash. Unlike the crude fiber utilization (55.20%) which was higher than that of this study (23.30%), the ACNU of EE (49.2%) obtained by Iheukwumere *et al.* (2008) was too lower compared to that of our study at 14% level of leuceana leaves (81.86%). In the present study, the ACNU of protein in diets containing *Leuceana* leaves was similar to that obtained with diets based on cassava leaves (Iheukwumere *et al.*, 2008), but higher than that recorded with *Cassia tora* leaves meal diets (Ayssiwede *et al.*, 2010.; Gupta *et al.*, 1970). According to Jean-Blain (2002), nitrogen retention is high when the protein had a better balance of essential amino acids, i.e. the good nutritional quality. Therefore the *Leuceana* leaves although less rich in protein (24.9% DM), have higher nutritional value than *C. tora* leaves. The nutritional quality of protein was related to the least represented essential amino acids, the best nutritional value of *Leuceana* leaves would probably due to their higher content of sulfur amino acids, 0.70% DM (D'Mello and Fraser, 1981) while these amino acids content in *C. tora* leaves are in very low rate, 0.024% DM compared to other essential amino acids (Mbaiguinam *et al.*, 2005).

Conclusion: The *Leuceana leucocephala* leaves are a good source of nutrients. It contained a large amount of protein, ether extract, crude fiber and minerals. Their inclusion in the indigenous Senegal chickens diet up to 21% as a partial substitution for groundnut cake showed no significant adverse effects on average daily weight gain, feed intake, feed conversion ratio and Apparent Coefficient of Nutrients and Energy Utilization (ACNU). It improved the digestibility and metabolic utilization of most of the nutrients in birds with the 7% dietary treatment. Feeding chickens by using *Leuceana* leaves meal may be an interesting alternative that could improve village poultry nutrition and productivity. Because of the high price of protein ingredient source (soya bean meal, groundnut cake or fish meal), it can allow traditional stockholders to have a low cost of production and improve their incomes. It would be useful and necessary to conduct a longer study on young indigenous chickens to evaluate the effects of these leaves meal inclusion in the diet on their breeding performances and productivity.

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