

Supplementation Strategies for Semi-Scavenging Chickens in Burkina Faso

Evaluation of Some Local Feed Resources

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Abstract

The objectives of the present study were to estimate the nutritional status of scavenging chickens by crop content analysis and to evaluate some locally available feed ingredients under different management regimes for their potential for confined and semi-scavenging growing pullets and laying hens.

The first study showed that the physical composition of the crop contents varied between the two locations and two breeds studied, and the proportions also varied according to seasonal agricultural activities. The chemical composition showed a higher metabolizable energy content in the rainy season and the crude protein content (CP < 12 %) in both areas studied did not meet requirements. The second experiment was carried out on-station with crossbred growing chickens either choice-fed maize and cowpea or given them as a complete mixed feed. Average daily gains were lower for the choice-fed treatments, and providing a vitamin-mineral supplement to the scavenging birds had no effect on performance. It was not economically advantageous to supplement maize and cowpea. In the third experiment, imported fishmeal was replaced by a mixture of local cottonseed cake and bran (wheat-maize) in diets for exotic layers kept under different management systems on-station. Egg production performance, feed conversion and gross margin were higher for the cottonseed cake and bran diet for both the confined and semi-scavenging hens. However, very poor egg production performance was seen for the scavenging only group, implying that supplementation is necessary for egg production. The final study showed CP contents of 23.4, 6.70 and 44.3 % of dry matter (DM), respectively, for traditional beer residue, shea-nut cake and cottonseed cake. True excreta digestibility of DM and the most limiting amino acids in the beer residue and cottonseed cake was high (> 90 %), indicating that these by-products are potentially useful protein supplements. However, more studies should be done, particularly with shea-nut cake, on the improvement of palatability, the optimum level of inclusion in the diets, and the nutritional availability for chickens, of these processed feedstuffs.

Keywords: Amino acids, Burkina Faso, Choice feeding, Cottonseed cake, Cowpea, Crop contents, Digestibility, Fishmeal, Maize, Nutritional status, Scavenging chickens, Shea-nut cake, Sorghum beer residue.

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Dedication

To the memory of my father Amadou Pousga
To my mother Kabore Setou, my sisters
Ami, Bintou, Safi and my brother Karim

Personne ne peut contre la volonté de Dieu !

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List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

- I S. Pousga, H. Boly, J.E. Lindberg and B. Ogle. 2005. Scavenging Pullets in Burkina Faso: Effect of Season, Location and Breed on Feed and Nutrient Intake. *Tropical Animal Health and Production*, 37 / 2005, pp. 623-634.
- II S. Pousga, H. Boly, J.E. Lindberg and B. Ogle. 2006. Effect of supplementation on feed intake and performance of confined and scavenging crossbred growing chickens in Burkina Faso. *Tropical Animal Health and Production*, 38 / 2006, pp. 323-331.
- III S. Pousga, H. Boly, J.E. Lindberg and B. Ogle. 2007. Effect of supplements based on fishmeal or cottonseed cake and management system on the performance and economic efficiency of exotic hens in Burkina Faso. *African Journal of Agricultural Research*, 2 / 2007, pp. 496-504.
- IV S. Pousga, H. Boly, J.E. Lindberg and B. Ogle. 2007. Evaluation of Traditional Sorghum (*Sorghum bicolor*) Beer Residue, Shea-Nut (*Vitellaria paradoxa*) Cake and Cottonseed (*Gossypium Spp*) Cake for Poultry in Burkina Faso: Availability and Amino Acid Digestibility. *International Journal of Poultry Science* 6 / 2007, pp. 666-672.

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Abbreviations

AA	Amino acids
ADG	Average daily gain
ASH	Total ash
CB	Cottonseed cake and bran
CF	Crude fibre
CP	Crude protein
DM	Dry matter
DMI	Dry matter intake
EE	Ether extract
FCR	Feed conversion ratio
FCS	Feed costs / kg weight gain
FM	Fishmeal
LSM	Least-squares mean
ME	Metabolizable energy
MJ	Mega-joule
NFE	Nitrogen-free-extract
OM	Organic matter
PDAV	Projet de developpement de l'Aviculture villageoise
TME	True metabolizable energy

1 Introduction

Village poultry make a substantial contribution to household food security throughout the developing world. It helps diversify incomes and provides high-quality food and fertilizer, and acts as a renewable asset in over 80 % of rural households (FAO, 2004). Irrespective of where the resource-poor areas of the world are located and where scavenging poultry are reared, there are certain aspects that are common: The keepers of scavenging poultry usually maintain a few (2-10) birds, are generally females and children, and are frequently the poorest people in their community (Acamovic *et al.*, 2005).

In the rural areas of Sub-Saharan Africa, 85 % of all households keep poultry, with women owning 70 % of the total number (Gueye, 1998; Branckaert & Gueye, 1999). Smallholder poultry production is primarily from free-ranging birds and there are few or no inputs. These birds are known around the world by different names, including family, scavenging, free range, desi, rural and backyard poultry, and chickens are the main species kept (Acamovic *et al.*, 2005). Many authors have described the indigenous domestic (*Gallus domesticus*) chickens reared in the African rural areas and have given them names, such as African chicken, bush chicken or runner chicken (Berte, 1987; Oluyemi, 1989; Kounta, 1991; Gueye & Bessei, 1997). Village chickens are not pure-bred animals because considerable crossbreeding has taken place (Van Eekeren *et al.*, 1995). These birds seem to be well adapted to their harsh environmental conditions, such as temperature extremes, heavy rain and periodic feed shortages (Gueye, 1998). Three types of village chicken production system have been reported:

The free range system: The birds find the main part of their daily rations by scavenging. There is generally little intervention in the life cycle of the birds (Sonaiya *et al.*, 1999), although feed supplements and water,

overnight housing and health care may be provided. Supplementation consists of giving household wastes or cereal grains, generally in the morning or late in the afternoon, according to the farmers' ability (Chrysostome *et al.*, 1995).

The backyard system: This is a system in which the birds are partly-confined within a fenced yard or merely within an overnight shelter, fed and watered, and is sometimes also referred to as the semi-intensive system (Kitalyi, 1999).

The semi-intensive system: Generally found in Asian countries, and in which the chickens are fed formulated diets, either bought commercially or produced from feed mills (Aini, 1999). In this system, flock size varies between 50 and 500 birds on average (Sonaiya *et al.*, 1999). The use of specialised rather than indigenous breeds is common (Roberts, 1999).

The characteristics of African traditional poultry husbandry practices are the following (IEMVT, 1987): The birds range freely during the day and are usually gathered at night into a basic shelter for protection against predators; The feeds are limited to the scavenging feed resources (insects, seeds, and kitchen wastes); Supplementation is done occasionally, according to the availability of the feedstuffs used in the household; Very poor productivity is normal, with low laying and growth performance and important losses in the flocks; Eggs are rarely consumed as they are preferably hatched; Chickens are occasionally consumed and are appreciated for their taste, their relatively tough meat being well adapted to the prolonged cooking practiced in Africa.

Small-scale producers are however constrained by poor access to markets, goods and services, weakness of institutions, and lack of skills, knowledge and appropriate technologies (Gueye, 2002). Under the existing systems, the productivity of scavenging chickens is also limited by both poor nutrition and by health problems. Newcastle disease has been recognized as the greatest constraint to scavenging chicken production (Aini, 1990). The control of the disease by vaccination has, until recently, been ineffective, due to the nature of the scavenging chicken production systems, the epidemiological factors of the disease and heat lability of the vaccine (Spradbrow, 2001). The arrival of the highly pathogenic H5N1 avian influenza on the African continent is also of great concern for human as well as animal health (WHO, 2005). In Africa, as in affected Asian nations, village chickens often mingle freely with wild birds and most such flocks scavenge for food, often entering households or sharing outdoor areas where children play.

In Burkina Faso village chickens subsist from scavenging, with very irregular supplementation. Sonaiya (1995) reported that scavenging chickens in south-western Nigeria receive less than 35g of grain supplement daily, and it is suggested that supplementation of scavenged feed with locally available feed resources will improve chicken productivity (Sonaiya, 1995; Roberts, 1999). For effective supplementation, there is a need to know the quantity of the available scavengeable feed. The concept of the scavengeable feed resource base (SFRB) can be used to determine the quantity of the available scavengeable feed in an environment (Roberts, 1992). It is a starting point in determining the quantity and nutritional characteristics of the feed that is required to supplement.

Objectives

The general objectives of the present study were to develop feed supplementation strategies for chickens kept by resource-poor people in Burkina Faso, based on the use of locally available feedstuffs. The specific objectives were:

- To estimate by crop content analysis the available scavenging feed and nutritional status of scavenging local and improved laying chickens in different locations of Burkina Faso, and in different seasons.
- To compare the response of crossbred chickens to different feeding and management regimes using diets based on maize and cowpea.
- To evaluate the effect of replacing low protein fishmeal by cottonseed cake and wheat-maize bran on egg production and the economical efficiency of exotic confined and semi-scavenging laying hens.
- To determine the variability according to location and time of year in the chemical composition of cottonseed cake, shea-nut cake and local beer residue, and to estimate the digestibility of

the dry matter and some essential amino acids in growing cockerels.

2 Background

Burkina Faso is located in the heart of West Africa (Fig.1) and is situated between latitudes 9°20' and 15°05' North, and longitudes 2°20' and 5°30' West. The country is one of the poorest in the world (PNUD, 2007). The surface area is 274 000 km² and the population in 2006 was estimated to be around 14 million inhabitants (Index Mundi, 2007). Approximately 94 % of the people under the poverty level live in the rural areas, as reported by Ouedraogo (2002). Extensive crop and extensive livestock production are the main activities of the population. These two activities play a key role in the economy, where livestock products constitute about 19 % of the exports, and more than 86 % of the population obtains at least part of their income from livestock production (MRA, 2003).

The total poultry population in Burkina Faso was estimated at 32 millions (MRA, 2004) (Fig. 2).



Figure 1. Location of Burkina Faso (<http://photos.photo.perso.cegetel.net/burkina.faso/>)

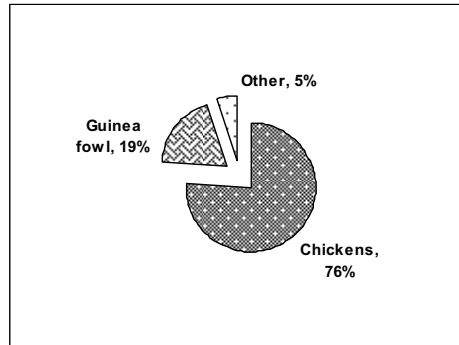


Figure 2. Poultry population in Burkina Faso

Poultry farming is an important part of the daily life of the population, especially the rural farmers, who raise village chickens for several purposes (Kondombo *et al.*, 2003), such as to supply meat and eggs and generate income. Chickens are also commonly used for gifts and sacrifices in social rites.

There are two main poultry production systems in Burkina Faso, the extensive and the intensive system. The former is well spread throughout the country, and virtually all rural farmers keep a few birds (chickens, guinea fowls, ducks, etc.) in the household in order to satisfy the family's financial needs. The intensive system is restricted to some peri-urban areas of the major towns, using exotic breeds, and the main objective is egg production for sale.

Local poultry are preferred because of their flavour. Despite the constraints faced in rural poultry production, such as diseases, and poor feeding and management, village poultry production is still important and widely distributed among smallholder farms. However, little published information is available in Burkina Faso on the effects of improved nutrition, and in general poultry production improvement and research represent only a minor part of the agricultural research and development programmes in the country.

2.1 Poultry Production Systems and Constraints in Burkina Faso

It has been estimated that only 0.8 % of the total poultry population is found in the cities and towns (MARA, 1997). Two dominant production systems have been described, industrial and traditional (Bonkougou, 2002). The industrial system is a well organised, intensive system with exotic day-old chicks or eggs imported for hatching, and the main objective is egg production, with 200,000 layer and only 40,000 broiler chicks per year (Royer & Vidon, 2001) imported from Europe (France, Belgium, and Netherland) and from neighbouring African countries (Cote D'Ivoire and Ghana) (MRA, 2001). Compared with other West African countries such as Senegal, Ghana and Cote D'Ivoire, there are few industrial broiler units around the cities in Burkina Faso. The greatest proportion of the meat of exotic birds in Burkina Faso is from layers at the end of lay (Ouedraogo & Zoundi, 1999). Intensive production is still embryonic and is practiced in the peri-urban areas by a few relatively wealthy entrepreneurs from the cities. In this system, the production inputs are higher and the constraints are minimized. Importation of feed ingredients, medicines, and equipment is coordinated by an organisation called "Maison de l'Aviculture", which is an association of producers using exotic breeds.

The traditional system is widespread in rural, urban and peri-urban areas, is practiced mainly by resource-poor people and is based on indigenous breeds with low genetic potential. This system is characterised by the free-range production in which the birds have to scavenge to find most of their feed, which is constituted mainly by materials from the environment and household leftovers (Pousga *et al.*, 2005b; Kondombo, 2005), although cereal supplements are often given to the birds in the early morning and late afternoon. The poor genetic potential of the birds, in combination with the harsh environmental conditions and poor nutrition lead to a low production output. The losses are usually higher in the rainy season (Pousga *et al.*, 2005b), due to diseases and predators. This system is also characterised as a traditional farming system where poultry are integrated with crop and livestock production, and where several poultry species of different ages are mixed together in the flock. Although the traditional system is limited by a number of constraints, it provides the main urban centres with poultry products, such as live birds, meat and eggs from chickens and guinea fowl during the breeding season. Village chicken use at farm level was described according to Yameogo (2003) (Fig. 3).

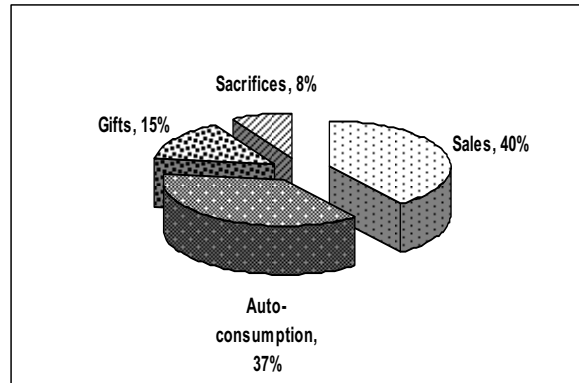


Figure 3. Village chicken utilization at farm level

There is little information on the genetic make-up of local poultry in Burkina Faso. However, Kondombo (2000) characterised chicken breed types according to body size and the colour of the feathers. The changes in the poultry (including chickens and guinea fowl) population in Burkina Faso from 1992 to 2005 are shown in Table 1.

Table 1. Poultry population of Burkina Faso in selected years between 1992 and 2005

Year	Total number
1992	17 784 900
1996	19 920 000
2000	22 420 318
2003	31 007 000
2004	31 937 000
2005	32 895 000

Source: MRA (2002); Mission Economique (2006)

Poultry are widely distributed throughout the country (MARA, 1997) (Fig. 4).

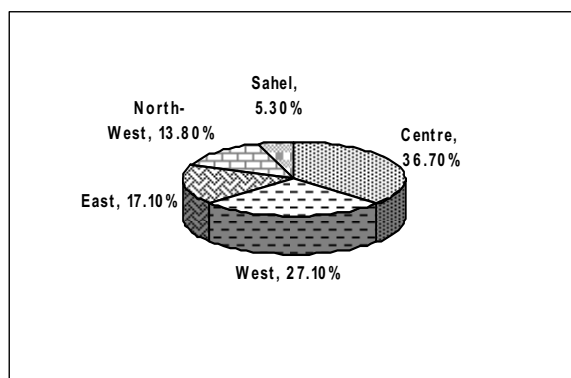


Figure 4. Poultry distribution in Burkina Faso

The average number of birds per household was reported to range between 1 and 50, with only 5 % of the farmers having more than 50 birds (Yameogo, 2003) . The body weight of local chickens reared in scavenging conditions ranges from 1.2 to 2.0 kg for adult males and from 0.9 to 1.2 kg for adult females (MAE, 1991; Ouandaogo, 1997; Pousga *et al.*, 2005 b). Some productivity parameters are presented (Table 2).

Table 2. Productivity parameters of local chickens in Burkina Faso

Parameter	Value
Onset of lay	170 ±15 days
Number of eggs per clutch	11 ±5
Number of clutches per year	2-3
Egg production / hen / year	30-45
Hatchability rate	79-85 %
Viability rate of chicks	89.3 %

Source: Yameogo (2003)

In the villages, natural incubation is done by the hens, which brood and hatch the eggs. It was shown that the hatchability of chicken eggs depends on the farming system (Kondombo, 2005).

2.2 Housing Conditions

In rural areas, the nature of the poultry house or shelter depends on the production system. Traditionally, young birds or chicks are generally raised in a large hut made with mud bricks and with a thatched roof. In some areas, farmers build small poultry houses with thatch (Boussini,

1995) to house laying hens and chicks at night, while other birds have to spend the night in the trees. Different poultry species are generally mixed together in the same house. Only 11% of the farmers build improved poultry houses and 80 % of poultry houses are traditional, with 73 % built with mud brick and 7 % with thatch or straw (Boussini, 1995; Bessin *et al.*, 1998).

2.3 Feeding Systems

In general, rural poultry find the main part of their diet by scavenging around the villages. The feeding systems adopted by the farmers depend on the age of the birds. Kondombo (2000) reported that poultry farmers regularly supplement chicks, while mature birds receive supplementary feed only when there is a surplus of cereals. Chicks are often supplemented with termites, and the main energy feedstuffs used as supplements are maize, millet and red sorghum, depending on location. These cereals are also staple foods for humans.

Many feed ingredients are used in standard diets used in intensive production, and the main poultry feed company is coordinated by PDAV through the Ministry of Animal Resources. Feed ingredients are also imported by a private wholesaler called “Maison de l’aviiculture”, an association of intensive chicken producers. A summary of the most important local and imported feedstuffs used in commercial feeds and the seasonal availability in Burkina Faso is shown in Table 3.

Table 3. Seasonal availability of poultry feed ingredients in Burkina Faso

Ingredients	Rainy season	Dry season	Remarks
Maize	**	***	
Wheat bran	**	***	Local and imported
Maize bran	**	***	
Soybean meal	-	-	Mostly imported
Groundnut cake	*	***	
Cottonseed cake	**	***	
Fishmeal	-	-	Imported
Blood meal	-	-	Imported
Mineral premix	-	-	Imported
Oyster shell	-	-	Imported
Bone meal	-	-	Imported sometimes
Sea shells	-	-	Imported
Vitamin premix	-	-	Imported
Lysine	-	-	Imported
Methionine	-	-	Imported

*: Rare

** : Less abundant

***: More abundant

2.4 Health and Mortality

The causes of losses in the traditional system were described by Kondombo *et al.* (2003) (Fig. 5).

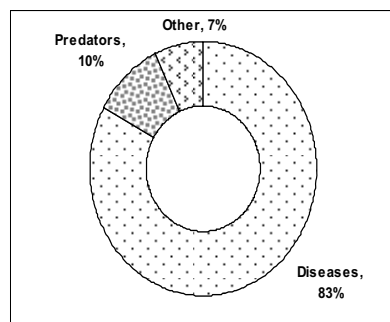


Figure 5. Causes of village poultry losses in Burkina Faso.

Disease control programmes have been adopted but results were generally not successful because these programmes require logistics, such as specialized workers with refrigeration facilities, and because they also require frequent travel to the villages, which is not practicable in the rural areas.

3 Summary of Materials and Methods

3.1 Study Sites and Periods

The feeding trials were carried out at the INAGOR research station, located in Sapone village, around 35 km from Ouagadougou, the capital, in the Central Region of Burkina Faso (experiments in Paper II, III and IV) (Fig. 6).



Figure 6. Study sites (http://www.routard.com/guide_carte/code_dest/burkina_faso.htm#top)

This part of the country is included in the Sudano-Sahelian zone, which lies between the 900 and 600 mm isohyets. From late September to mid-December 2005 (Paper II), average minimum and maximum temperatures of 22.8°C and 31.2°C were recorded and mean relative humidity was 63.4 %. From September 2006 to February 2007 (Paper III), average minimum and maximum temperatures of 15.8°C and 40.0°C, and minimum and maximum relative humidities of 16 and 86 %, were recorded.

The poultry yard in the station has an area of around 1000 m² and is dominated by *Vitellaria paradoxa* and *Eucalyptus alba* trees, and various species of grass. The chickens also had access to fields adjacent to the station, where maize, cowpea, sorghum, onion, tomatoes and various legume crops are often cultivated. The experiment in Paper I was carried out in the arid and dry Sahelian zone in the North (Korea village) and in the sub-humid Soudano-guinean zone in the South (Bounouna village) (Fig.6). Bobo-Dioulasso, where samples were collected for the study in Paper IV, is also situated in the Soudano-guinean zone. The Sahelian zone is characterised by high mean temperatures ($30 \pm 7^\circ\text{C}$), low annual rainfall ($350 \pm 80\text{mm}$), and a long dry season (8 months), while the Soudano-guinean zone is characterized by relatively high mean rainfall ($950 \pm 50\text{ mm}$) and a longer rainy season (5 months).

3.2 Experimental Design (Paper I, II, III and IV)

The experiment in Paper I had a 2*2*2 factorial design, with season, location and breed as factors. The experiments in Paper II and III had a completely randomized design, with five treatments and four replicates for Paper II, and four treatments with three replicates in Paper III. The digestibility study in paper IV had a completely randomized design with three treatments (by-products) and six replicates.

3.3 Experimental Procedure

Paper I: In total 128 scavenging chickens (64 local and 64 crossbred) between 5-6 months old were purchased from the farmers in Korea and Bounouna villages, and slaughtered for physical and chemical analysis of the crop contents. The local breeds included various indigenous breeds of Burkina Faso (mainly Noa-kuiguiga and Noa Rigre), while the

crossbred birds were the offspring of crossings between Rhode Island Red or Isa Brown and local chickens.

Paper II: This experiment included 100 male and 100 female crossbred birds (local hens x Rhode Island Red cockerels). The chicks were confined and given a commercial starter diet until four weeks of age, when they were divided randomly into 5 treatment groups, with 4 replicates for each treatment (10 birds/replicate, 5 males and 5 females). The dietary treatments were: CMx(+), confined and given a mixed feed *ad-libitum* with a vitamin-mineral premix; CS(+), confined and choice-fed cracked maize and cowpea *ad-libitum* with a vitamin-mineral premix; ScS(+), scavenging from 09.00 to 16.00h and offered the previous diet from 16.00 to 09.00h; ScS(-), same as above, but without the vitamin-mineral premix, and ScO, scavenging only, with no supplement provided.

Paper III: A total of 120 exotic laying hens (Isa Brown) at 28 weeks of age was randomly distributed to four feeding / management regimes, with 3 replicates and 10 birds per replicate. The feeding regimes were: CCB, confined and given *ad-libitum* a mixed diet (CB) containing cracked maize, cottonseed cake, cereal brans and a vitamin-mineral premix, and with oyster shells provided separately; SCB, scavenging in the daytime (08.00h to 16.00h), with the CB diet available between 16.00h and 08.00h; SFM, management as in SCB, but with fishmeal replacing cottonseed cake and cereal bran (diet FM); SO, scavenging only with no supplement provided.

Paper IV: Sun-dried sorghum beer residue (n = 144) and shea-nut cake (n = 36) samples were collected each month in two different locations during a period of six months (including three months of the rainy season and three months of the dry season), while cottonseed cake samples were purchased monthly in a local market for the same period (n = 24). The by-products were analyzed for chemical composition, and then a force-feeding trial was carried out using crossbred cockerels (n = 36), for the estimation of true excreta amino acid digestibility. Some samples of shea-nut cake and sorghum beer residue from the two locations were pooled, and 8 g of each of the three by-products was tested, with six replications per treatment (2 birds per replication, paired on a weight basis, as fed and fasted).

3.4 Housing and Management (Paper I, II, III and IV)

Paper I: In 4 households in each of the two villages, the birds were allowed to scavenge together during the day time and were confined together at night in the same pen, and leg painted for identification. In each location and season, after 4 weeks of scavenging together, 4 representative local and 4 crossbred pullets were slaughtered for crop content analysis at the end of the dry season (May) and in the middle of the rainy season (August).

Paper II: The birds were vaccinated against Bronchitis, Infectious bursitis, Newcastle disease and Fowl pox. Prophylactic measures were also taken against Coccidiosis and parasites. The chicks were confined and given a commercial starter diet until 4 weeks of age, when they were assigned to the dietary treatments.

Paper III: All the birds were vaccinated against Newcastle disease and Fowl pox, and were also treated against internal and external parasites. The birds in all treatments except CCB were confined at night, and the pens were 2.0 m x 1.5 m, with sawdust as litter. Legs were painted for identification.

Paper IV: In total 36 crossbred cockerels, between 0.5 and 0.6 kg live weight, were paired on a weight basis and placed in individual metabolism cages (0.25 x 0.25 x 0.35 m). The force-feeding trial was carried out according to Likuski & Dorrell (1978) and Sibbald (1979) with respect to the feeding technique, and the estimation of endogenous amino acids was done according to Likuski & Dorrell (1978) and Song *et al.* (2003).

3.5 Feed Ingredients and Diets(Paper II, III and IV)

Paper II: The mixed feed in CMx(+) was a diet consisting of 50 % maize and 50 % cowpea, supplemented with a vitamin-mineral premix (0.2 %). The choice-fed diets [CS(+), ScS(+) and ScS(-)] were cracked maize and cowpea given separately with (+) or without (-) the vitamin-mineral premix.

Paper III: Feed ingredients were maize, wheat-maize bran, cottonseed cake, vitamin-mineral premix, dicalcium phosphate and oyster shell. The CB diet had a crude protein content of 19.3 % of DM and a metabolizable energy level of 14.2 MJ / kg, while the FM diet had a crude protein content of 13.9 % and 15.3 MJ / kg of metabolizable energy. The two diets were balanced according to the Ideal Protein concept for layers.

Paper IV: Samples of sorghum beer residue and shea-nut cake were collected in two locations (Sapone and Bobo-Dioulasso) and were pooled according to ingredient. Cottonseed cake samples from different batches were also pooled, and the amino acid digestibility of each by-product was determined in cockerels.

3.6 Sample Analysis and Calculations(Paper I, II, III and IV)

Feed ingredients were analysed for dry matter (DM), crude protein (CP) (N*6.25), crude fibre (CF), total ash (Ash), and organic matter (OM) using standard AOAC methods (AOAC, 1985). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined according to Van Soest *et al.* (1991) (Paper I and II). ADF in Paper III and IV was determined according to AOAC (1985), and NDF according to Chai & Uden (1998). Crude fat (EE) was measured after extraction with petroleum ether in a Soxtec apparatus (Paper I and II) and after acid hydrolysis (AOAC, 1985) (Paper III and IV). Minerals were determined using spectrometry (FAO, 1980; AOAC, 1985). Amino acids were determined using standard methods (AnalyCen, Lidköping, Sweden). Metabolizable energy (ME) was calculated by an indirect method, using the following equation (INRA, 1987):

$$\text{True ME (MJ / kg DM)} = (3951 + 54.4\text{EE} - 88.7\text{CF} - 40.8\text{Ash}) \times 0.004184$$

Where: EE = % Ether extract, CF = % of Crude fibre, Ash = % of Ash.

Nitrogen Free Extract (NFE) was calculated following the formula:

$$\text{NFE (\%)} = 100 \% \text{ DM} - (\text{CP} + \text{EE} + \text{CF} + \text{Ash}).$$

Dressing percentage was calculated according to the formula:

$$\text{Dressing percentage} = (\text{Carcass weight}) / (\text{live weight at slaughter}) \times 100$$

The diets in Paper II and III were formulated by Uneform Software (Thomson, 1997) using Microsoft Excel for Windows 2003.

Apparent and True amino acid digestibility in Paper IV was calculated according to McNab (1994):

$$\text{Total tract AA digestibility} = \frac{\text{AA consumed} - \text{AA in faeces}}{\text{AA consumed}}$$

$$\text{True AA digestibility} = \frac{\text{AAC} - (\text{AAF} - \text{EAAF})}{\text{AAC}}$$

AAC = amino acid consumed

AAF = amino acid in faeces from fed birds

EAAF = endogenous amino acids in faeces from unfed birds.

3.7 Statistical Analysis

The data in all experiments were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of MINITAB Reference Manual Release 13.31 and 14 for Windows 2000. Pair-wise comparisons of means were made using the Tukey test.

4 Summary of Results

4.1 Nutritional Status of Scavenging Local and Crossbred Chickens (Paper I)

Paper I. Visually, and in order of importance, the main components of the crop contents were cereal grains, cereal brans, forages, seeds, insects and worms, kitchen waste, and other household by-products. The mean fresh weight of the crop contents was higher in the dry season compared to the rainy season ($P < 0.05$). The proportion of grain (maize, millet and milo) and seed was higher in the rainy season than in the dry season ($P < 0.05$) (Fig. 7). A higher proportion of grain was found inside the crops of local birds, while a higher proportion of bran was found in the crossbred pullets ($P < 0.05$). The proportion of kitchen waste found inside the local birds was higher than in the crossbred birds ($P < 0.05$), and the proportion of grass and leaves was higher for the crossbred compared to the local breed pullets ($P < 0.05$) (Fig. 8).

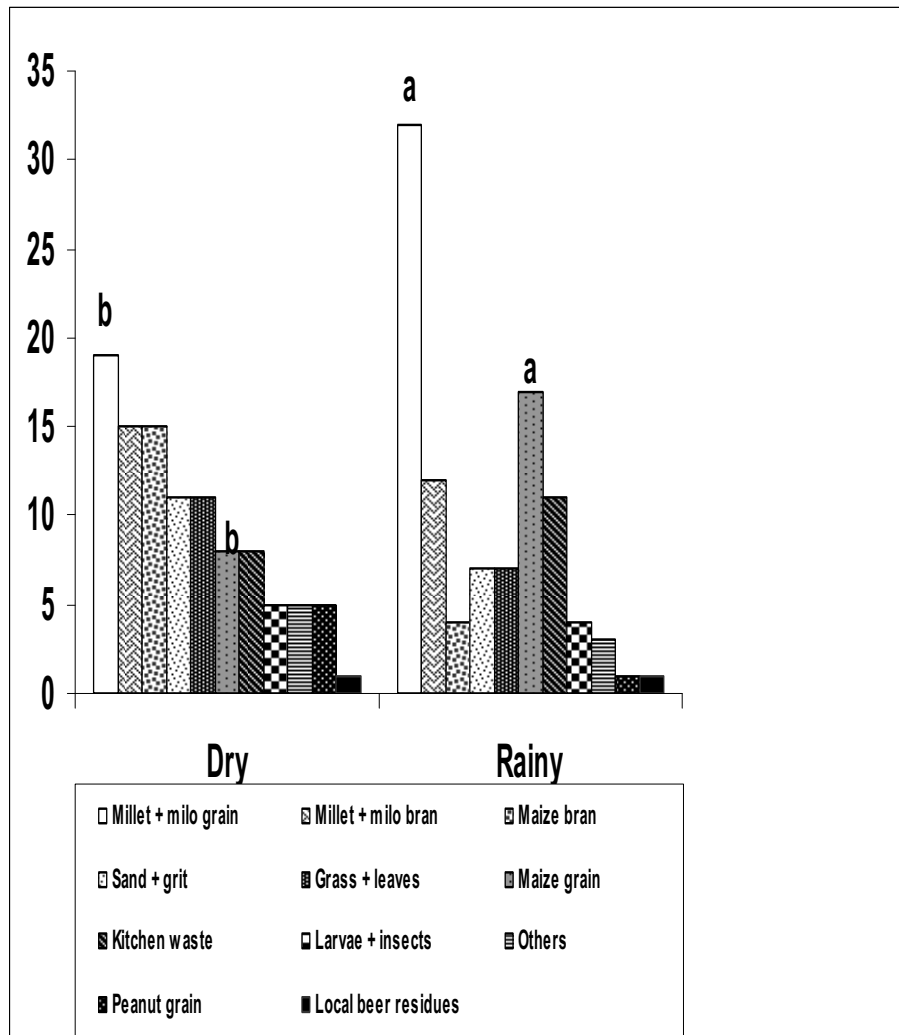


Figure 7. Effect of season on the physical composition of crop contents of scavenging hens (% of total fresh weight)

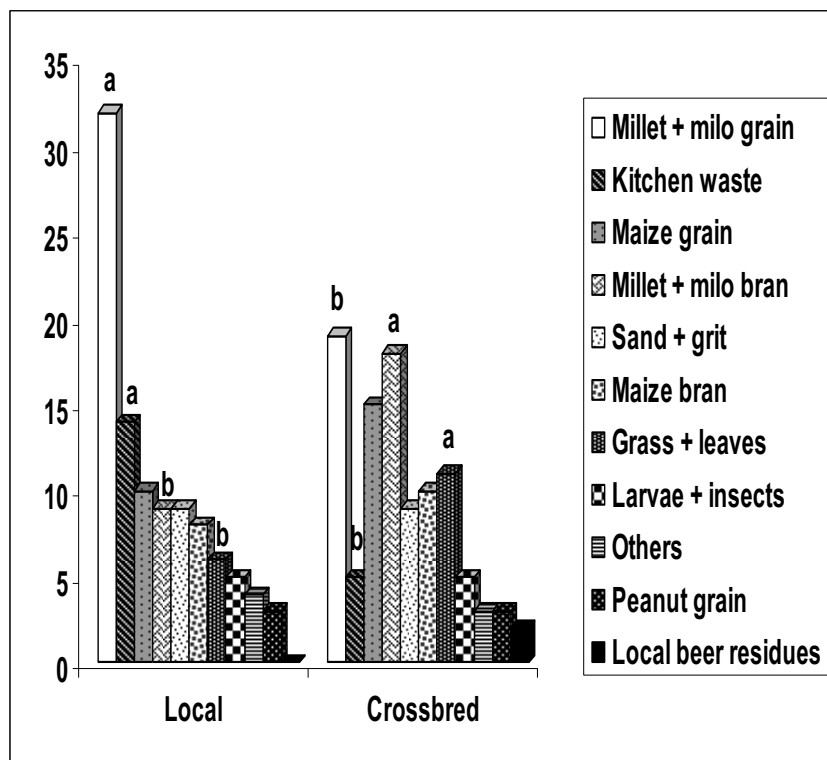


Figure 8. Effect of breed on the physical composition of the crop contents of scavenging hens (% of total fresh weight)

Overall fresh crop content weight was higher in the northern Sahelian village of Korea than in the sub-humid southern village of Bounouna ($P > 0.05$). Millet and milo grain and bran proportions were higher in Korea, while the maize proportion was higher in Bounouna (see Fig. 9). The proportion of kitchen waste was higher in the crops from Bounouna ($P < 0.05$), while the proportion of dry forages was higher in Korea ($P < 0.05$). Rice and local beer residue were not found in the crops from Korea. The chemical composition of the crop contents showed significant differences between seasons ($P < 0.05$), but not between breeds and villages. Dry matter, ash and potassium contents were higher in the dry season ($P < 0.05$), whereas ME concentration was higher in the rainy season than in the dry season ($P < 0.05$).

Overall, mean live weight at slaughter and mean carcass weight were higher in the dry season compared to the rainy season ($P < 0.05$).

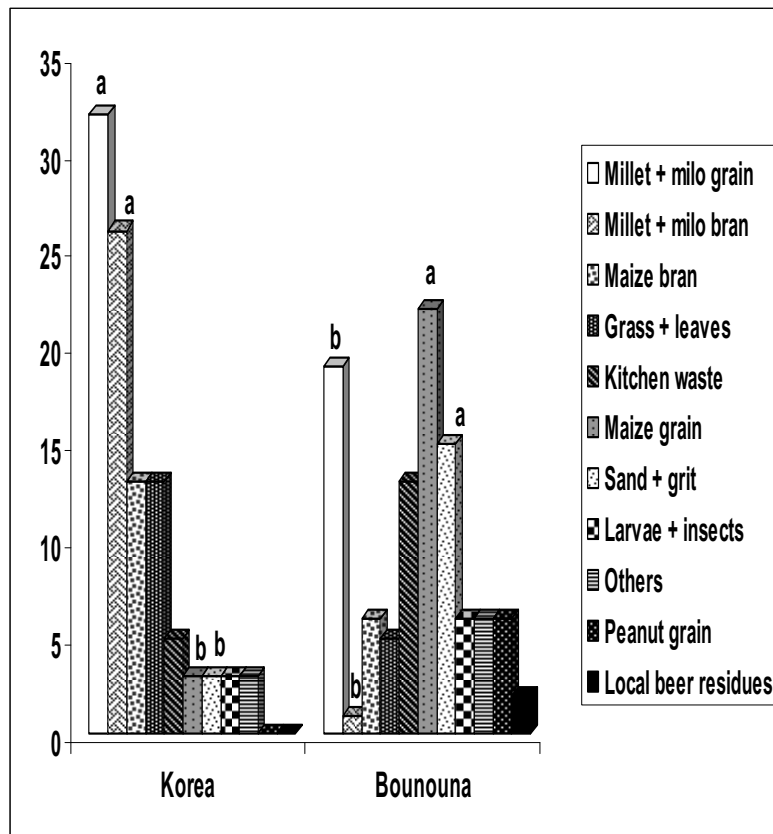


Figure 9. Effect of location on the chemical composition of the crop contents of scavenging hens (% of total fresh weight)

4.2 Source and Composition of Feed Ingredients (Paper II, III and IV)

The maize used in the trials was a local variety of white maize with CP and ME contents of 8.34 % and 15.8 MJ / kg, respectively. The cowpea used (Paper II) was one of the local varieties of black-eye pea, commonly called *Niebe* in West Africa, and contained 23.1 % CP and 11.3 MJ / kg ME. The cottonseed cake used (Paper III and IV) was decorticated

expeller, which is locally available in Burkina Faso after oil extraction in the factories. The bran used (Paper III) was a mixture of by-products from small-scale wheat and maize processing mills. Local beer residue (Paper IV) is available in Burkina Faso after home brewing, usually done by women, generally with red sorghum. The local brewing technique is summarised in Fig. 10. Shea-nut cake is a by-product of the indigenous technology for extraction of fat from the kernels of the shea butter tree (*Butyrospermum parkii* or *Vitellaria paradoxa*). The local technique for the fat extraction is described in Fig. 11.

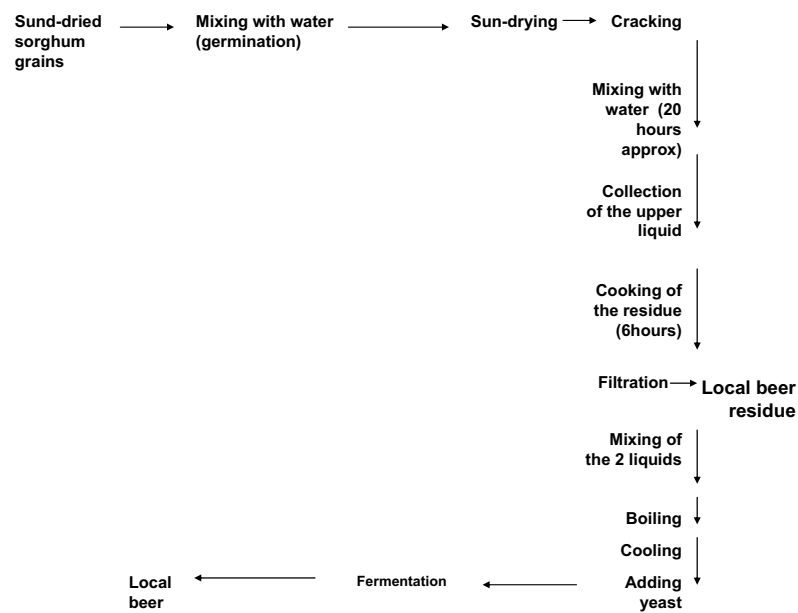


Figure 10. Artisan beer brewing technique in Burkina Faso

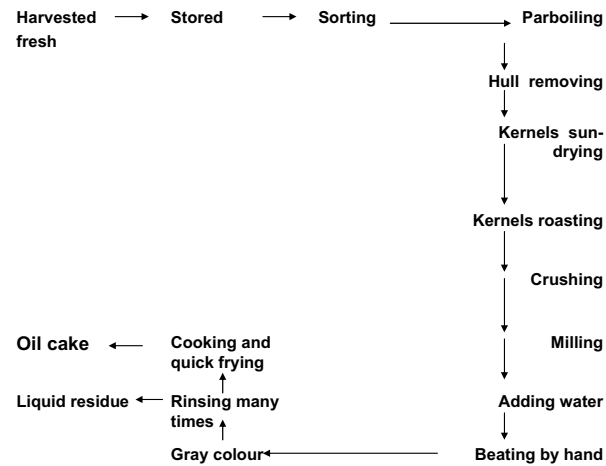


Figure 11. Artisan technique for shea fat extraction in the West of Burkina Faso

4.3 Effect of Supplementation with Local Feed Ingredients on Intake, Growth Performance and Economic Efficiency

Paper II: The highest daily DM intake (43.5 g) was observed in the confined group that was choice-fed maize and cowpea with a vitamin-mineral premix (CS(+)), while the lowest intake (33.6 g) was seen in the confined group given the mixed feed (CMx(+)) ($P < 0.05$), with an intermediate value for the semi-scavenging treatment. In the free-choice treatments the proportion of cowpea of total intake was higher for the semi-scavenging groups receiving the diet with a vitamin-mineral premix (ScS(+)), resulting in higher CP and ME intakes from cowpea in treatment ScS(+) than for CS(+) and the corresponding semi-scavenging treatment without a vitamin-mineral premix (ScS(-)) ($P < 0.05$).

Average daily weight gain (ADG) was significantly higher (8.15 g) for CMx (+) than for all other treatments, and lower in the scavenging only group (ScO) (Fig. 12). Average daily gain and final live weight were higher for the males compared to the females ($P < 0.05$) (Fig. 13). The

highest feed conversion ratio (FCR) was observed in CS(+) and the lowest in CMx(+) ($P < 0.05$).

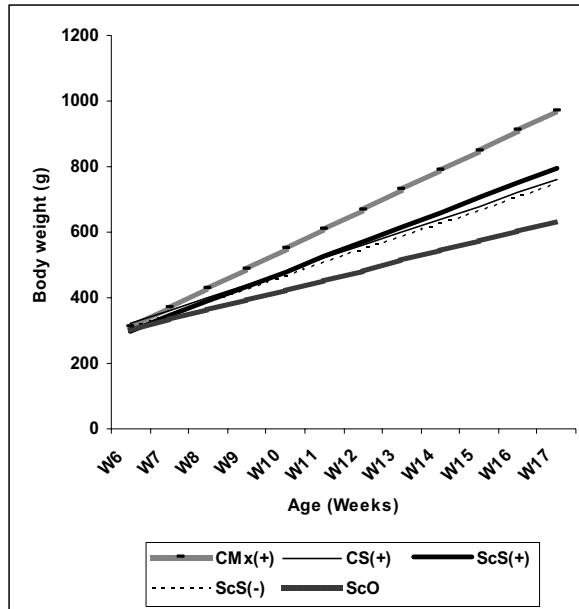


Figure 12. Effect of feeding and management on the growth of crossbred chickens.

CMx(+): Confined, mixed feed *ad-libitum*; CS(+): Confined, choice-fed *ad-libitum*; ScS(+): Semi-scavenging, choice-fed and with a vitamin-mineral premix; ScS(-) same as ScS(+) but without the vitamin-mineral premix; SO: Scavenging only.

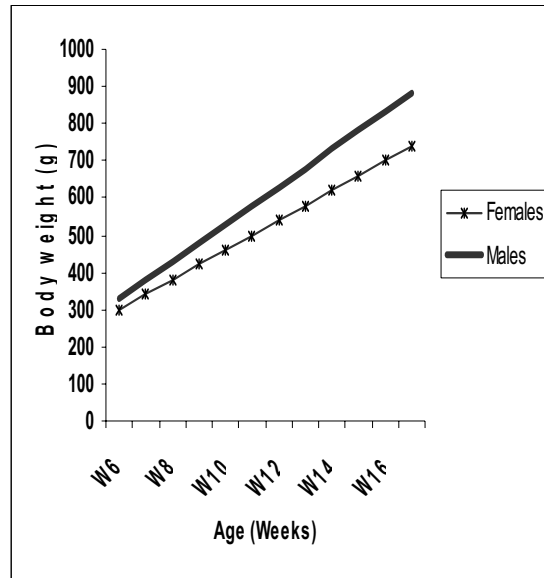


Figure 13: Mean body weight changes of crossbred male and female chickens under different feeding and management regimes

Feed costs (USD / kg of weight gain) were higher in CS(+) (5 USD) and ScS(-) (4 USD) compared to CMx(+) (3 USD) and ScS(+) (3 USD) ($P < 0.05$). Higher mortalities were seen in the scavenging treatments compared to the confined treatments.

Mean live body weight at slaughter was highest for the cockerels in CMx(+) (1048 g) and lowest in ScO (600 g) ($P < 0.05$). No significant difference was found among the other treatments. Carcass percentage was higher in ScS(+) (65.1%) and lower in ScO (53.0 %) than in the other treatments ($P < 0.05$ %). No significant difference in carcass percentage was found between ScS(+) and ScS(-). The highest thigh weight was found in ScS(+), while the lowest value was seen in treatment CMx(+).

4.4 Effect of Replacing a Low-Protein Fishmeal Diet by a High Protein Diet Based on Local Feed Ingredients on the Performance and Economic Efficiency of Semi-Scavenging Exotic Layers

Paper III. Higher daily DM and nutrient intakes were observed in the confined treatment (CCB) (103 g DM) compared to the semi-scavenging groups (52.9 and 66.7 g DM, respectively, for birds scavenging and receiving the fishmeal diet in late afternoon (SFM) and the corresponding scavenging birds that were fed the cottonseed cake and bran diet in late afternoon (SCB) ($P < 0.05$). In the semi-scavenging treatments, daily DM and nutrient intakes were higher in SCB compared to SFM, the differences being significant for DM, CP and amino acids. Daily intakes of ash, calcium and NFE were higher in SFM than in SCB ($P < 0.05$).

Final body weight was lower than initial body weight in SFM and SO, but was higher in SCB and CCB ($P < 0.05$). No significant difference in body weight was found among the semi-scavenging treatments. Mean total egg production per pen, and hen-day and hen-housed percent, were higher in CCB (1047, 72.4 % and 58.3 %, respectively) than in SCB (503, 29.0 % and 27.9 %, respectively) and SFM (375, 20.8 % and 20.8 %, respectively) ($P < 0.05$), and were lowest in SO (40, 2.30 % and 2.24 %, respectively) ($P < 0.05$). The egg production curves are shown in Fig. 14. Higher mortality was found in the confined treatment compared to the scavenging treatments.

Feed conversion ratio was lower for the confined treatment (CCB: 2.92 kg feed DM / kg eggs) compared to SCB (4.90 kg feed DM / kg eggs). No significant difference was found between the semi-scavenging groups for FCR (5.11 and 4.90 kg feed DM / kg eggs for SFM and SCB, respectively). Feed cost / kg eggs produced was lowest for the confined birds (0.60 USD / kg eggs), followed by the SCB group (1.0 USD / kg eggs) and SFM (1.6 USD / kg eggs) ($P < 0.05$). Gross margins of sale price over feed costs per kg eggs were 2.0, 1.5 and 1.0 USD for treatments CCB, SCB and SFM, respectively.

No significant difference was noted in mean egg weight and shell thickness between the confined and the corresponding scavenging treatments. In the semi-scavenging groups, these parameters were higher for SCB compared to SFM ($P < 0.05$). The SO hens laid the smallest eggs, and with a deeper yolk colour. Yolk colour was paler in the confined treatments compared to the corresponding scavenging treatments.

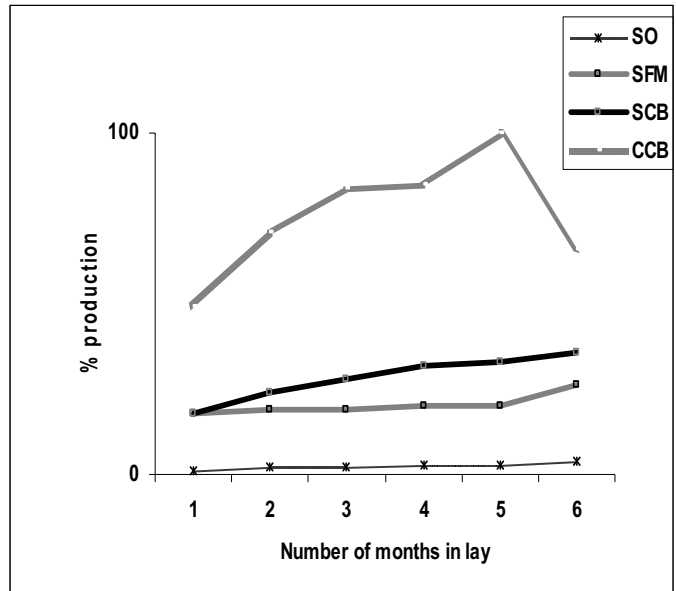


Figure 14. Effect of feeding and management system on the egg production of exotic layers.

SO: Scavenging only; SFM: Scavenging with the fishmeal diet from 16.00h to 08.00h; SCB: Scavenging with the cottonseed cake and bran diet from 16.00 h to 08.00h; CCB: Confined with the cottonseed cake and bran diet *ad-libitum*.

4.5 Chemical Composition and Digestibility of Some Local By-Products

Paper IV. The data showed acceptable crude protein (CP), metabolizable energy (ME) and crude fat (EE) contents for local sorghum beer residue (23.4 %, 13.4 MJ / kg and 5.6 %, respectively). However, mineral and amino acid concentrations were low (0.14 and 0.25 % for calcium and phosphorus, and 0.87, 0.44, 0.41 and 0.63 %, respectively, for lysine, methionine, cystine and threonine). Fibre contents were higher in Sapone, in the Soudano-Sahelian zone, compared to Bobo-Dioulasso, in the Soudano-Guinean zone. Overall, no significant differences were found in proximate composition between the two locations, and higher nutritive values were found from October to December compared to July to September.

The proximate composition of shea-nut cake showed mean values of 6.7 %, 7.3 % and 13.1 MJ / kg, respectively, for CP, EE and ME. No significant difference was found in proximate composition between the two locations, but CP and ME contents were numerically higher in Bobo-Dioulasso compared to Sapone, while ash, CF and EE were higher in Sapone. Mean calcium and phosphorus contents were 0.40 and 0.19 %, and amino acid contents were 0.27, 0.14, 0.09 and 0.23 %, respectively, for lysine, methionine, cystine and threonine.

Analysis data for cottonseed cake showed CP, EE and ME contents of 44.3, 5.9 % and 12.7 MJ / kg, respectively. Mean calcium and phosphorus contents were 0.34 and 1.3 %, and lysine, methionine, cystine and threonine contents were 1.6, 0.80, 0.82 and 1.9 %, respectively. Higher nutritive values for cottonseed cake were found in November and December.

True DM digestibilities were 93, 96 and 91 %, respectively, for beer residue, shea-nut cake and cottonseed cake. Overall, high digestibility values were found for the most limiting essential amino acids in all the three by-products.

5 General Discussion

5.1 Effect of Season, Location and Breed on Feed and Nutrient Intake from Scavenging

The Scavengeable Feed Resource Base (SFRB) was clearly affected by the environment and the availability of the household refuse. The results in Paper I confirmed that the quantity and the quality of the materials consumed by the birds varied according to household socio-cultural activities and religion, and consequently according to location. The variability according to the farmers' activities, such as sowing or harvesting, found by Gunaratne *et al.* (1993) and Goromela *et al.* (2007) was highlighted and confirmed in this study. However, the higher crop content weight found in the dry season compared to the rainy season was unexpected, and was probably due to the fact that the rainy season was earlier in the northern part of Burkina Faso at the time of the study, compared to previous years.

The SFRB in Burkina Faso is of low quality, with poor nutritive value, in particular with respect to crude protein and metabolizable energy contents, as was shown by the chemical data and the live weight gains of pullets between 5–6 months old in Paper I. In addition, the results of the feeding trials in Paper II and III showed that the nutrient intakes from scavenging were insufficient to meet the chickens' requirements for maintenance, growth and egg production. The poor performance and the higher mortality of the scavenging growing chickens in Paper II supported the conclusion of Goromela *et al.* (2006) that starvation was the main cause of the high mortality rates in village chicks and growers in Africa and South-East Asia. This is also in agreement with Sonaiya *et al.* (2002), who found by applying the “bird unit” concept for the

estimation of the SFRB that the quantity available for a chick for instance was very low. The poor performance of the semi-scavenging birds in Papers II and III demonstrated that the SFRB was obviously very limited and variable in the regions of Burkina Faso studied, confirming that the SFRB varies effectively according to climate and location. However, other studies in Asia (Minh *et al.*, 2004) and Africa (Smith, 2001; Acamovic *et al.*, 2005) reported higher performance under semi-scavenging conditions compared to the present study. The physical data of the crop contents of local pullets showed that these birds were more selective in scavenging compared to crossbred pullets, and the poor performance of the scavenging birds in Papers II and III supported the conclusion that exotic birds are not well adapted to harsh scavenging conditions. The variability in the quality and quantity of the SFRB can also be linked to the “bird unit concept” of Sonaiya *et al.* (2002), confirming that the availability of the SFRB also varies within a flock according to the category of bird, and also because of competition for the SFRB.

5.2 Availability, Nutritive Value and Digestibility of Some Feedstuffs for Poultry

For improving the nutrient intake and economics of village chicken production, better use should be made of the available local feedstuffs. Because of the inherent low productivity and low feed conversion efficiency of local breeds (Saunders, 1984; Van Eekeren *et al.*, 1995) they are unable to efficiently utilize high quality feeds. In Burkina Faso, some locally available materials that can be fed to village chickens have been described: for example, Ouedraogo (1987) outlined a technique for the production of maggots and termites as protein supplements for chicks, while Ouele (1989) listed groundnut cake, cottonseed cake, soybean, brewery malt, and imported ingredients such as fishmeal, blood meal and milk powder as potential protein feedstuffs for poultry. For chickens kept by resource-poor people in the rural areas of Burkina Faso, supplementation should be based on the use of the cheapest suitable feed ingredients that are available at village level. Consequently, the present study includes evaluations of feedstuffs such as maize, cowpea, wheat-maize bran, sorghum beer residue, cottonseed cake and shea-nut cake, as potential supplements for chickens. In West Africa in general, and in Burkina Faso in particular, cereals (millet, sorghum, maize, fonio and rice) are the staple food crops, and together occupy over 85 % of the

cultivated land (Les Editions Jeune Afrique, 1998), and are therefore widely available.

Maize (*Zea mays*) is the preferred cereal for feeding to domestic fowls. White and yellow maize are the common varieties found in Burkina Faso, and their dietary energy concentration is the highest among the most common cereals produced in the country. However, maize is deficient in protein (9 % CP in DM) and the amino acid profile is unbalanced, with deficiencies of lysine and tryptophan (Labrier & Leclercq, 1994). The protein content of the white variety of maize used in the present study was slightly lower (8.3 %), and the metabolisable energy content of 15.9 MJ / kg DM was in agreement with values reported for other varieties of maize in Africa (Dana & Ogle, 2002).

Cowpea (*Vigna unguiculata*) is the most popular legume, and the largest part of total world production originates from Africa. Burkina Faso is one of the most important cowpea producers in Sub-Saharan Africa, with a mean annual production in 2005 of 443,400 tonnes (Mission Economique, 2006). This legume is relatively easy to cultivate in harsh environments, and ensures food security for rural subsistence households (Lambot, 2002). The protein (23 % of CP) in cowpea seed is richer in lysine and tryptophan compared to cereals, but is deficient in methionine and cystine compared to animal proteins (Davis *et al.*, 1991).

In the rural areas of Burkina Faso, cereal and legume seeds are the main supplements for poultry, but are usually only provided on an irregular basis, according to availability. Because of its high nutritive value and ease of cultivation, cowpea is a potentially valuable protein supplement for chickens kept by resource-poor people in the rural areas. However, cowpea should first be treated, for example by boiling for a short time, to increase the palatability and to reduce the anti-nutritional problems linked with the presence of tannins (Martin *et al.*, 1980) and a trypsin inhibitor (Cabezas *et al.*, 1982).

Cottonseed (*Gossypium spp.*) cake and cereal brans (wheat and maize) are the agro-industrial by-products that are the most commonly used as ingredients in poultry feeds in Burkina Faso. Farmers are aware of the importance of these by-products, and many purchase them to supplement to their animals when other feed resources in the immediate environment are limited, in particular in the dry season (Kondombo, 2005). Current market conditions for the agro-industrial by-products in general, and cottonseed cake in particular, determine their availability and price for the farmers. According to Savadogo (2000), agro-industrial by-products were not previously available in Burkina Faso, or were so

expensive that farmers could not afford them, although the situation has improved since then. The glandless variety of cotton cultivated in Burkina Faso allows higher inclusion levels of the seed cake in poultry diets. The results in Paper III show that it could completely replace fishmeal in layer diets when combined with wheat-maize bran, because of the higher crude protein content (44 % of DM on average) compared to un-decorticated meals (McDonald *et al.*, 2002; Göhl, 1981).

Virtually all the fishmeal used in livestock feeds in Burkina Faso is imported, and is generally unavailable for rural farmers because of the high cost. In addition, there is considerable variation in quality and nutritive value between batches. For example, to increase profits, sand, sawdust and other materials are sometimes mixed with fishmeal in some countries in West Africa. These practices, in addition to inadequate storage conditions, can explain the poor quality of the fishmeal observed during this study i.e., development of rancidity (personal observation) and probably also the low crude protein content (39 % of DM). In view of these problems it was considered important to find alternatives to fishmeal, and two potential candidates at village level are shea-nut cake and beer residue. Traditional sorghum beer residue has an acceptable nutritive value and is available in the villages throughout the year. However, special measures should be taken to increase its palatability, as Kondombo (2005) found that amounts consumed by chickens were often rather low.

The shea tree grows throughout the semi-arid Sahel region of West Africa, but the largest concentration is in Burkina Faso, where shea butter and unprocessed shea kernels represented the country's third most important export after cotton and livestock in 2000 (Harsch, 2001). The harvesting and processing of shea is primarily an activity of rural women (Elias & Carney, 2007), and its earnings directly benefit some of the poorest villagers, in a country classified as one of the poorest in the world. Shea-nut cake, the by-product after butter extraction was investigated as a potential protein supplement, but the unexpected low crude protein content (Paper IV) indicated only very limited value, in contrast with other studies, where values of 16 – 18 % CP were reported (Morgan & Trinder, 1980; Atuahene *et al.*, 1998; Olorede *et al.*, 1999). The discrepancy can be attributed to the oil extraction technique used at village level in Burkina Faso, which includes repeated boiling and roasting, making the protein susceptible to degradation as a result of the Maillard reaction (Hodgkinson, 2006), confirmed by the dark colour of the traditional shea-nut cake. However, the cake is available almost all

the year round, and could be a useful feed for chickens, in particular during periods of feed shortage in the dry season, when women have more free time to produce shea-butter.

Relatively high fibre content was found in cottonseed cake, traditional beer residue and shea-nut cake, but the digestibility values of the dry matter and selected essential amino acids indicate that they could be used as ingredients in chicken feed. The relatively high CP content of local beer residue and cottonseed cake testifies to their potential value for monogastrics, although the low CP content of the shea-nut cake is a major problem. However, these by-products have undergone heat and pressure during processing, which, despite the fact that these processes contribute to inactivating some anti-nutritional factors in the raw material (Gatel, 1994; Nagalakshmi *et al.*, 2007) may induce chemical reactions such as the early Maillard reaction, which may render some of the amino acids nutritionally unavailable for the animal (Hodgkinson, 2006). Methods of evaluation such as bioassays for the evaluation of the real nutrient availability to monogastric animals, and feeding trials to determine the effect of different inclusion levels in the diet on growth and egg production performance are necessary. Shea-nut cake from commercial “press” extraction should also be considered, due to its higher protein content, rather than the cake from traditional oil extraction.

5.3 Effect of Choice-Feeding on Feed Intake and Growth Performance of Crossbred Confined and Semi-Scavenging Chickens

The principle underlying choice feeding (the so-called cafeteria method) of poultry is that individual birds reared in a flock are able to select between various feed ingredients according to individual needs and production capacities, which may increase efficiency when compared to a complete diet (Pousga *et al.*, 2005a). In Paper II, none of the choice-fed birds succeeded in meeting their requirements for protein and essential amino acids, resulting in lower performance compared to other studies (Olver & Malan, 2000; Erener *et al.*, 2003), mainly because of the lower than expected intake of the cowpea, that was intended to supply the necessary protein. The variability in the results reported in choice-feeding studies (Olver & Jonker, 1997; Dana & Ogle, 2002; Cruz *et al.*, 2005) emphasises the challenges facing the application of this feeding technique in poultry. Therefore, it is important to consider the

conclusions of Cruz *et al.* (2005), that the adjustment of intakes to meet nutritional requirements not only depends on the ability of the birds to select the correct proportions of the feeds offered, but might also depend on palatability and intake, and also on ingredient quality. The lower cowpea intake in Paper II was attributed to its low palatability, probably due to the presence of anti-nutritional factors reported in other studies, such as trypsin inhibitors (Cabezas *et al.*, 1982) and tannins (Martin *et al.*, 1982).

The slow growth of the birds in the semi-scavenging treatment would have partly been a result of the nutritional poverty of the SFRB in the study site. However, using the results reported in Paper I, where daily DM intake was 35 g in real scavenging conditions, and assuming that the birds fill their crop in four hour cycles of eating (Feltwell & Fox, 1978), it appears that in Paper II the intake from scavenging would have been around 70 g, which would have been expected to increase growth performance. However, this was not the case, probably because of the restricted scavenging conditions in the research station, which did not reflect the real village environment. The poor feed conversion efficiency and the high feed costs lead to the conclusion that it is not economically advantageous to feed untreated cowpea at current market prices to crossbred confined or scavenging chickens during the crop harvesting period at the end of the dry season.

5.4 Effect of Replacing Fishmeal by Cottonseed Cake and Wheat-Maize Bran in Layer Diets

Feed supply is the most important limiting factor in the improvement of poultry production in Sub-Saharan Africa in general and in Burkina Faso in particular. The high cost of imported feed ingredients, such as fishmeal, methionine and lysine necessitate the use of local by-products as replacement for conventional ingredients. Local chickens have low productivity, characterized by poor laying ability, low growth rate (Dessie *et al.*, 2000; Kondombo *et al.*, 2003) and low feed conversion efficiency (Saunders, 1984; Van Eekeren *et al.*, 1995). On the other hand, when local chickens in Burkina Faso were fed a standard commercial feed the result was a very low gross margin per bird, even though biological performance was improved (Kondombo, 2005). The experiment in Paper III was designed to evaluate the replacement of fishmeal by some local by-products, such as cottonseed cake and bran in exotic layer diets under different feeding regimes. Calculations of feed cost / kg eggs produced and sale price / kg eggs showed higher

economic returns for a cottonseed-wheat and maize bran diet compared to a fishmeal based diet in semi-scavenging conditions, as a result of higher egg production and the lower cost of cottonseed cake and wheat-maize bran compared to fishmeal. The problems facing the efficient utilization of fishmeal in Burkina Faso are a result of it being imported from the neighbouring countries of Ivory Coast, Senegal and Ghana.

The quality thus is very variable, due to differences in processing technique, transport and storage conditions, confirmed in the present study. The poor quality of the fishmeal used (39 % CP) in the experiment was the main factor behind the poor egg production performance observed. Higher inclusion levels of the fishmeal in order to meet requirements would have increased feed costs, and could have further reduced palatability and intake unless good quality fishmeal had been used (Smith, 2001). Conversely, higher egg production performance and good economic returns were obtained with the cottonseed and bran diet, and increasing the inclusion level of these local by-products would have further reduced feed costs. In addition, this would also have meant that it would have been possible to reduce the inclusion level of maize, which is a staple food for the human population in Burkina Faso.

The evidence of the poverty of the SFRB in the study site was highlighted, and it was obvious that in real-world scavenging conditions, the cottonseed cake and wheat-maize bran diets would have probably given even better egg production performance and superior economic returns compared to the confined groups. The relatively good performance and economic efficiency of the confined birds showed that exotic layers can also be reared advantageously in confinement by resource-poor farmers, using inexpensive, locally available feedstuffs such as cottonseed cake and brans as protein ingredients. The poor performance of the unsupplemented scavenging groups indicates that exotic breeds should not be reared in full scavenging systems without supplementation in the dry tropics, where the SFRB is usually very limited.

6 Conclusions

The scavenging feed resource base, evaluated in two agro-ecological zones of Burkina Faso by crop content analysis, was found to be influenced by the ecology of the poultry yard and immediate environment, and was dominated by grasses, weeds, leaves, insects, worms and seeds. The scavengeable feed also included household leftovers such as kitchen food waste, seeds and cereals and their by-products. There was found to be considerable diversity in the composition of the various feed items found in the crop that varied between seasons and locations and according to breed. Scavenging pullets were estimated to be getting around 60g of feed / day from scavenging, and the chemical analysis of the materials in the crop indicated that scavenging only cannot meet the nutrient requirements of crossbred pullets, in particular with respect to protein. However, it was concluded that scavenging only, without supplementation, was the most economical feeding strategy for crossbred growing chickens, at least during the harvesting period at the end of the rainy season. It was not economically advantageous to provide supplements of maize and cowpea to crossbred growing chickens, because of the lower intake of the cowpea due to its low palatability. This implies that the adjustment of intakes to meet nutritional requirements when birds are given free-choice access to different feedstuffs depends on their palatability and quality.

Evaluation of performance and economic efficiency showed that exotic layers could be reared advantageously in a semi-scavenging system and in confinement by resource-poor farmers, using locally available feedstuffs such as cottonseed cake and brans as protein ingredients. The poor performance of the scavenging only groups implied that exotic breeds are not particularly adept at scavenging and may need a long period of training in order to adapt to the system.

Alternative ingredients to imported protein feeds were evaluated and it was found that cottonseed cake could advantageously replace fishmeal in exotic layer diets when combined with wheat-maize bran, as a result of its high crude protein content, and also because the glandless (gossypol-free) variety commonly cultivated in Burkina Faso allows higher levels of inclusion. Another by-product produced at village level, beer residue, was also found to be potentially useful, due to the fairly high protein content and high digestibility values of some essential amino acids. However, the shea-nut cake resulting from the artisan extraction of the butter was found to have a low content of crude protein.

6.1 Implications and Recommendations

The scavengeable feed resource base in the regions of Burkina Faso that were studied is poor in quantity and quality, particularly during the dry season, which lasts for almost eight months of the year. Inputs for poultry in the rural areas are low, mainly because of the high cost of conventional feeds and also due to competition between humans and chickens for potential feed ingredients such as cereals. Poultry is a class of small livestock that resource-poor people can afford, including neglected groups such as women and the landless, and therefore is one of the most important sustainable sources of income and capital accumulation available to the poor. However, rural poverty persists, due amongst other things to the rapidly increasing human population and natural factors, including diseases such as avian influenza, that negatively influence the expansion of village poultry. Burkina Faso was officially the fifth African country (after Nigeria, Egypt, Niger and Cameroun) to be affected by the highly pathogenic avian influenza (HPAI) virus in April 2006. The affected populations were intensively reared chickens and guinea-fowl, and free-ranging chickens and ducks (OIE, 2006). Some of the measures taken to contain the HPAI included preventative culling of poultry in the infected areas, and a census of traditionally raised poultry and their elimination in a sequestration zone. The smallholder poultry sector was blamed for the spread of the disease, and it was suggested that a higher degree of control should be enforced with respect to smallholder producers. For example the authorities required that smallholders prevent their poultry from scavenging and instead, keep them confined in an enclosure. Taking into consideration smallholders' restricted economic situation, however, and the reality of village conditions, it seems highly unlikely that this ban is realistically feasible. However, the results in this

thesis show clearly that confinement and supplementation can lead to better performance as well as improved bio-security, and therefore, to promote poultry production in the rural areas, the following recommendations are suggested:

- Measures to improve disease control
- Evaluation and promotion of confinement systems for small-scale producers
- Government policy should take into consideration the possibility of subsidising agro-industrial by-products for poultry producers in the rural areas.

6.2 Future Research

Further research focusing on poultry production systems suitable for resource-poor people in Burkina Faso and neighboring countries could include:

- Development of bioassay techniques to evaluate the nutritive value of by-products produced at village level.
- Techniques for improving the palatability and intake of cowpea, local beer residue and shea-nut cake should be developed. Then feeding trials should be carried out at village level, to evaluate the effect of inclusion level of these by-products on growth and egg production performance. In addition, studies on the utilisation of shea-nut cake by poultry should be done on oil cake from commercial “press” extraction, due to its higher protein content, rather than the cake from traditional artisan oil extraction.
- Studies should also be carried out in Burkina Faso on disease control in scavenging systems; for example to evaluate the effect of supplementation and improving the scavenging feed resource base on the prevalence of parasites and infectious diseases.
- The feasibility of introducing the so-called “Bangladesh Model” in Burkina Faso should be investigated.

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Stratégies de Supplémentation des Poulets en Système Semi-intensif au Burkina Faso : Evaluation de Certaines Ressources Alimentaires Locales

Résumé

L'objectif général de cette étude visait à estimer le statut nutritionnel des poulets détritivores à partir de l'analyse des contenus de jabot et à évaluer certains ingrédients localement disponibles sur la base d'essais alimentaires. Les objectifs spécifiques consistaient d'une part à analyser l'utilisation de quelques ingrédients locaux (maïs, niébé, mélange son de blé et son de maïs, et farine de poisson) sous différents régimes alimentaires et d'autre part, évaluer certains sous produits tels que la drêche de bière locale de sorgho, le tourteau de coton décortiqué et le tourteau de karité à travers l'analyse chimique, la digestibilité de la matière sèche ainsi que de certains acides aminés, en vue de leur possible incorporation dans les rations de poulets.

La première phase de l'étude focalisée sur l'analyse des jabots a démontré que la ration des poulets détritivores se composait des débris alimentaires présents autour des concessions ainsi que des résidus de ménage. La composition macroscopique du contenu des jabots différait en fonction de la localité et de la race, la proportion des différents éléments variait également selon les activités saisonnières. La composition chimique n'a révélé aucune influence ni de la localité ni de la race. Cependant, la teneur en énergie métabolisable était plus élevée en saison des pluies (13.5 MJ / kg) et le taux de protéine brute (PB < 12 %) dans les deux sites étudiés était inférieur aux besoins.

La seconde étape de l'étude a été conduite en station sur des poulets métisses en croissance sous système intensif, semi-intensif et extensif. Les régimes alimentaires testés concernaient le maïs et le niébé, donnés sous forme de mélanges ou séparément, avec ou sans complément minéral vitaminé. Les résultats ont montré que le système purement extensif était le plus profitable lorsque l'environnement est favorable en débris alimentaires pour les poulets en croissance. En effet, il n'était pas économiquement rentable de supplémenter cette catégorie de poulet avec des régimes à base de maïs et niébé (niébé cru) en fin de saison pluvieuse.

La troisième partie de l'étude qui a été conduite également en station était basée sur des pondeuses (Isa Brown) en système intensif, semi-intensif et extensif. La farine de poisson a été remplacée par la combinaison tourteau de coton et son de blé-maïs dans les rations. L'analyse des performances de ponte, l'indice de consommation ainsi que la marge brute a montré que le tourteau de coton local combiné avec le son (blé-maïs) pouvait remplacer avantageusement la farine de poisson importée dans les rations pour pondeuses élevées aussi bien en confinement qu'en système semi-intensif. En revanche, le système extensif pure n'était pas profitable pour les pondeuses à cause de la pauvreté de l'environnement en ressources alimentaires, mais aussi probablement à cause des difficultés liées à l'adaptation à ce type de système.

La dernière section de l'étude concernait l'évaluation de certains sous-produits locaux. Les taux de protéine brute de 23,4, 6,7 et 44,3 %, respectivement pour la drêche de bière locale, le tourteau artisanal de karité et le tourteau de coton décortiqué ont été trouvés. Une étude parallèle sur la digestibilité vraie de la matière sèche ainsi que de certains acides aminés des sous-produits ci-dessus énumérés a démontré leurs potentialités nutritives pour les poulets et cela, malgré la teneur en fibre relativement élevée. Cependant, ces sous-produits ont été soumis à la pression et ont subi l'effet thermique lors des processus de transformation. Ces processus sont favorables à l'inactivation de certains facteurs anti-nutritionnels, mais par contre pourraient exposer ces produits à la "Réaction de Maillard" précoce qui réduirait la valeur nutritive de certains acides aminés tels que la lysine. De ce fait, des études sur l'augmentation de la palatabilité ainsi que l'effet du taux d'inclusion dans la ration sur les performances doivent être envisagées. De plus, les études sur le tourteau de karité devraient s'intéresser au tourteau obtenu après l'extraction d'huile par les "presses" car ce tourteau semble être plus riche en protéine brute par rapport au tourteau artisanal de karité.

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