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Effects of *Moringa oleifera* (Lam.) Leaves Meal Incorporation in Diets on Growth Performances, Carcass Characteristics and Economics Results of Growing Indigenous Senegal Chickens

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Abstract: The purpose of this study carried out from July to October 2010 was to assess the effects of *Moringa oleifera* leaves meal inclusion in diets on growth performances, carcass and organs characteristics and economics results of growing indigenous Senegal chickens. Ninety six (96) indigenous Senegal chicks of 5 weeks old were randomly allocated into four groups of 24 chicks each with similar body weight. Each group subdivided in two repetitions of 12 birds, corresponded to each of the four (4) dietary treatments MO0, MO8, MO16 and MO24 containing respectively 0, 8, 16 and 24% of *Moringa* leaves meal in substitution of groundnut cake meal. During the experiment (6-17th week old), zootechnical parameters of birds and economical data were recorded and analyzed per dietary treatment. At the end of the 12 weeks trial, the final Live Body Weights (LBW) were 721.60 g, 911.70 g, 812.85 g and 720.05 g/bird, the average daily weight gain (ADWG) were 6.49 g, 8.77 g, 7.61 g and 6.50 g/day, the Daily Feed Intake (DFI) of 39.10 g, 39.76 g, 36.28 g and 34.24 g/bird and the Feed Conversion Ratio (FCR) of 7.58, 5.75, 6.11 et 7.24 respectively for birds fed MO0, MO8, MO16 and MO24 diets. The *Moringa* leaves meal inclusion in the diets up to 24% had not caused any adverse impact on LBW, ADWG, FCR, mortality, carcass and organs characteristics in birds compared to their controls. Except the significantly decrease of DFI obtained in birds of MO16 and MO24 treatments, significantly better growth performances, feed costs and economic margins were recorded in birds fed MO8 and MO16 diets. Thus these two dietary treatments were the only most economically profitable (respectively 357 and 206 FCFA/kg carcass of additional profit) compared to the control.

Key words: Growth performances, feeding, economic margin, indigenous chickens, *Moringa oleifera* leaves, carcass and organ characteristics, Senegal

INTRODUCTION

The indigenous poultry farming, although very little concerned by development projects (states paying more attention to the industrial poultry), accounts for 75-80% of poultry herd and is practiced by almost all peasants, including women and children of rural areas of Senegal or in sub-Saharan Africa (Agbede *et al*., 1995; Gueye, 2000; Bebay, 2006; Traore, 2006). It remains the most widespread or common way of livestock handling and constitutes an important pillar of food security improvement, socio-cultural and economic development despite the remarkable growth recorded in recent years in industrial poultry (Kitalyi and Mayer, 1998; Missohou *et al*., 2002; Alders, 2005; Dieye *et al*., 2010). In most developing countries, indigenous chickens or its products in the market are more expensive than that of selected exotic chickens. Traditional poultry farming contributes to 70% of poultry production and provides about 20% of the consumed protein by the population in these countries (Alders, 2005; Fotsa *et al*., 2007; Teno, 2009). Despite these many important roles, the traditional poultry development is still limited by various constraints among which food is a major challenge. Apart from diseases and predators, village poultry is hampered by a recurring quantitative and qualitative food shortage particularly in poor agricultural or household

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residues environment in addition to the inadequate or lack of dietary supplement (Buldgen *et al*., 1992; Bonfoh *et al*., 1997; Gueye, 1997; Hofman, 2000; Tadelle and Ogle, 2001; Sonaiya and Swan, 2004; Rashid *et al*., 2005; Pousga *et al*., 2005; Halima *et al*., 2007a). Moreover, the commons protein sources (groundnut cake, soybean, etc.) and other ingredients used in poultry feeding have become too expensive because of their excessive demand in Senegal or in international market due to the context of their diversion to biofuel production (Doumbia, 2002). All this, consequently, had highly reduced access to these resources for poor traditional stockholders compared to industrial poultry farmers, with the resulting a low productivity of village poultry flock. Several authors had shown that fed in partial or total improved dietary supplement, particularly with diet based on local and cheaper ingredients is necessary to maximize productivity and profitability in village chickens breeding (Buldgen *et al*., 1992; Kondombo *et al*., 2003; Rashid *et al*., 2004; Riise *et al*., 2004; Pousga *et al*., 2006; Halima *et al*., 2007b; Kingori *et al*., 2007). In these conditions and in order to allow indigenous poultry livestock to contribute effectively to the poverty and food insecurity alleviation, it would be useful and essential to increase their productivity by improving their feeding strategies through available unconventional and local feed resources' utilization. At this end, studies carried out on leguminous or by-products such as *Moringa oleifera* leaves available in Senegal, have reported that they were important feed resources relatively rich in nutrients, energy and vitamins (Makkar and Becker, 1996 and 1997; Nuhu, 2010; Ayssiwede *et al*., 2011; Mutayoba *et al*., 2011). They were known to be very poor in anti-nutritional factors and have been used both in ruminants (Foidl *et al*., 2001; Sarwatt *et al*., 2002; Soliva *et al*., 2005) and in poultry or monogastrics feeding with various performance results depending on their nutritional value and inclusion level in the diet (Kaijage *et al*., 2003; Kakengi *et al*., 2007; Nuhu, 2010; Olugbemi *et al*., 2010a and 2010b). Ossebi (2010) had previously found that the inclusion of *Moringa* leaves meal in the diets of adult indigenous chickens up to 24% in partial substitution of groundnut cake meal, did not caused any adverse effect on nutrients retention and had significantly improved apparent coefficients of crude protein, energy and minerals utilization. The purpose of this study was then to evaluate the effects of *Moringa oleifera* leaves meal incorporation in the diets on growth performances, carcass and organs characteristics and economics results in growing indigenous Senegal chickens.

MATERIALS AND METHODS

Vegetable material and other ingredients used in experimental diets: The *Moringa oleifera* 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 in the neighbourhood villages' fields. Branches of plants bearing leaves were cut and transported to the ENSAT where they were displayed evenly under a semi-open shed for 1-2 days. The branches and twigs were then removed and the leaflets of the leaves were retrieved. They were sun-dried during 1-2 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 present in the leaves (Tangendjaja *et al*., 1984; Wee and Wang, 1987). These sun-dried leaves were then processed into meal using a grinder mesh of 4 mm in diameter. The leaves meal was packaged in bags of 50 kg and stored until use. The other ingredients used, reported in Table I, were bought at the markets of Dakar and Thiès. Samples of the various ingredients including *Moringa* leaves meal were subjected to proximate analyses before being used in the experimental diets formulation.

Proximate analyses and experimental diets formulation: Chemical analyses were carried out in the laboratory of food and animal nutrition of Dakar's Inter-states School of Sciences and Veterinary Medicine (EISMV). They were focused both on the various ingredients and the experimental diets and concerned the determination of Dry Matter (DM), total ash, Crude Protein (CP), Ether Extract (EE), Crude Fiber (CF) and minerals, particularly calcium and phosphorus. 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 using the Soxhlet apparatus described by the same standard. The CF determination was carried out following AFNOR (1993) standard based on the Weende's method. The calcium was 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). The Metabolizable Energy (ME) of experimental diets analyzed, was calculated according to the regression equations of Sibbald *et al*. (1980) cited by Leclercq *et al*. (1984). From the different ingredients analyses results (Ayssiwede *et al*., 2011 and 2010a), four approximately isonitrogenus and isocaloric experimental growing chickens diets (MO0, MO8, MO16 and MO24) were formulated to contain respectively 0, 8, 16 and 24% of *Moringa oleifera* leaves meal in a partial substitution to groundnut cake, major protein source of the diets. The ingredients composition and calculated nutritive value of these four *Moringa* experimental diets are presented in Table 1.

Table 1: Ingredients composition and calculated nutrients values of *Moringa oleifera* (MO) experimental diets for growing indigenous senegal chickens

Ingredients	Ingredients prices (FCFA[1]/kg)	Dietary treatments MO$_0$	MO$_8$	MO$_{16}$	MO$_{24}$
Yellow maize (%)	160.00	24.00	24.50	25.00	25.00
White sorghum (%)	150.00	16.00	13.10	12.00	9.00
Millet (%)	185.00	15.58	16.00	15.00	16.00
Groundnut oil (%)	1110.00	0.00	0.83	1.60	2.35
Wheat bran (%)	100.00	17.00	14.10	9.65	6.00
Groundnut cake (%)	150.00	23.00	17.20	14.00	10.40
Moringa leaves meal (%)	75.00	0.00	8.00	16.00	24.00
Fish meal (%)	415.00	0.10	2.62	3.42	4.30
Dicalcium phosphate (%)	184.00	1.40	0.50	0.65	0.55
Food chalk (%)	90.00	0.30	0.65	0.24	0.00
Lysine (%)	2480.00	0.32	0.20	0.14	0.10
Methionine (%)	4500.00	0.00	0.00	0.00	0.00
Macrovitamix (CMV) (%)	860.00	2.00	2.00	2.00	2.00
Liptol[2] (%)	1640.00	0.15	0.15	0.15	0.15
Fintox[3] (%)	1045.00	0.15	0.15	0.15	0.15
Total	-	100.00	100.00	100.00	100.00
Calculated nutrients values					
Dry matter, DM (%)		90.53	90.69	90.80	90.92
Crude protein, CP (% DM)		20.77	20.67	20.67	20.63
Ether extract, EE (% DM)		6.81	7.50	8.33	9.13
Crude fiber, CF (% DM)		4.93	5.12	5.25	5.46
Lysine (% DM)		0.93	0.92	0.92	0.94
Methionine (% DM)		0.40	0.42	0.42	0.42
Total ash (% DM)		6.12	6.90	7.49	8.05
Calcium, Ca (% DM)		1.03	1.05	1.05	1.05
Phosphorus, P (% DM)		0.70	0.68	0.69	0.69
Metabolizable energy, ME (kcal/kgDM)		3090.40	3128.23	3188.90	3242.30
[ME/CP] Ratio (kcal ME/g CP)		14.88	15.13	15.43	15.72

FCFA[1]: Money of the French Community of Africa, 1€ = 655.957 FCFA; MO$_0$: Control diet containing 0% of *Moringa oleifera* leaves meal); MO$_8$: diet containing 8% of *Moringa oleifera* leaves meal in substitution of groundnut cake; MO$_{16}$: diet containing 16% of *Moringa oleifera* leaves meal in substitution of groundnut cake; MO$_{24}$: diet containing 24% of *Moringa oleifera* leaves meal in substitution of groundnut cake; 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.

Liptol[2]: antifungal and antibacterial preservative.

Fintox[3]: preservative absorbing mycotoxins

Indigenous Senegal chicks production and management: The experimental birds were products of indigenous Senegal cockerels and hens and/or crosses between Blue Holland cockerels and local breed hens which were bought from four principal regions (Dakar, Thies, Louga and Kolda) of Senegal. The resulting eggs obtained from their breeding were collected for artificial incubation using an electronic incubator of 252 eggs capacity. After hatching, the ninety six (96) indigenous chicks obtained were confined and fed a commercial ordinary starter diet until five (5) weeks of age. The chicks were vaccinated against the Newcastle and Gumboro diseases. Amprolium 20%® or Anticox® was dissolved in the drinking water for 3 days to prevent avian coccidiosis, Piperazine-citrate® or Polystrongle® was given for 1-2 days against digestive tract parasites while Néoxyvital® or Coliteravet® was used for stress prevention. Globally, it have been applied to the birds the prophylactic measures against some common chicken diseases in Senegal according to the vaccination and disease control programme shown in Table 2.

Back ground, experimental design and data collection: The experiment was undertaken at the EISMV Breeding Application Centre located in Keur N'diaye LO, Rufisque department, in the Niayes area. It is an agro-ecological zone found at the outskirts of Dakar (30 km) characterized by a special microclimate with an average moderate temperature ranging from 24-28°C and an annual rainfall about of 620 mm. It is well suited to farming gardening and livestock activities and most of the industrial poultry farmers are located there. The trial was carried out from July to October 2010 and involved the 96 previous indigenous Senegal chicks of five (5)

Table 2: Vaccination and disease prophylactic control program applied to growing indigenous senegal chickens

Age of chicks (days)	Diseases	Veterinary products administrated
1	Newcastle disease	Imopest HB1 (oral tract)
1-4	Stress prevention	Néoxyvital (oral tract)
9	Bursitis Infectious (Gumboro)	Hipra-Gumboro-CH80 (oral tract)
9-11	Stress prevention	Néoxyvital (oral tract)
17-20	Avian coccidiosis	Amprolium 20% (oral tract)
21	Newcastle disease	Imopest HB1 (oral tract)
21	Bursitis infectious (Gumboro)	Hipra-Gumboro-CH80 (oral tract)
21-23	Stress prevention	Néoxyvital; Coliteravet (oral tract)
28-29	Digestive tract parasite	Pipérazine citrate+Amin Total (oral)
42-45; 63-65; 91-93	Avian coccidiosis	Anticox, Amprolium 20% (oral tract)
56-57; 84-85	Digestive tract parasite	Polystrongle+Amin Total (oral tract)

weeks old. At the end of the 5th week of age, the chicks were individually identified in their wing using a special bird ring and divided according to a completely randomized design into four dietary treatment groups, with 2 replicates of 12 birds for each treatment. The four treatment groups of birds, having substantially identical live body weight, were corresponded each to the four previous *Moringa* experimental diets: MO0, MO8, MO16 and MO24. Data collection started after the five weeks of age, i.e. from 6th to 17th week of age. For 12 weeks trial, the birds of each treatment groups were fed respectively with the corresponding *Moringa* experimental diets. During the first five days of the experiment, the birds receiving the *Moringa* leaves meal based diets (MO8, MO16 and MO24) were adapted to their feed by a gradual diet transition which consisted in linearly replacing of feed usually distributed by *Moringa* leaves based diets in the total daily feed offered. The birds were reared on ground litter constituting of wood chips in a semi-open house, with aluminum roof and double slope, where breeding standards (cooling, ventilation, water-troughs, feeders, etc...) were largely respected. They were lit by natural light during the day and by two artificial lights of 60 watts capacity at night. The density applied for the treatment groups was 8 birds/m^2. The feed were distributed to growing chickens twice a day (at 8 h AM and 5 h PM) in linear galvanized feeders while plastic siphon water-troughs of 5 liters capacity were used to provide them water *ad libitum*. During the experiment, the environmental factors in the trial local, certainly temperature and humidity were regularly measured and recorded using a thermo-hygrometer, as well as zootechnical parameters such as live body weight, feed consumption and chickens mortality. Monitoring of deaths and feed consumption (quantity of feed offered- feed refused) were done on a daily basis while the individual live body weights of birds were undertaken at weekly using an electronic scale SF-400.

Carcass and organs characteristics evaluation: At the end of the experiment (17 weeks old), 24 indigenous chickens (either 6 birds/treatment group) were randomly selected, weighed and killed by severing the jugular vein to assess the impact of *Moringa* leaves meal inclusion in the diets on carcasses and organs characteristics. Chickens slaughtered per dietary treatment were dipped in hot water, defeathered, eviscerated and their carcasses were weighed. Then the various organs identified in bird carcasses, especially liver, heart, lungs and spleen were also dissected, weighed separately and recorded per dietary treatment. The yellow coloration of the skin and abdominal fat of carcasses was measured using a similarly technical scoring applied by Kaijage *et al*. (2003) or Onibi *et al*. (2008) in which the score varied from 1 to 4 according to the intensity of the yellowing observed (1: no yellow color, 2: light to moderate yellow color, 3: enough to well yellow color and 4: intense to dark yellow color).

Zootechnical parameters and economics results determination: Data collected on live body weight, feed consumption, mortality, carcass weight, organs weight, yellow scores of the skin and abdominal fat, etc., were entered into the Microsoft Excel table and zootechnical parameters of birds were calculated. The economic appraisal of the experimental diets was made basis, firstly on the local market prices of various ingredients and by-products used (Table 1) during the period of the study to determine the feed price per kg diet and secondly, on feed costs per kg live body weight or per kg carcass and selling price per kg carcass of chickens. The *Moringa oleifera* leaves meal incorporated in the diets were not bought. But in assessing the feed price/kg experimental diet (MO0, MO8, MO16 and MO24) produced, a flat price of 75 FCFA/kg of sun-dried leaves was determined to take into account the opportunity cost induced by the time spent for their harvesting and processing. The Daily Feed Intake (DFI), Average Daily Weight Gain (ADWG), Feed Conversion Ratio (FCR), Dressing Carcass (DC), Mortality Rate (MR), as well as feed costs, selling price, Gross Margins Food (GMF) and profits or Supplementary Net Margins (SNM) generated per bird or per kg carcass were similarly determined and recorded per dietary treatment according to the formulas below:

DFI (g/bird/day) = [(Quantity of feed offered - Quantity of feed refused)/day ÷ Number of birds]
ADWG (g/day) = Weight Gain of the period (g) ÷ Length of the period (days)
FCR = Feed intake during a period (g) ÷ Weight Gain of the period (g)
DC (%) = (Carcass weight of the bird ÷ Live body weight of the bird)*100
MR (%) = [(Initial number of birds - Final number of birds) ÷ Initial number of birds]*100
Feed Cost/bird (FCFA) = FCR * Feed price/kg diet * Live body weight of bird (kg)
Feed Cost/kg carcass (FCFA) = [(Feed Cost/bird) ÷ Carcass weight of bird (kg)]
Selling price/bird carcass (FCFA) = Carcass weight of bird (kg) * Selling price/kg carcass
Gross margins food (GMF)/bird carcass (FCFA) = (Selling price/bird carcass) - (Feed Cost/bird)
Gross margins food (GMF)/kg carcass (FCFA) = (Selling price/kg carcass) - (Feed Cost/kg carcass)
SNM/kg carcass (FCFA) = (GMF/kg carcass/group) - (GMF/kg carcass of control group)

Treatment and statistical analyses: Data collected on birds performances and economics evaluation per dietary treatment were recorded and treated with Microsoft Excel table. They were then subjected to one factor analysis of variance (ANOVA) at 5% level ($p<0.05$) using the Statistical Package for Social Science (SPSS) software. When ANOVA analysis test showed significant dietary treatments effects between the results, means were completely separated using Duncan's Multiple Range Test of the same statistical software.

RESULTS

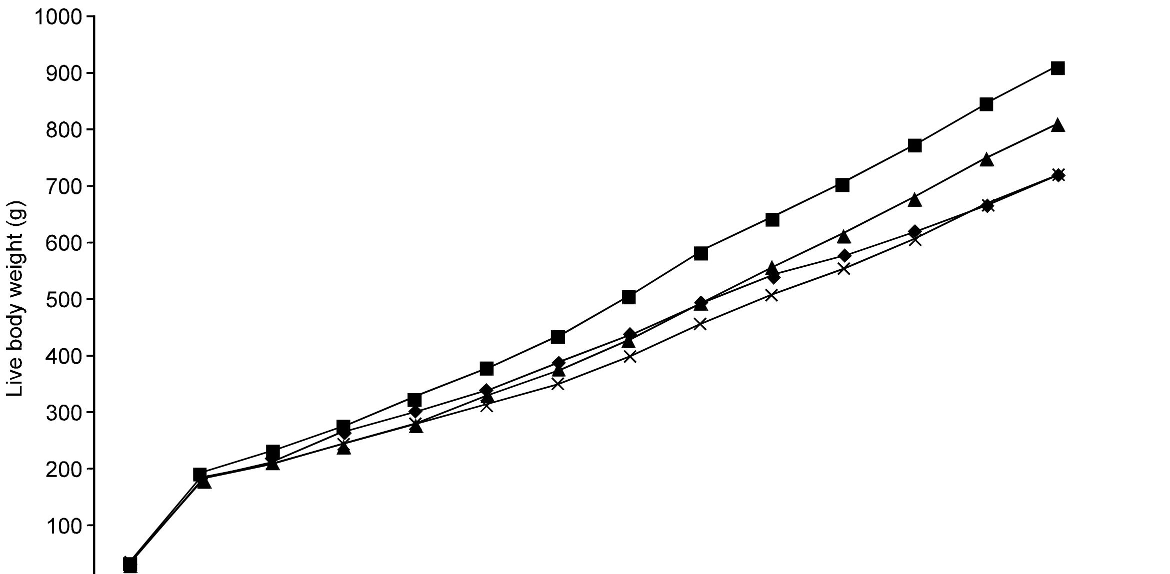
Ambiance parameters and nutrients composition of Moringa experimental diets: Although the experiment was started during the rainy season (July to October), the ambient temperature recorded in the breeding local of birds throughout the trial was relatively high ranging from 26.7-33.1°C, either an average of 29.79°C. The air humidity in the local meanwhile, ranged between 51 and 84% with an average about of 74%. The nutrients composition and calculated Metabolizable Energy (ME) content of *Moringa* experimental diets determined were reported in Table 3. From these results, it appears that *Moringa* leaves meal inclusion had significantly and proportionally increased the Crude Protein (CP), Ether Extract (EE) and ME contents in the diets while that of Nitrogen Free Extract (NFE) was decreased. However this significant difference did not negatively affect the [ME/CP] ratio values of the different experimental diets except that of MO_8 diet which was relatively higher (17.27) compared to others (17.19, 17.05 and 17.10 respectively for MO_0, MO_{16} and MO_{24} diets).

Growth performances, health status or mortality rate of indigenous Senegal chickens: The effects of *Moringa oleifera* leaves meal inclusion in the diets on Live Body Weight (LBW) development of growing indigenous Senegal chickens according to age are illustrated in Fig. 1. From the 5th to the 13th week of age, the LBW of birds in all dietary treatments increased similarly, but with a no significantly advantage in birds fed diet containing 8% of *Moringa* leaves meal (MO_8). From the 14th week until the end of the experiment (17 weeks old), the LBW advantage of birds fed MO_8 diet was maintained, followed by those fed the diet containing 16% of *Moringa* leaves meal (MO_{16}). The difference between LBW of indigenous chickens per treatment was significantly higher ($p<0.05$) only for MO_8 treatment group at 17 weeks of age compared to other dietary treatments, MO_0, MO_{16} and MO_{24}. Overall, the birds in MO_8 treatment group recorded the highest LBW (911.70 g), followed by those of MO_{16} treatment (812.85 g). The birds in MO_{24} treatment group had the lowest live body weight (720.05 g), but similar to that of the control group (721.60 g) at the end of trial. At 8, 12, 16 and 17 weeks old, the global LBW means recorded for all indigenous birds in the trial were respectively 296.00 g, 505.11 g, 733.98 g and 791.55 g (Table 4). The results of *Moringa* leaves meal inclusion on Average Daily Weight Gain (ADWG), Daily Feed Intake (DFI), Feed Conversion Ratio (FCR) and mortality rate of growing indigenous Senegal chickens are summarized in Table 4. For all dietary treatments, the ADWG of birds increased according to age. From one day to 9 weeks old, the ADWG were relatively low and were not significantly different between groups. From 10-17 weeks of age, the *Moringa* leaves meal inclusion in the diets significantly improved ($p<0.05$) the ADWG of growing indigenous chickens, particularly in birds fed MO_8 diet, followed by those in MO_{16} dietary treatment compared to other treatments. The increasing rate of ADWG were 35.34% and 17.44% respectively in birds fed MO_8 and MO_{16} diets compared to the control treatment birds which showed the lowest ADWG. For all the trial period, the ADWG recorded were 6.49, 8.77, 7.61 and 6.50 g/day respectively for birds in MO_0, MO_8, MO_{16} and MO_{24} dietary treatment groups; the global ADWG mean was 7.34 g/day. At one, two, three and four months of age, the global ADWG of all indigenous chickens in this trial were respectively 4.36, 5.53, 8.49 and 8.06 g/day (Table 4). From the 6th until the end of the trial, the Daily Feed Intake (DFI) were significantly higher ($p<0.05$) for birds in MO_0 (39.10 g) and MO_8 (39.76 g/bird) treatment groups than those of MO_{16} (36.28 g) and MO_{24} (34.24 g/bird) treatments. From the 6th to the 13th week of age, the *Moringa* leaves meal inclusion in the diets decreased significantly the DFI, particularly in birds fed MO_{16} and MO_{24} diets. But despite the significantly higher DFI recorded in birds fed *Moringa*

Table 3: Aanalyzed nutrients composition of *Moringa oleifera* (MO) experimental diets for growing indigenous Senegal chickens

	Dietary treatments			
Analyzed nutrients values	MO_0	MO_8	MO_{16}	MO_{24}
Number of samples	03	03	03	03
Dry matter, DM (%)	90.88±0.03^{a}	91.97±0.60^{a}	90.94±0.14^{a}	91.11±0.03^{b}
Crude Protein, CP (% DM)	20.40±0.08^{a}	20.72±0.05^{b}	20.98±0.03^{c}	21.02±0.05^{d}
Ether extract, EE (% DM)	4.82±0.07^{a}	6.01±0.15^{b}	6.60±0.40^{c}	7.60±0.03^{d}
Crude fiber, CF (% DM)	4.05±0.14	4.10±0.32	4.20±0.04	4.50±0.03
Nitrogen Free Extract, NFE (% DM)	62.24±0.05^{d}	60.78±0.24^{c}	59.50±0.90^{b}	57.86±0.09^{a}
Total Ash (% DM)	8.48±0.10	8.32±0.40	8.78±0.45	9.05±0.02
Calcium, Ca (% DM)	0.95±0.02^{ab}	0.90±0.03^{a}	0.97±0.03^{ab}	1.01±0.04^{b}
Phosphorus, P (% DM)	0.86±0.12^{b}	0.68±0.03^{a}	0.66±0.01^{a}	0.63±0.00^{a}
Metabolizable energy (kcal/kg DM)	3508.00±12.0^{a}	3579.00±22.4^{b}	3577.00±1.10^{b}	3593.00±0.30^{b}
[ME^1/CP] Ratio (kcal/g)	17.19±0.13^{ab}	17.27±0.10^{b}	17.05±0.03^{a}	17.10±0.05^{ab}

^{a,b,c,d}Means within rows with different superscripts are significantly different at 5% level ($p<0.05$). MO_0: Control diet containing 0% of *Moringa oleifera* leaves meal); MO_8: diet containing 8% of *Moringa oleifera* leaves meal in substitution of groundnut cake; MO_{16}: diet containing 16% of *Moringa oleifera* leaves meal in substitution of groundnut cake; MO_{24}: diet containing 24% of *Moringa oleifera* leaves meal in substitution of groundnut cake. Metabolizable Energie, ME^1 (kcal/kg DM) = 3951 + 54.4*EE - 40.8*Ash - 88.7*CF, in [Leclercq *et al*., 1984]



Age (weeks)	D1	5	6	7	8	9	10	11	12	13	14	15	16	17
MO_0	31.86	185.75	228.60	263.90	300.55	337.85	387.05	436.45	492.15	542.00	577.25	618.20	666.85	721.60
MO_8	31.86	185.70	231.05	274.40	323.50	378.40	434.70	506.25	583.80	644.05	703.50	775.35	847.40	911.70
MO_{16}	31.86	183.70	214.70	243.20	281.05	326.80	372.85	427.95	494.75	558.00	612.45	680.50	750.85	812.85
MO_{24}	31.86	182.33	211.85	244.83	278.90	313.78	352.30	400.55	457.75	508.95	556.95	607.33	670.80	720.05

Fig. 1: Evolution of live body weight of growing indigenous Senegal chickens fed diets containing respectively 0 (MO_0), 8 (MO_8), 16 (MO_{16}) and 24% (MO_{24}) of *Moringa oleifera* leaves meal according to age

leaves based diets than those in the control diet from the 14th to the 17th week of age, the significantly reduction of DFI was maintained for all the trial period with a decreasing rate of 13.16% and 18.52% respectively for MO_{16} and MO_{24} dietary treatments compared to the DFI of birds in control dietary treatment (MO_0). From the 6th to the end of the experiment, the inclusion of *M. oleifera* leaves meal in the diets had no significant adverse effects ($p>0.05$) on Feed Conversion Ratio (FCR) of growing indigenous Senegal chickens in different dietary treatments compared to the control. It had significantly reduced ($p<0.05$) the FCR in birds fed *Moringa* leaves based diets from 14-17 weeks of age compared to the control birds. For all the trial period, the birds in MO_8

Table 4: Effects of various levels of *Moringa oleifera* leaves meal inclusion in the diets on growth performances and mortality of growing indigenous Senegal chickens

Chickens parameters	Dietary Treatments MO_0	MO_8	MO_{16}	MO_{24}	Global mean	SEM	p-value
Initial number of birds/treatment	24.00	24.00	24.00	24.00	96.00	-	-
Live body weight at day one, D_1 (g)	31.86	31.86	31.86	31.86	31.86	0.00	1.000
Live body weight at 5 weeks old (g)	185.75±66.62	185.70±95.50	183.70±86.13	182.33±90.81	184.37±89.60	10.02	0.999
Live body weight at 8 weeks old (g)	300.55±70.62	323.50±151.28	281.05±92.64	278.89±87.52	296.00±102.68	14.83	0.697
Live body weight at 12 weeks old (g)	492.15±140.88	583.80±226.69	494.75±156.04	457.75±168.16	507.11±177.56	22.08	0.218
Live body weight at 16 weeks old (g)	666.85±167.01	847.40±279.10	750.85±287.48	670.80±203.02^a	733.98±219.45	27.89	0.070
Live body weight at 17 weeks old (g)	721.60±162.47^a	911.70±285.90^b	812.85±189.32^{ab}	720.05±206.61^a	791.55±223.44	28.33	0.048
ADWG 0-5 weeks old (g/day)	4.40±1.90	4.40±3.30	4.34±2.46	4.30±2.60	4.36±2.56	0.28	0.999
ADWG 6-9 weeks old (g/day)	5.43±2.06	6.88±3.20	5.11±2.92	4.70±1.93	5.53±2.66	0.30	0.051
ADWG 10-13 weeks old (g/day)	6.74±2.20^a	9.94±3.71^c	9.47±2.40^{bc}	7.83±3.05^{ab}	8.49±3.12	0.35	0.003
ADWG 14-17 weeks old (g/day)	6.80±2.15^a	9.60±2.88^b	8.56±2.65^{ab}	7.31±3.44^a	8.06±2.97	0.33	0.010
ADWG 6-17 weeks old (g/day)	6.49±1.76^a	8.77±2.80^b	7.61±2.04^{ab}	6.50±2.26^a	7.34±2.40	0.27	0.005
DFI 6-9 weeks old (g/bird/day)	29.97±3.08^c	27.58±1.66^b	25.51±1.02^a	26.68±4.18^{ab}	27.43±3.18	0.35	0.000
DFI 10-13 weeks old (g/bird/day)	36.02±5.31^b	36.80±2.87^b	31.28±3.03^a	29.35±3.90^a	33.36±4.96	0.55	0.000
DFI 14-17 weeks old (g/bird/day)	51.27±4.33^b	54.92±6.30^c	52.04±4.85^{bc}	46.70±6.19^a	51.23±6.14	0.68	0.000
DFI 6-17 weeks old (g/bird/day)	39.10±4.24^b	39.76±3.61^b	36.28±2.97^a	34.24±4.76^a	37.34±4.47	0.50	0.000
FCR 6-9 weeks old	7.29±2.91	5.83±3.49	7.72±3.50	7.62±4.21	7.12±3.57	0.40	0.311
FCR 10-13 weeks old	6.19±3.29	4.57±1.74	4.48±1.87	6.57±4.93	5.46±3.30	0.37	0.090
FCR 14-17 weeks old	9.27±3.39^b	6.85±2.45^a	6.13±1.53^a	7.54±2.64^a	7.45±2.80	0.31	0.002
FCR 6-17 weeks old	7.58±2.62	5.75±2.11	6.11±1.70	7.24±3.11	6.67±2.51	0.28	0.059
Final number of birds/treatment	20.00	24.00	22.00	23.00	89.00	-	-
Mortality rate (%)	16.66^d	0.00^a	8.33^c	4.16^b	7.28	1.41	0.000

^{a,b,c,d}Means within rows with different superscripts are significantly different at 5% level (p<0.05). MO_0: Control diet containing 0% of *Moringa oleifera*leaves meal); MO_8: Diet containing 8% of *Moringa oleifera* leaves meal in substitution of groundnut cake; MO_{16}: Diet containing 16% of*Moringa oleifera* leaves meal in substitution of groundnut cake; MO_{24}: Diet containing 24% of *Moringa oleifera* leaves meal in substitution of groundnut cake. ADWG: Average Daily Weight Gain; DFI: Daily Feed Intake; FCR: Feed Conversion Ratio

dietary treatment had recorded the lowest FCR (5.75), followed by those in MO_{16} (6.11), MO_{24} (7.24) and MO_0 (7.58) treatment groups; the global FCR mean was 6.67. The non significant decreasing rate of FCR were 24.14%, 19.39% and 4.48% in birds fed diets containing respectively 8, 16 and 24% of *Moringa* leaves meal compared to the control birds.

The *Moringa* leaves meal inclusion in the diets did not cause any adverse effects on health and indigenous chickens' mortality. It would rather reduce their mortality rate compared to the control group. Indeed, from the one to the 13th week of age, birds in different dietary treatments showed no health problems. During the 14th week of age, it was noted some mortality cases of birds, particularly in the control group (4 deaths, either 16.66%), followed by the MO_{16} (2 deaths, i.e. 8.33%) and MO_{24} (1 death, i.e. 4.16%) treatment groups despite the disease prophylactic program applied. Any mortality was not recorded among indigenous chickens in MO_8 treatment group. The fowlpox disease was suspected to be the probable cause of these 7 mortalities (7.28%) recorded during the trial with the high mortality rate in birds fed the control diet (MO_0).

Carcass and organs characteristics and economics results of indigenous senegal chickens: The results related to the impacts of *Moringa* leaves meal inclusion in the diets on carcass and organs characteristics and economic margins of growing indigenous Senegal chickens are summarized in Table 5. Except the lungs and spleen's weight which was significantly increased in birds fed MO_8 and MO_{16} diets, the inclusion of *Moringa* leaves meal had no adverse effect on dressing carcass, liver weight, heart weight, all organs (liver, heart, lungs and spleen) weight and the ratio [organs weight/live body weight] of birds fed *Moringa* leaves based diets compared to the control group. It globally had a no significant improvement in whole organs weights and this increasing of organs (liver, heart, lungs and spleen) weight was proportional to the live body weight of indigenous chickens. Moreover, the *Moringa* leaves meal inclusion in the diets had produced significantly and proportionally yellow coloration of the skin and abdominal fat (Fig. 2) of carcasses in traditional chickens compared to the control treatment. As for economic results, the price per kilogram of feed had increased with the level of *Moringa* leaves meal inclusion in the diets. It was evaluated at 175, 182, 186 and 191 FCFA/kg respectively for the MO_0, MO_8, MO_{16} and MO_{24} diets. The feed costs per kg carcass obtained were significantly different between all treatment groups. Birds fed the diet containing 24% of *Moringa* leaves had recorded the highest feed cost (1795 FCFA/kg carcass) while the lowest (1369 FCFA/kg carcass) was obtained in MO_8 dietary treatment, followed by MO_{16} (1520 FCFA/kg carcass) and MO_0 (1726 FCFA/kg carcass) treatments. For a selling price of 2000 FCFA/kg of carcass, the Gross Margins Food (GMF)/kg carcass generated per dietary treatment were significantly different (p<0.05): 274, 631, 480 and 205 FCFA/kg carcass respectively for

Table 5: Effects of various levels of *Moringa oleifera* leaves meal inclusion in the diets on carcass and organs characteristics and economics results of growing indigenous senegal chickens

Parameters	Dietary treatments MO$_0$	MO$_8$	MO$_{16}$	MO$_{24}$	Global mean	SEM	p-value
Birds killed/treatment	5.00	5.00	5.00	5.00	20.00	-	-
Carcass and organs characteristics							
Average live body weight of bird (g)	719.40±142.47^a	969.60±245.60^b	813.00±196.74^{ab}	763.60±265.64^a	816.40±222.17	49.68	0.049
Average carcass weight (g)	553.40±108.42	742.40±195.71	609.80±152.94	592.40±218.06	624.50±175.47	39.24	0.373
Dressing (%)	76.98±1.84	76.48±1.98	74.90±1.16	77.20±2.06	76.39±1.89	0.42	0.212
Liver weight, LW (g)	19.60±2.30	25.40±7.63	22.20±4.97	20.00±5.24	21.80±5.47	1.22	0.335
Heart weight, HW (g)	3.60±1.14	4.20±1.79	3.60±1.34	3.62±1.16	3.75±1.29	0.29	0.869
Lungs+Spleen weight, LSW (g)	4.20±1.30^a	8.40±2.19^b	6.40±2.07^{ab}	7.20±2.86^{ab}	6.55±2.54	0.57	0.048
Liver+Heart+Lungs+Spleen weight (g)	27.40±3.05	38.00±11.34	32.20±7.56	30.80±8.76	32.10±8.52	1.90	0.269
[(LW+HW+LSW)/ALBW] ratio (%)	3.88±0.54	3.88±0.48	3.96±0.19	4.11±0.48	3.96±0.42	0.09	0.827
Yellow color score of skin	1.00±0.00^a	1.20±0.44^a	1.40±0.54^a	2.40±0.54^b	1.50±0.68	0.15	0.001
Yellow color score of abdominal fat	1.00±0.00^a	1.00±0.00^a	1.60±0.54^b	2.80±0.44^c	1.60±0.82	0.18	0.000
Economics results							
Experimental feed price (FCFA[1]/kg)	175.00	182.00	186.00	191.00	184.00	-	-
Feed cost/bird, 6-17 weeks old (FCFA)	956±189	1015±257	925±224	1057±368	988±251	56.0	0.865
Feed cost/kg carcass (FCFA)	1726±42^c	1369±35^a	1520±24^b	1795±47^d	1602±176	39.0	0.000
Selling price/kg carcass (FCFA)	2000.00	2000.00	2000.00	2000.00	2000.00	-	-
Selling price/bird carcass (FCFA)	1107±217	1485±391	1220±306	1185±436	1249±351	78.0	0.373
Gross margin food/bird (FCFA)	151±38^a	470±138^c	294±83^b	127±75^a	261±163	36.0	0.000
Gross margin food/kg carcass (FCFA)	274±42^b	631±35^d	480±24^c	205±47^a	398±176	39.0	0.000
SNM/kg carcass[2] (FCFA)	0.00^a	357±51^c	206±32^b	-68±84^a	124±179	40.0	0.000

[a,b,c,d]Means within rows with different superscripts are significantly different at 5% level ($p<0.05$), MO$_0$: Control diet containing 0% of *Moringa oleifera* leaves meal; MO$_8$: diet containing 8% of*Moringa oleifera* leaves meal in substitution of groundnut cake; MO$_{16}$: diet containing 16% of*Moringa oleifera* leaves meal in substitution of groundnut cake; MO$_{24}$: diet containing 24% of *Moringa oleifera* leaves meal in substitution of groundnut cake. ALBW: Average Live Body Weight.

FCFA[1]: Money of the French Community of Africa, 1€ = 655.957 FCFA.

SNM[2]: Supplementary net margin generated in comparison to the control

Fig. 2: Normal color (left pictures) and intense yellow color (right pictures) of skin (1st line pictures) and abdominal fat (2nd line pictures) of carcasses of growing indigenous Senegal chickens fed diets containing respectively 0 (MO$_0$) and 24% (MO$_{24}$) of *Moringa oleifera* leaves meal

birds in MO_0, MO_8, MO_{16} and MO_{24} dietary treatments. Compared to the control dietary treatment, the MO_8 and MO_{16} treatments had allowed achieving respectively an additional net margin of 357 and 206 FCFA/kg carcass while the MO_{24} treatment had resulted in a loss of 68 FCFA/kg carcass (Table 5). From these results, it appears that apart from the significant yellowing of skin and abdominal fat, the inclusion of *Moringa* leaves meal up to 24% in the diets, had no adverse effect on carcass and organs characteristics of growing indigenous Senegal chickens and was more economically profitable at the rate of 8 and 16% inclusion.

DISCUSSION

The temperature (26.7-33.1°C) and air humidity (51-84%) obtained in this study were higher than the ambient parameters (19-27°C and 40-70%) recommended by Bordas and Minvielle (1997), Rekhis (2002) and ITAVI (2003). These high ambient parameters values recorded could be explained by the fact that in Senegal the period from July to October during which the trial was undertaken corresponded to a particularly hot and rainfall season. The significantly higher Ether Extract (EE) and Metabolizable Energy (ME) contents recorded in *Moringa* leaves based diets than the control may be explained by the increasing contribution of ground nut oil in the diets with the incorporation of *Moringa* leaves meal. These latter being less energetic, the gradual increase of their inclusion had decreased the ME content of the diets (Ossebi, 2010). However, because of the increasing of Crude Protein (CP) content in experimental diets, this difference obtained between their ME content did not negatively affect the [ME/CP] ratios which remained almost similar except for the MO_{16} diet.

For all experimental period (6-17 weeks of age), the inclusion of *M. oleifera* leaves meal in the diets had no adverse effects on Live Body Weight (LBW), Average Daily Weight Gain (ADWG), Feed Conversion Ratio (FCR) and mortality of growing indigenous Senegal chickens compared to the controls. It had improved the LBW and ADWG significantly ($p<0.05$), reduced but not significantly the FCR of birds in MO_8 and MO_{16} treatments compared to the control and MO_{24} treatments. These observations were similar to those obtained by Tendonkeng *et al*. (2008) and Olugbemi *et al*. (2010a and 2010b) by including *Moringa* leaves meal in broilers and laying birds diets up to 5-10%. The Daily Feed Intake (DFI) significantly decreased with the *Moringa* leaves meal inclusion, particularly in MO_{16} and MO_{24} treatments. This finding is in line with those of Gupta *et al*. (1970) and Suliman *et al*. (1987) who observed a significant decrease in DFI by including respectively 10% of raw and 5% of fermented *Cassia tora* leaves meal, Ravindran *et al*. (1986) and Iheukwumere *et al*. (2008) with 10% inclusion of cassava (*Manihot esculenta*) leaves meal in the rations of chickens. It is the same with those obtained with *Leuceana leucocephala* (D'Mello *et al*., 1987; Bhatnagar *et al*. 1996; Mutayoba *et al*., 2003; Atawodi *et al*. 2008) or *Gliricidia sepium* (Osei *et al*., 1990; Odunsi *et al*., 2002) leaves meal incorporation in the diets for chickens and laying hens. The low performance or DFI obtained with *Leuceana* or *Gliricidia* leaves have been attributed by the authors (D'Mello, 1992; Bhatnagar *et al*. 1996; Odunsi *et al*., 2002; Atawodi *et al*. 2008) to the presence of anti-nutritional factors, especially mimosine and tannins. However, *Moringa* leaves are known to be very poor in anti-nutritional factors (Makkar and Becker, 1996 and 1997), the reduction of DFI in our study could be explained, firstly by the ME content and secondly by the palatability of the diets. The DFI regulation being primarily energetic in poultry, it appears to be normal that the *Moringa* leaves based diets more energetic (Table 3) should be less consumed than the control diet. But according to some authors (Ash and Petaia, 1992; Omekam, 1994; Foidl *et al*., 2001), chickens did not eat voluntarily fresh or dried legumes leaves and could often showed a decline in their performances, particularly DFI due to the lack of appetite when fed diet containing high level of leaves. This is disagreement with the findings of Kakengi *et al*. (2007) and Olugbemi *et al*. (2010a) or Ravindran *et al*. (1983) in which the DFI had significantly increased respectively with the *Moringa* or cassava leaves meal inclusion levels in the diets.

The Live Body Weight (LBW) means of 296.00 g, 505.11 g and 733.98 g globally recorded respectively at 8, 12 and 16 weeks old for indigenous chickens in this study are consistent with those obtained (242-358, 381-588 and 541-826 g) in Senegal (Missohou *et al*., 2002), Tanzania (Msoffe *et al*., 2004), Nigeria (Adedokun and Sonaiya, 2001; Fayeye *et al*., 2005) and in Ethiopia (Halima *et al*., 2007b). The LBW mean 791.55 g (720-912 g) obtained at 17 weeks of age is in line with that of Pousga *et al*. (2006) in Burkina Faso, but higher than that found at 18 weeks of age (600-783 g) by Mohammed *et al*. (2005) in Sudan. However, these LBW recorded at 8, 12 and 16 weeks of age are lower than those obtained in station at the same ages in Cameroon and Congo (384-511, 467-622, 782-1102 g) by Fotsa (2008) and Akouango *et al*. (2010), in Senegal (525-617-4, 718-847 and 954-1040 g) by Ali (2001) and in Nigeria (480, 821 and 1035 g) by Adebanjo and Oluyemi (1981). Also, similarly higher LBW (800-838 g and 1677-1724 g) were found respectively at 12 and 19 weeks of age by Ndegwa *et al*. (2001) in Kenya. The Average Daily Weight Gain (ADWG) mean, 7.34 g/day (6.49-8.77) obtained in traditional chickens in our study is in agreement with those found by most authors (Buldgen *et al*., 1992; Adedokun and Sonaiya, 2001; Ali, 2001; Msoffe *et al*., 2004; Pousga *et al*., 2006; Halima *et al*. 2007b; Akouango *et al*., 2010). However, it remained lower than those (7-12 g/day) recorded in Cameroon (Fotsa, 2008) and in Nigeria (Adebanjo and Oluyemi, 1981). These variations could be explained not only by feeding or breeding conditions, geographical or seasonal differences of areas, but also by age, sex, diversity or genetic variability existence in the indigenous African chickens' population. Our experiment birds containing some crosses from blue Holland cockerels and local hen, the ADWG was often higher in crosses or males' chickens than in pure local breeds or females, lower in scavenging birds than housed and regularly fed birds (Buldgen *et al*., 1992; Pousga *et al*., 2006; Halima *et al*. 2007a,b). It was also shown that indigenous chickens with such fast fledge grow slower than slow ones fledge (Fotsa, 2008).

The Daily Feed Intake (DFI) mean 37.34 (34-40 g/jour) obtained from the 6th until the end of the trial (17 weeks old) is consistent with those recorded by Buldgen *et al*. (1992), Fall and Buldgen (1996), Pousga *et al*. (2006), Halima *et al*. (2007b), but remains relatively lower than those found by Ali (2001), Ayssiwede *et al*. (2010a and 2010b) and Ossebi (2010). Indeed, the DFI of village chickens from 0-24 weeks of age was ranged from 5 to 98 g/day (Buldgen *et al*., 1992; Halima *et al*., 2007b) while from 6 to 17 weeks of age, it was about of 36-48 g/day (Fall and Buldgen, 1996; Pousga *et al*., 2006; Halima *et al*., 2007b). The DFI varies according to age, ambient temperature, nature and energy level of the diet. In adults village chickens, it was higher, 62-72 g of medium to high-energy (2600-3000 kcal ME/kg DM) diets and 88 g/day of low-energy (2400 kcal ME/kg DM) diet with a Feed Conversion Ratio (FCR) respectively about of 5.6-7.4 and 12.8 (Ali, 2001; Ayssiwede *et al*. 2010a and 2010b; Ossebi, 2010). The FCR recorded 6.67 (5.75-7.58) in this study is globally similar to those obtained by most authors (Buldgen *et al*., 1992; Pousga *et al*., 2006; Ayssiwede *et al*., 2010a and 2010b; Ossebi, 2010). But it is relatively higher than that (3.9-5) recorded by Fotsa (2008) in Cameroon and lower than those (7.4-12.8) found by Ali (2001) in Senegal and Halima *et al*. (2007b) in Ethiopia by providing ordinary feed to these birds.

The *Moringa* leaves meal inclusion in the diets globally had no adverse effect on dressing carcass. It had a no significant improvement in whole organs (liver, heart, lungs and spleen) weight and this increasing of organs weight was proportional to the live body weight of the indigenous chickens. Dressing carcass obtained in this study 76.39% (74.9-77.20%) is similar to those recorded in Congo (71.5-78.4%) by Akouango *et al*. (2010), in Burkina (66-80%) by Kondombo (2005) and in Senegal (67-79%) by Ali (2001) and Buldgen *et al*. (1992). But it is higher than those obtained in Nigeria (54-68.5%) by Adebanjo and Oluyemi (1981) and Joseph *et al*. (1992) and in Ethiopia and Cameroon (62-64%) by Halima *et al*. (2007b) and Fotsa (2008). The liver weight obtained in this study, 21.80 g (19.86-25.40 g) is higher than that recorded by Fotsa (2008) at 16 weeks of age while the heart weight, 3.75 (3.60-4.20 g) remained below that (4.75 g) of this author. These variations could be due to the age, live body weight and sex of birds, type of carcass, chicken ecotypes or seasons. Cockerels often having higher Dressing Carcass (DC) than hens, the prevalence of male chickens in groups can increase the DC mean and reciprocally. Also, organs development is often proportional to live body weight or age. Kondombo (2005) had shown that the DC of traditional chickens slaughtered in dry season was higher than that of birds killed in rainy season. Moreover, *Moringa* leaves meal inclusion had produced significantly and proportionally yellow coloration of skin and abdominal fat in carcasses of growing traditional chickens compared to the control treatment group. According to the ecotypes of indigenous chickens, white (44%), pink (22%), yellow (28%) or black (7%) pigments of skin of carcasses were reported by Moula *et al*. (2009) in Algeria. However, the yellowing of the skin, abdominal fat or egg yolk may be influenced by the diet composition in xanthophylls pigments (Talpin *et al*., 1981; D'Mello *et al*., 1987; Surai *et al*., 2001; Agbede and Aletor, 2003). The yellowing observed in our study probably indicates that *Moringa oleifera* leaves are rich in pro-vitamins A or carotenoids pigments which were efficiently absorbed and utilized by the birds. This observation is supported by the findings of Kaijage *et al*. (2003), Olugbemi *et al.* (2010a and 2010b) in which the *Moringa* leaves meal inclusion about 10-20% in the diet of laying or broiler chickens had significantly and proportionally increased the yellowing of skin, abdominal fat and egg yolk. Similar results were recorded by Talpin *et al*. (1981), Quang Hien and Duc Hung (1998) or Onibi *et al*. (2008) with the inclusion of 6-20% of *Leuceana* or *cassava* leaves meal in the diets of laying and broiler chickens.

Unlike to Onibi *et al*. (2008), our feed price/kg diet increased with the inclusion level of *Moringa* leaves meal in the diet, ranging from 175 FCFA/kg (control diet, MO_0) to 191 FCFA/kg (MO_{24} diet). This controversy could arise from the fact that Onibi *et al*. (2008) had excluded the opportunity cost of harvesting and processing of leaves. However this price was lower than that (240-280 FCFA/kg) practiced in Senegalese markets for the industrial poultry feed. For all the experimental period, except the MO_8 treatment which had the lowest feed cost (1369 FCFA/kg carcass), followed by MO_{16} (1520 FCFA/kg carcass), the feed costs were significantly higher, 1726 and 1795 FCFA/kg carcass respectively in control and MO_{24} treatment groups. As a result, Gross Margin Food (GMF)/kg carcass was significantly higher in MO_8 treatment (631 FCFA) and decreased with the rate of *Moringa* leaves meal in the diet, 480 and 205 FCFA/kg carcass respectively in MO_{16} and MO_{24} while that of the control was 274 FCFA/kg carcass. Thus, compared to the control, the MO_8 and MO_{16} dietary treatments had allowed realizing respectively a

Supplementary Net Margin (SNM) of 357 and 206 FCFA/kg carcass while the MO24 treatment had resulted a loss of 68 FCFA/kg carcass. These results are in line with those obtained by Quang Hien and Duc Hung (1998) and Quang Hien and Thi Inh (1998) in which the inclusion of 5-6% of *Leuceana* leaves treated with ferrous sulphate in the diets had significantly reduced the feed costs/kg LBWG or kg egg produced respectively in broiler and laying chickens. They are also supported by the findings of Onibi *et al*. (2008) in Nigeria or Tendonkeng *et al*. (2008) in Cameroon in which the feed costs/kg LBW of broiler finishers were increased with *Leuceana* or *Moringa* leaves meal inclusion in the diets. The increasing of feed price and feed costs along with reduction of economic margins can be explained by the influence of the high price of groundnut oil incorporated, the opportunity cost of harvesting and processing leaves and the feed conversion ratio increasing recorded with *Moringa* leaves meal inclusion.

Conclusion: The inclusion of *Moringa oleifera* leaves meal up to 24% in the diet of growing traditional Senegal chickens had no negative impact on live body weight, average daily weight gain, feed conversion ratio, carcass and organs characteristics, health and mortality rate in birds compared to their controls. Except the significant decrease of daily feed intake observed in MO_{16} and MO_{24} dietary treatment groups, significantly better growth performances, feed costs and economic margins were recorded in growing indigenous chickens fed diet containing 8% and 16% of *Moringa oleifera* leaves meal, making these dietary treatments the most economically profitable. Considering these results and the high price of raw ordinary ingredients, particularly protein ingredient sources in poultry feeding; the recovering of these leguminous leaves in the diets of village chickens is a real opportunity for traditional stockholders to improve at lower cost, not only the productivity and nutritional status of their birds but also their income.

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