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Effect of meal from the leaves of *Manihot esulenta* and *Tithonia diversifolia* as a protein substitute to soybean cake in the diet on growth and laying performances, egg quality of local hen (*Gallus gallus*) in the Sudano-guinean zone

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Abstract

The leaves of *Manihot esculenta* and *Tithonia diversifolia* are valuable protein and mineral supplement for local chickens. The evaluation of the effect of the incorporation of meals from the leaves of these plants in the diet of the local laying hen on growth and laying performances, and quality of eggs was investigated. Fourty five hens and nine cocks local breeds were weighed and randomly distributed to three dietary treatments: RWL, RML and RTL which contained no leaves (control/RWL), meals of *M. esculenta* (RML) and *T. diversifolia* (RTL) included in the same proportion (7%). Each treatment was replicated 3 times in a completely randomized design. The hens were subjected to natural mating, eggs laid were collected according to breeding groups hatched and analyzed. Feed intake was comparable ($p>0.05$) between treatment groups as from the 4th week till the end of the experiment. Average daily gain and Laying rate evolved in a sawtooth-like manner regardless of the treatment considered. Hens fed RML recorded lowest (week 3) ($p<0.05$) and highest (weeks 6, 7, 12) ($p<0.05$) Feed conversion ratio. Hens in the control recorded higher ($p<0.05$) egg weight, egg shape index, width and laying rate but lowest ($p<0.05$) egg length. Fertility, hatchability, embryo mortality and chemical composition of eggs were similar ($p>0.05$) in all treatments. This study suggest that dried leaves of *M. esculenta* and *T. diversifolia* can be used as protein sources in local chicken's feed during laying.

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Introduction

The indigenous chicken (*Gallus gallus domesticus*) is a domesticated fowl and globally spread with a worldwide population of more than 24 billion in 2003 (Addass *et al*., 2012). Approximately 80% of poultry in Africa are raised in rural areas where they contribute substantially to egg and meat (Addass *et al*., 2012). In Cameroon, the breeding of indigenous chicken is practiced by more than 70% of the rural population and constitutes approximately 56 to 70% of the national herd (Fotsa and Manjeli 2001). Indigenous chickens in Africa are increasingly being preferred for consumption by consumers due to their unique organoleptic properties such as taste, flavour, darker cooked meat colour, chewy texture and low chemical contamination when compared to commercial chickens (Chumngoen and Tan 2015; Magala *et al*., 2012; Odunitan-Wayas *et al*., 2018). Village chickens are the supreme domestic animals that can endure heat, cold, wet and drought. They can survive in poor housing in sheltered or unsheltered cages or roosting in trees (Hlabano 2017).

Despite the importance of these indigenous chickens their productivity has been hindered by many constraints, including poor management practices in particular the lack of proper healthcare, poor nutrition and housing. Chickens reared under a free-range system do not meet their nutrient requirements. Indeed, at smallholders level, these birds depend primarily on scavenging feed resources and may occasionally benefit from kitchen wastes and left overs, which may be highly variable and inadequate in nutrient supply (Kingori, *et al*., (2010). Moreover, supplements offered to birds in traditional farms, such as cereals and their by-products, or various products ingested through scavenging cover mainly energetic requirements, proteins being limited. On the other hand, poor resource farmers cannot afford to buy concentrated feed to supplement their chickens and therefore accentuating the low performance of their chickens. Hence, there is a need to identify protein source or non-conventional feed ingredients that are available at village level and that can be used in place of soybean to supplement protein in order to improve productivity of indigenous chickens (Kingori *et al*., 2007; Hlabano, 2017) without unnecessary higher cost implication.

Africa and in particular Cameroon abounds in various plants that are not or under-valued in terms of their nutritional values. This is the case with *Manihot esculenta* and *Tithonia diversifolia* which leaves are known for their rich content in protein: 14-40% DM (Oluwatoyin 2010, Udo and John 2015) for the former, 22.15-28% DM (Jama *et al.* 2000; Wambui *et al* 2006) for the latter and also in minerals and vitamins. Despite the interesting chemical characteristics of the leaves of these two plants, the anti-nutritional factors present in these leaves limit their wide use in animal feed which can be overcome by sun drying (Togun and Olabanji 2006; Dahouda *et al*., 2009). The work carried out by several authors, both in poultry farming and in other types of farming, has shown that the incorporation of these leaves at low rates has improved the reproduction and production performances of the animals (Dahouda *et al.* 2009; Ramírez-Rivera *et al*., 2010; Houndonougbo *et al*., 2012; Ekeocha and Afolabi 2012; Buragohain and Kalita 2015; Mweugang *et al*., 2014, 2016; Buragohain 2016; Okedu *et al*., 2019). Although these plants have been used in animal feed, very few studies have investigated their use in local hens. Thus, this work aims to promote the use of dried leaves of *Manihot esculenta* and *Tithonia diversifolia* as alternative sources of proteins in the diet of local hens.

Materials and methods

Study Site

The study was conducted at the University of Ngaoundere, capital of the Adamawa region in Cameroon. This town is located between the 6th and 8th degrees of North latitude and between the 11th and 15th degree of East longitude on the Adamawa ridge. Ngaoundere is a transition zone between the northern lowlands and the southern Cameroon plateau. This position gives it a Sudano-Guinean climate with a rainy season of 8 months, from April to November and a dry season of 4 months, from December to March.

The plant cover consists of Sudano-Guinean shrub savannah. The annual rainfall varies between 900 and 1500mm. Average temperatures vary between 23 and 25°C. The region of Adamawa, thanks to its climate and its vegetation cover, is a zone of strong potentialities.

Collection of Cassava (M. esculenta) and Mexican sunflower (T. diversifolia) leaves and preparation of their meals

The leaves of cassava (*M. esculenta*) and those of Mexican sunflower (*T. diversifolia*) were collected from different locations around the University of Ngaoundere, Cameroon. The leaves harvested at the pre-flowering stage were separated from stems, pooled together and sun-dried until the leaves become crispy while still retaining the greenish coloration. The dried leaves were then milled using a hammer grinding machine to produce leaf meal and stored in airtight condition until utilization.

Animal, housing and experimental design

A total of 45 hens (1120±0.45g) and 09 cocks (1734±0.25g) purchased from local markets of Ngaoundere were randomly divided in to three dietary treatment groups. Each treatment contained 15 hens with three replicates each and there were 5 birds per replicate.

The birds were reared on deep litter (10cm) in mesh boxes of 2.2m long, 1.9m wide and 2.45m high and equipped with laying nests measuring 35x38x30cm (depth, height and width respectively) all mounted in a house (9m long and 4m wide) built in hard, the upper third being made of wire mesh to allow good ventilation and sufficient natural light.

A ratio of 1:5 (cock: hen) for natural mating was used. The experimental groups were designated as RWL (Diet without cassava and Mexican sun flower leaves meal), RCL (Diet with cassava leaf meal) and RTL (Diet with Tithonia leaf meal). The experiment lasted for a period of 03 months and animals have been regularly vaccinated and dewormed against the main avian pathologies (Infectious bronchitis, Newcastle disease, Gumboro disease and Coccidiosis).

Diet formulation and feeding management

Three experimental iso-nitrogenous diets (RWL, RML and RTL) in which soybean was completely replaced by meals from *M. escuenta* (MLM) and *T. diversifolia* (TLM) leaves were formulated to meet the nutritional requirements of birds according to the standards of NRC (1994).mLM and TLM were incorporated in diets at 0% (RWL-0), 7% (MLM-7), 7% (TLM-7) level of the total diet. The quantities of conventional ingredients (maize, maize bran, soybean cake, fish meal, calcium carbonate, and premix 2% for laying) were adjusted to balance the diets. These diets were fed along the experimental period (Table 1). The total amounts of feed offered and residue left within 24 h were recorded daily for calculation of average daily feed intake. The individual body weights were taken at weekly interval.

Table 1. Percentage composition of the experimental diets.

Ingrédients	RWL	RML	RTL
Maize	58	61	57
Maize bran	15	09	13
Soybean cake	09	00	00
Fish meal	07	12	12
Bone meal	01	01	01
Calcium Carbonate	08	08	08
Cassava leaf meal	00	07	00
Tithonia leaf meal	00	00	07
Premix 2%	02	02	02
Total	100	100	100
Calculated chemical composition			
ME (Kcal/Kg MS)	2571,22	2492,09	2591,27
CP	15,85	15,67	15,52
E/P	163,16	157,46	164,85
Ca/P	1,14	1,43	1,51

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Characterization and incubation of eggs

The eggs were collected daily and placed in separate cells per batch. The number of eggs laid in the different batch was recorded daily. Five (05) eggs from each batch were then chosen by random draw each week for metric measurements (length and width) carried out using a digital caliper with a range of 0-150mm and precision 0, 01mm. At the end of the experiment, 6 fresh eggs per batch (2 eggs per subgroup) were chosen for chemical composition determination.

After removing cracked and abnormal size eggs, these eggs were set in a 264-egg capacity incubator. Candling was done on the 10^{th} and 18^{th} day of incubation and all clear eggs and dead embryos removed. All unhatched eggs were inspected for evidence of embryo development and embryo mortality (Saleh *et al.* 2017).

Data collection

Feed intake (FI), Average daily gain (ADG), total gain (TG) and Feed conversion ratio (FCR) were determined according to the formulas:

- ✓ FI (g) = (Quantity of food served - Quantity of food refused) / Number of subjects;
- ✓ TG (g) = Weight of the animal at the end of the period considered weight of the animal at the start of the considered period;
- ✓ ADG (g / d) = TG / duration of the considered period;
- ✓ FCR (g/d) = TG/FCR (g/g) = Food consumption during a period (g) / Mass of eggs laid during the period (g) of the considered period.

The laying rate (LR) was determined according to the formula (Sauveur 1988):

- LR (%) = [Q / (n1 + n2 +... + nk)] × 100, with: Q = total number of eggs produced by treatment and n1 + n2 +... + nk = sum of the numbers of hens present each day of the day 1 to day k.

The number of eggs laid per hen and per day was determined according to the formula:

- Number of eggs laid / hen / day = number of eggs laid in a day in a batch / number of hens present in the batch.

The egg parameters were determined according to the formulas:

- Egg weight (g) = Total weight of eggs laid (g) / Number of eggs
- Egg length (mm) = Sum of lengths of eggs laid (mm) / Number of eggs collected
- Egg width (mm) = Sum of Egg widths (mm) / Number of eggs collected
- Egg shape index: ESI = (EW / L) × 100 with; EW: Egg width; L: length of egg laid

The chemical composition of the eggs were determined : water content (AFNOR 1984), protein content (AOAC,1990) and fats content (Folch *et al* (1957).

Egg incubation was evaluated according to the formulas:

- Egg fertility rate (%) = (number of fertile eggs / total number of eggs incubated) x100
- Hatch rate (%) = (number of eggs hatched / total number of eggs incubated) x 100

Statistical analysis

The data collected were subjected to ANOVA analyzes of variance using SPSS software version 21.0. Duncan's Multiple Range Test (Steel and Torrie 1980) was used to separate the means when differences were declared significant.

Results

Growth performances

All through the experimental period, the growth curve of experimental chickens was sigmoid. Body weights increased among the dietary experimental treatments without significant difference ($p>0.05$) though the curve of hens fed on RML diet was above that of other groups (Fig. 1).

The evolution of feed intake (FI) was similar ($p>0.05$) among treatments as from the 4^{th} week of the trial till the end (Fig. 2). Highest ($p<0.05$) but comparable FI was observed in Control and RTL groups the first three weeks of the experiment.

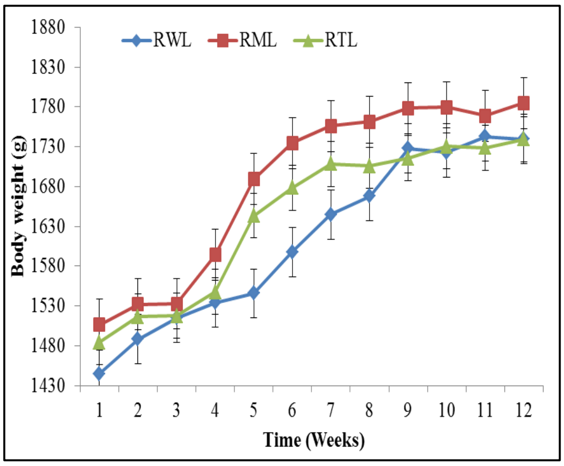

Fig. 1. Curve evolution of body weight according to the experimental diets

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta leaf* meal; RTL= Diet with *T. diversifolia* leaf meal**.**

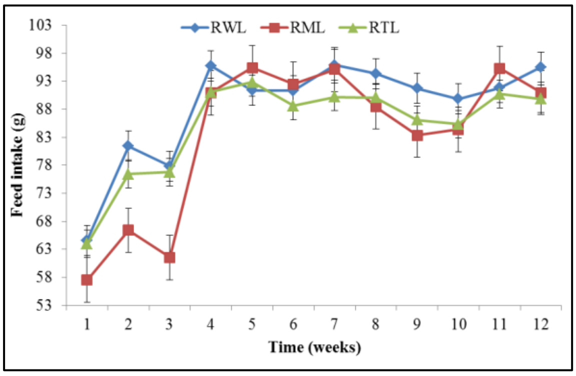

Fig. 2. Curve evolution of feed intake according to the experimental diets.

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal**.**

The average daily gain (ADG) according to protein sources evolved in a sawtooth-like manner regardless of the treatment considered with variations in weight gain and loss (Fig. 3). Hens of the supplemented batches recorded a low ($p<0.05$) but comparable weight gain during all the trial out of week 4.

The weight losses were also observed in all the batches except that at week 10 the weight losses were considerable to the point where the value of the loss in the RML batch drops below 0 (-1.52 g). The Feed conversion ratio (FCR) evolved in an irregular manner with hens fed with RML diet registering lowest ($p<0.05$) FCR value during the 3rd week but highest values ($p<0.05$) during weeks 6, 7 and 12 (Fig. 4).

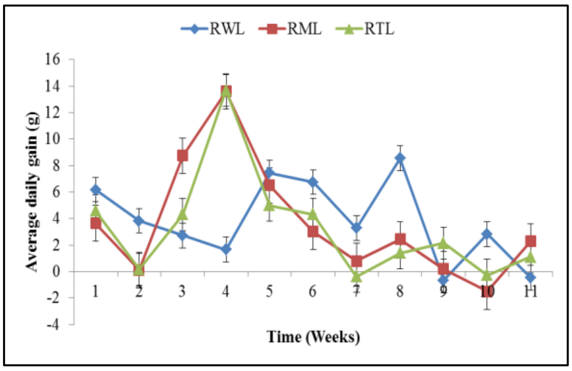

Fig. 3. Curve evolution of Average daily gain according to experimental diets.

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal**.**

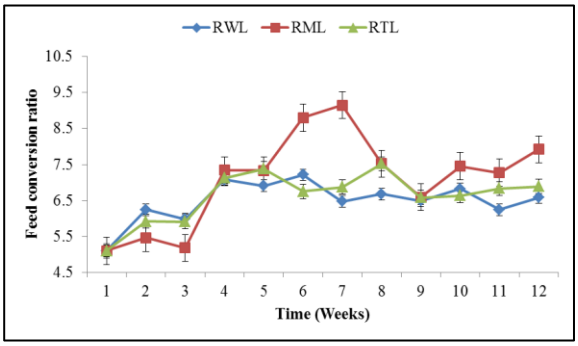

Fig 4. Curve evolution of the Feed conversion ratio according to the experimental diets.

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Laying performances

The egg-laying evolution curve showed that the egg-laying progressed very irregularly in all groups and throughout the study period (Fig. 5) with peaks of laying occurring in the weeks 1-2, 5-6 and 10-12 for the control batch, 2, 4 and 8 for RTL batch.

Significant differences were observed between the batches during the weeks 4, 5, 10 and 12. In general, all through the trial period, the evolutionary egg-laying curve of hens receiving RML diet was significantly ($p<0.05$) low compared to other batches.

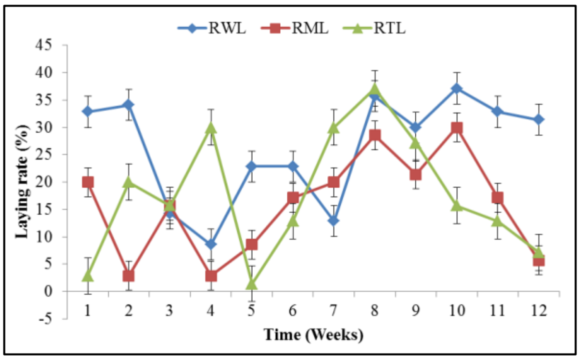

Fig. 5. Curve evolution of the laying rate according to the experimental diets.

RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Egg quality

The egg weight was as follow: 46.57g (control batch) > 45.28g (RML) > 43.13g (RTL) (Table 2).

Higher (p<0.05) egg width (39.92mm) and egg shape index (76.10%) were observed in the control batch. RML (52.57mm) and RTM (53.26mm) batches registered higher (p<0.05) but comparative egg length. The chemical composition of the eggs did not show any significant difference between the batches (Table 3).

Table 2. Egg characteristics according to experimental diets.

Parameters	Treatments			Probability
	RWL	RML	RTL	
Egg Weight (g)	46.57±2.57^{a}	45.28±2.12^{b}	43.13±1.22^{c}	0.000
Egg Length (mm)	50.49±0.02^{b}	52.57±1.73^{a}	53.26±1.57^{a}	0.000
Egg Width (mm)	39.22±0.04^{a}	36.67±1.82^{b}	35.66±1.68^{b}	0.000
Egg shape index (%)	76.10±3.07^{a}	73.61±2.85^{b}	74.54±1.96^{b}	0.000

^{a,b,c}: Means within the same line without a common superscript differ significantly (p<0.05); RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Table 3. Chemical composition of eggs according to the experimental diets.

Parameters		Treatments			Probability
		RWL	RML	RTL	
	N= 18				
Water (%)	Yolk*	54.30±5.70	50.97±1.87	50.23±8.96	0.468
	White*	87.29±1.06	87.82±0.91	87.26±0.75	0.498
Fats (g)	Yolk*	31.59±3.56	30.59±20.02	28.28±8.48	0.468
	White*	0.03±0.03	0.03±0.03	0.07±0.03	0.274
Proteins (g)	Yolk*	17.72±1.99	16.33±0.49	16.31±2.34	0.131
	White*	13.00±0.64	12.44±0.47	12.55±0.47	0.91

*: No significant (p<0.05) recorded between the means of the different parameters; RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Table 4. Laying parameters of hens according to experimental diets.

Parameters	Treatments			Probabilty
	RWL	RML	RTL	
Number of eggs laid/day	0.26±0.09^{a}	0.19±0.11^{a}	0.17±0.11^{a}	0.07
Laying rate (%)	26.30±13.31^{a}	23.16±12.06^{b}	22.25±13.02^{b}	0.00
Fertility rate (%)	82.29±5.24^{a}	81.46±5.00^{a}	81.78±6.45^{a}	0.32
Hatching rate (%)	89.28±3.12^{a}	88.03±5.37^{a}	87.03±6.11^{a}	0.45
Embryo mortality (%)	2.21 ± 1.57^{a}	3.10 ± 0.64^{a}	3.15 ± 0.52^{a}	0.51

$^{a, b}$: Means within the same line without a common superscript differ significantly (P<0.05); RWL= Diet without cassava and Mexican sunflower leaves meal; RML= Diet with *M. esculenta* leaf meal; RTL= Diet with *T. diversifolia* leaf meal.

Fertility, hatchability and mortality

Except for the laying rate which was the highest (26.30) (p<0.05) in the control batch, other parameters were similar whatever the treatment received (Table 4).

Discussion

Appropriate nutrition is essential for adequate productivity in animals. Diet plays a pivotal role in maintaining growth, health and reproduction. Among the many dietary factors, protein and energy have special importance in maintaining growth and reproduction in poultry (NRC 1994; Saleh *et al.*, 2018). The increasing trend of the weight evolution curve from the 1st to the 12th week of the trial, agrees with the study of Kana *et al.* (2013) and Kana *et al.* (2015) on Cameroonian local barred-chicken and Kabir hens and that of Osei-Amponsah *et al.* (2012) on Ghanian local-chickens under improved management system. The similar (p>0.05) increase in body weight recorded among all treatment groups may be an indication that all the diets met the minimum requirement for maintenance and laying as observed by Saleh *et al.* (2017) and (Kingori *et al.*, 2010).

It can also suggest that the leaves of *M. esculenta* and *T. diversifolia* were tolerated and valued by the hens (Dahouda *et al.*, 2009) meaning that the processing method used in this study (sun drying) may have contributed to the effective detoxification of cassava and Mexican sunflower leaves, hence, improving the growth performance of laying hens.

The comparative ($p>0.05$) feed intake (FI) registered in all groups in this study suggests that *M. esculenta* and *T. diversifolia* leaves were palatable and preferred by laying hens. This finding disagrees findings of Kana *et al.* (2015) who recorded decreasing FI with increasing level of *Moringa oleifera* leaf meal in the diet of Kabir hens in Cameroon. Our results are in agreement with those of some studies (Cho etal. 2004; Kingori *et al.*, 2010; Kakengi *et al.*, 2007) who reported no increase in FI of laying hens offered dried leftover feed, of laying hens fed graded levels of *M. oleifera* leaf meal and in indigenous chickens fed dietary crude protein levels respectively. The FI values of this study are lower than those obtained by (Kana *et al.*, 2015) who recorded FI >200g in Kabir hens, by Mube (2016) in the barred hen (93 g) from West Cameroon and by Hassen *et al.* (2006) in Gellilia hens (98 g) in Ethiopia. These values are superior to those obtained by Ouattara *et al.* (2014) in local chickens (78.34g) in Ouagadougou. The differences observed between the values can be attributed to the genetic and feeding regimes types.

Feeding meals of *M. esculenta* and *T. diversifolia* leaves led to great variations in ADG in laying hens with significant differences ($p<0.05$) between treatment groups during certain periods. This may be due to the fact that during laying, the hens consume less food compared to the period when no laying was observed thereby increasing or decreasing average daily weight gains. These variations may also be attributed to certain uncontrolled breeding factors (Ouattara *et al.*, 2014).

The feed conversion ratio (FCR) is a criterion used in zootechnic to measure the effectiveness of the feed. It translates the overall feed efficiency and Fig. the production yield (Adrian *et al.*, 1998). Generally, the FCR obtained in our work were significantly affected ($p<0.05$) by the protein source. The higher FCR values observed in the supplemented batches would reflect poor protein digestibility and low feed efficiency of these diets. This poor digestibility is thought to be due to the presence of residues of anti-nutritional factors (tannins, cyanogenetic glycosides) still present in the leaves after drying which form complexes with proteins, thus preventing their digestion and promoting their excretion (Adebowale *et al.*, 2005; Du Than 2007). Our results are lower than those obtained by Ouattara *et al.* (2014) which were 8.37-8.52, by Hassen *et al.* (2006) who reported FCR of 9.5 and 8.7 respectively for the Debre-Ellias and Gassay hens but higher than those of Fotsa (2008) which ranged from 2.97 to 5.90 between the 32th and 36th week of age with different ecotypes of local hens. These differences would depend on the genetic type and the climate.

The egg-laying curve evolved in a sawtooth-like manner throughout the study period. This result is due to the brooding reflex which characterizes unselected populations like ours. Indeed, during brooding, the hen stops laying for several days which causes a drop in laying. Similar results were obtained in F1 crossbred hens resulting from Label Rouge (T55XSA51) and two local ecotypes as parental line of Benin (Youssao *et al.*, 2011), and in the barred hen of Cameroon (Mube 2016).

The number of eggs laid per hen per day did not show a significant difference between the different batches. The results of our study are lower than those obtained by Mube (2016) who found a number of eggs / hen / day of 0.43 ± 1.25 in the barred hen from West Cameroon. The low number of eggs laid in our study is thought to be due to the difference in genetic type.

The protein content of diet rather than energy may be a limiting factor for egg formation in birds, since protein is an important component of eggs (Gunawardana *et al.*, 2008; Saleh *et al.*, 2017). Egg weights in this study (43.13±1.22 to 46.57±2.57 g) were superior to those of Samandoulougou *et al.*

(2016) who obtained an average egg weight of 33.86g in Burkina Faso from local chickens and those obtained by Keambou *et al.* (2009) who reported an average egg weight of 44.89g for local breed hens from West Cameroon. Our values are inferior to those found by Kakengi *et al.* (2007) who reported values of eggs weights ranging from 52.5±0.1 to 54.2±0.1g in laying hens in Tanzania, by Dahloum *et al.* (2015) who had an average weight of 52.23g in local chickens in Algeria and by Moula *et al.* (2012) who reported weights ranging between 50.23 and 54.32g in local hen in "Basse Kabylie". This difference in weight could be explained by genetic divergence (Egahi *et al.,* 2013), the feeding of local breeds from one locality to another, the climate and the environment. The lower egg weight values could have been due to the fact that laying chickens used in the present study were within the first phase of egg production. Indeed, eggs in first phase are usually smaller than in 2nd and 3rd phase (Kakengi *et al.*, 2007).

The egg shape index recorded in this study range between 73.61 and 76.10. This is in agreement with those reported in local barred chickens layers by Kana *et al.* (2013). The present shape index is low compared to the shape index reported in Kabir chickens (77 to 78) in Cameroon by Kana *et al.* (2015). The egg shape index of the control batch is greater than the value of 75 of the standard for eggs to be packaged in standardized packaging (Smith 1992) but those obtained in the test batches are lower than this value. According to King'ori (2012), the size, age, health status and internal structure of the hen are, among other factors, which can strongly influence the egg shape index.

The low laying rate observed in the supplemented batches may be attributed to residues of anti-nutritional factors present in the leaves of *M. esculenta* and *T. diversifolia* after processing which increase endogenous losses and modify the digestibility and the site of digestion of nutrients, including minerals, proteins and amino acids in monogastrics (Fasuyi 2005; Mweugang *et al.*, 2014; Buragohain 2016). Similar results were obtained by Kakengi *et al.* (2007) who observed decreasing laying rate with an increase of *M. oleifera* leaf meal proportion in the diet of laying hens in Tanzania but the opposite trend was registered by Kana *et al.* (2015) with Kabir chickens also fed graded levels of *M. oleifera* in Cameroon. The values recorded for laying rate were low compared to the values reported by Ouattara *et al.* (2014) who obtained mean egg-laying rates of 29.67% and 30.52% respectively for the control diet and the experimental diet. The variability among these studies suggests that egg weight and laying rate are influenced by more other factors than nutrition such as genotype, stage of laying, age at laying and climate (Kakengi *et al.*, 2007).

ietary intake of cassava and Mexican sun flower leaves did not significantly affected fertility, hatchability and embryo mortality of local hens. The values recorded for fertility [81.46-82.29%] in this study were superior to values reported by Ouattara *et al.* (2014) (63.40-64.73%) and Kana *et al.* (2015) [75.31-81.86%]. The values of hatchability [87.03-89.28%] are similar to those obtained by Kouadio *et al.* (2013) (73.05-87.56%) but superior to those reported by Ouattara *et al.* (2014) (53.81-58.70%), Kingori *et al.* (2010) (65.6-72.9%), Kana *et al.* (2015) [53.78-66.16%] and Fotsa (2008) (34.52-53.26%). The embryo mortality values [2.21-3.15%] were similar to those reported by Kana *et al.* (2015) [2.12-3.74%] but were found within values obtained by Kingori *et al.* (2010) (1-7%).

This study showed that the length (L) and the width (l) of the eggs of the hens of the different batches are greater than the values of 35.24 and 23.59mm respectively for the length and the width of the eggs presented by Fayeye *et al* (2005) in Morocco and the values of L = 48.58mm and l = 36.19mm found by Samandoulougou *et al.* (2016). In addition, our results are close to those found by Keambou *et al.* (2009) in Western Cameroon which are respectively 54.26mm and 39.43mm for length and width.

The values of the water content (WC) of the egg yolk obtained in our study are higher than those found by Sauveur (1988) which varied from 46.5% to 49.0% but those of the egg white correspond to those found by this author. The values of the fat content of the egg yolk and of egg white of this study are lower than the values 32.76g and 0.82g respectively found by Samandoulougou *et al.* (2016). It should be noted that the overall lipid content of the yolk is stable, around 33% and cannot be changed via the lipid content of the hen's diet (Bouvarel *et al.*, 2010). The variations observed in our study would be due to the loss of an amount of the lipids which would have been attached to the materials during handling. The values of the protein content of the egg yolk obtained in our study correspond to the values found by Sauveur (1988) which ranged from 16 to 17g. Those of white are superior to those found by this same author (9.5-11.5g). This could be explained by the fact that when separating the white from the egg yolk, a small amount of the egg yolk would have inserted into the egg white thus increasing its protein content.

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Conclusion

Dietary intake of meals from *M. esculenta* and *T. diversifolia* leaves did not affect growth and laying performances except for the laying rate which decreased in the supplemented groups. Consuming these leaves did not affect chemical composition of eggs but increases their length width without increasing the egg weight, width and egg shape index. Therefore, protein potentials of dried *M. esculenta* and *T. diversifolia* leaves can be interestingly valorized in the diet of local hens as substitute to soybean cake. However the influence of maternal dietary protein of these leaves on offspring performances after hatchability needs to be investigated.

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