Characteristics of feed production for intensive broiler breeding in Burkina Faso:the case of the of OUAGADOUGOU's city

Abstract:

Background: One of the major constraints of intensive peri-urban poultry farming in Burkina Faso is the loss of production and mortality of broilers, frequently linked to problems of nutritional feed quality. The aim of the present study was to characterize the quality of feed produced for broiler rearing in the peri-urban zone of the city of Ouagadougou.

Methods: In fact, a survey was carried out among the main feed manufacturers in order to inventory the different types of feed produced, and to take samples of these products for laboratory analysis. A total of 83 feed samples were collected and analyzed using standard methods to determine their bromatological and mineral compositions.

Results: Analysis of the feeds studied showed that the energy, protein, calcium and phosphorus contents were globally higher than those recommended in the literature.Average Crude protein (CB) levels were 21.13±3.63, 17.61±5.64 and 20.43±4.41% for the starter, grower and finisher phases respectively. Mean ME values were 3745.67, 3704.92 and 3704.92 kcal/kg DM for starter, grower and finisher feed respectively. Phosphorus levels were 4.78±2.16, 5.35±1.97 and 4.63±1.79 g/kg DM for the starter, grower and finisher phases respectively. Calcium levels were 11.38±2.29; 8.15±3.75 and 8.94±3.25 g/kg DM for the start-up, growth and finishing phases respectively.

Conclusion: These various results could be used as a referential for the animal feed industry and Burkinabe government officials responsible for monitoring and inspecting feed to ensure it meets nutritional and health standards.

Keywords: Intensive poultry farming, nutritional problems, feed raw materials, mineral sources, feedstuffs, Burkina Faso

1. Introduction

In Burkina Faso, the poultry flock is estimated at over 44 million head and the production segment of the sector involves nearly 1.6 million households[1]. It is the main source of income for over 86% of rural households. Its products are used to supplement cereals in the

human diet and help meet protein requirements[2–4]. Three systems coexist in poultry farming in Burkina Faso: extensive, semi-intensive and intensive one[5,6]. In the semi-intensive and intensive systems, poultry production requires special management, due to its more than commercial objective[7]. Semi-intensive and intensive poultry farming practices are particularly prevalent in peri-urban areas. On these improved farms, birds are raised in almost complete confinement and are unable to roam freely in nature searching for nutrients that are missing from their basic feed.In poultry farming, feed is the main factor affecting economic profitability, as it can account for 70% of variable costs [8]. High-quality feed is therefore a key factor in the success of modern poultry farming. Feed must provide the nutrients needed to cover the nutritional requirements of poultry in line with production targets[9]. They must also contain the required quantity and balance of nutrients known as protective and metabolism-activating nutrients, such as minerals. Calcium and phosphorus are the main minerals most widely distributed in the chicken body. Bones serve as a mineral reservoir in chickens, and the recovery of calcium and phosphorus from the diet plays an essential role in maintaining biological homeostasis[10].

Trace elements such as zinc, copper, iron, selenium and manganese play vital roles in animal growth and metabolism [11,12]. Suboptimal levels or unbalanced incorporation of these nutrients in poultry feed cause declines in production or lead to mortality. This considerably limits the zoo-economic yields of poultry farms, particularly those for meat production[13]. A Contrarious, for the majority of modern poultry farms in Burkina Faso, the supply of poultry feed remains highly varied in sources and their quality poorly controlled. The aim of the present study was to contribute to a better characterization of the nutritional potential of feeds for poultry on intensive peri-urban farms in Ouagadougou.

2.Materials and methods

2.1 Data collection from feed mills

Surveys were conducted among the main feed manufacturers. The choice of these feed manufacturers focused on those who were in compliance with the regulations of the Ministries in charge of animal and fisheries resources and industry, trade and handicrafts, and who were listed in the databases of these two ministerial departments. Eight (8) feed mills were selected for the surveys. Using survey forms, these eight (8) feed mills were initially asked to collect

data identifying the factory unit, and to inventory the different types of feed produced for broiler feed. Data were also collected on how these products were packaged and stored.

Feed samples were taken using a ladle for laboratory analysis. The sampling was preceded by the operator wearing protective gloves, and between successive samples, the measuring cup was thoroughly cleaned. Samples were immediately stored in a Ziplock bag and labelled according to pre-established codes for each sampling site. A duly completed sampling sheet was used to record information on the targets and food samples collected. A total of 83 feed samples were collected for laboratory's analyses.

2.2. Laboratory's analyses:

The parameters analyzed in the laboratory were: dry matter (DM), total nitrogen matter or Cride protein (CP), fat matter (FM), crude cellulose (CC), mineral matter (MM) or crude ash, phosphorus (P), calcium (Ca), zinc (Zn), copper (Cu) and iron (Fe) for feed only.

The determination of dry matter (DM) and mineral matter (MM) was based on AOAC standard methods (AOAC, 1984).

Dry matter was determined after oven-drying 2.5 g of the sample for 12 hours at 105°C. After drying, the sample was weighed to determine DM.

For crude ash (total mineral matter), feed samples were weighed and placed in an electric muffle furnace at 550°C for 3 hours, and the products obtained were weighed and expressed as relative dry matter values for each sample.

Nitrogenous matter was determined using the method of [14], which involves mineralizing the samples with sulfuric acid (95%) at 480°C for 167 min in the mineralizer, distilling using a distillation apparatus and titrating the distillates.

Fats were dosed using the[15] method, in accordance with ISO 659[16] using di-ethyl ether as the solvent [17].

Calcium, zinc, copper and iron were determined by atomic absorption spectrophotometry (AAS), using the Perkin Elmer AAS 300 Equipment, according to Beer-Lambert's law. One (1) ml of extract is diluted with 10 ml of 1% lanthanum solution. The diluted solution is then run through the AAS 300 to determine the above-mentioned elements [18].

P levels in the mineralization were determined using a manual colorimeter in the presence of potassium tartrate antimony and ammonium molybdate as indicator.

Determinations of DM, CP, CC and MM were carried out at the Laboratory ofResearch inAnimal Production andHealth (LaRePSA) of the Institute of the Environmentand theResearches onAgriculture (INERA) of the National Center for Scientific and TechnologicalResearch (CNRST) of Burkina Faso.

Fats were determined at the laboratory for feed biotechnology(LBTA) of the Institute for Research in Applied Sciences and Technology(IRSAT) of the National Center for Scientific and Technological Research (CNRST).

Mineral analyses were carried out at the Bureau National des Sols (BUNASOL) laboratory of the Burkina Faso Ministry of Agriculture, Animal and Fisheries Resources (MARAH) of Burkina Faso.

For the determination of feed energy, two (2) equations reported by[19] were used, one applying to simple feeds (raw material feeds) for the determination of gross energy (GE) and the other applying to compound feeds (feeds from poultry feed manufacturers) for the determination of metabolizable energy (ME).

The equation of[20] was used to determine the gross energy (GE) of feedstuffs:

$GE=57.2xCP +95.0xFM+47.9xCC+41.7xNNE+\Delta t$, (in kcal/kg)

With:

GE = gross energy (in kcal/kg)

CP = crude protein (in p.100)

FM = fat (in p.100)

CC = crude cellulose (in p.100)

NNE = non-nitrogenous extractive (in p.100)
Δt = correction factor for certain raw materials

Sibbald's equation (1982) was used to determine the metabolizable energy (ME) of compound feeds:

ME=3951 +54.4xFM-88.7xCC-40.8xCA, (in kcal/kg DM)
With:
FM = fat (in p.100)
CC = crude cellulose (in p.100)
CA = crude ash (in p.100)
DM = Dry mater

2.3. Statistical analysis of data

All the parameters collected were entered into a Microsoft Excel spreadsheet to constitute a database. Frequencies were generated using Excel's pivot table method. Means and standard deviations of the parameters studied were obtained using the descriptive method of SPSS version 21 software.

3. Results

3.1. Characteristics of the producers involved in poultry feed production and their production's units

Almost all the feed mill owners surveyed were men. They had all benefited from formal education. Indeed, 87.5% had higher education and 12.5% had secondary education. Thirty-eight percent (38%) were aged between 20 and 40, and 62% between 40 and 60. Most of the poultry feed mills surveyed were located in the Ouagadougou communal area. Indeed, 94% of these industrial units were located in the commune of Ouagadougou, compared with just 6% in the commune of KOUBRI, 25 km from the city of OUAGADOUGOU. Seventy-five percent (75%) of the mills surveyed had the status of « Limited Liability Company (LLC) », while the remaining 25% were « Anonymous Societies (AS) ».

Most of the feed mills surveyed indicated that they used software to formulate their feeds, and that they also relied on the expertise of third persons. They declared that they had carried out quality controls on their feeds by having them analyzed by certain local laboratories. Only one

factory in the survey had its own analysis laboratory, but with very limited functionality in terms of quality control, particularly with regard to the diversity of nutrients to be determined. Most of the feed produced (62.5%) was in pellet form, with the remainder (37.5%) in powder form. These feeds were packaged in 25-50 kg bags for sale. Storage time for these feeds was estimated at between 7 and 10 days maximum.

All the factories visited were operating below their production capacity, which, according to the information gathered, ranged from 3,000 to 35,000 tons a year. Maximum annual production actually achieved at the time of the investigation and reported was 5,000 tons on average per Mill.

3.2. Broiler feeds from surveyed feed mills and their nutritional qualities

Three (3) types of broiler feed were identified from the feed mills surveyed. These were starter feed, grower feed and finishing feed. Six (6) of the eight (8) feed mills surveyed produced their broiler feed according to the three (3) physiological stages: start-up, growth and finishing. The other two (2) mills only produced feed corresponding to two phases, i.e. start-up and growth-finish.

All the three (3) feed types surveyed and analyzed had DM contents above 90%. The average of CP rates measured were 21.13±3.63, 17.61±5.64 and 20.43±4.41% respectively for the start-up, growth and finishing phases (Table 1). Mean ME values were 3,745.67, 3,704.92 and 3,704.92 kcal/kg DM for starter, grower and finisher feed respectively. The fat contents evaluated were 7±4; 8.08±4; 7±2%. Mean CC values obtained were 3.42±1.71; 3.53±2.47; 4.14±2.47% for the starter, grower and finisher phases respectively.

In terms of the mineral content of the meat feeds analyzed (Table 2), phosphorus levels were 4.78±2.16 (approx. 0.5%); 5.35±1.97 (0.54%) and 4.63±1.79 g/kg DM (0.5%) for the start-up, growth and definition phases respectively. Calcium ratios were 11.38±2.29 (1.4%); 8.15±3.75 (0.82%) and 8.94±3.25 g/kg DM (0.9%) for the start-up, growth and definition phases respectively. Phospho-calcium (Ca/P) ratios were 2.31±0.90; 1.64±1.14 and 1.89±0.71 for the start-up, growth, and finishing phases, respectively.

Average zinc levels for starter, grower and finisher feed were 85.25, 113.54 and 250.57 ppm respectively. Copper rates were 13.61, 11.72 and 9.65 ppm respectively.

Table 1. Organic composition of broiler chicken feed from the feed mills surveyed (Means, maximum, minimum)

Feeding Phases		DM (%)	CA (%)	CP (%)	CC (%)	FM (%)	ME (kcal/k
Startup	means	91.73 N (37)	8.35 N (37)	21.13 N (37)	3.42 N (37)	7 N (37)	3745.6 N (37
	maximum	93.17	11.68	24.76	5.13	11	4026.5
	minimum	90.29	5.02	17.5	1.71	3	3464.8
Growth	means	90.57 N (26)	11.22 N (26)	17.61 N (26)	3.53 N (26)	8.04 N (26)	3704.9 N (26
	maximum	98.55	16.2	23.25	6	12.04	3986.5
	minimum	82.59	6.24	11.97	1.06	4.04	3423.3
Finish	means	91.9 N (20)	10.1 N (20)	20.43 N (20)	4.14 N (20)	7 N (20)	3692.1 N (20
	maximum	94.3	13.2	24.84	6.61	9	4002.4
	minimum	89.5	7	16.02	1.67	5	3381.8

DM:dry matter, CA:crude Ash, CP:crude protein, CC:crude cellulose, FM: fat matter, ME:metabolizable energy, N:number of Samples

Table2. Mineral composition of broiler chicken feed from the feed mills surveyed (Means and SDs)

Feeding Phases	P (g/kg)	Ca (g/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Ca/P
Startup	4.78±2.16 N(37)	11.38±2.29 N(37)	13.61±2.24 N(37)	85.25±6.54 N(37)	463±158 N(37)	2.31±0.90 N(37)
Growth	5.35±1.97 N(26)	8.15±3.75 N(26)	11.72±1.83 N(26)	113.54±29.41 N(26)	205.03±126.06 N(26)	1.64±1.14 N(26)
Finish	4.63±179 N(20)	8.94±3.25 N(20)	9.65±1.51 N(20)	250.57±96.14 N(20)	1077±207 N(20)	1.89±0.71 N(20)

P:Phosphorus; Ca:calcium;Cu:copper;Fe:iron;N: numberof Samples, Ca/P: ratio calcium/phosphorus

4. Discussion

The results of the study show that almost all the feed mill managers surveyed were men. This situation highlights the particular nature of this sector of economic activity in Burkina Faso, linked to the importance of the working time to be devoted to it and the financial capacity to be satisfied. Indeed, setting up an industrial unit such as a feed mill requires a significant investment of time and funds, which are not always affordable for women[21]. The food industry also requires a certain maturity in age and a good level of education. In fact, feed mill management must be carried out by people who are qualified in feed and in the nutritional and sanitary quality of feed, and therefore those who have benefited from training or appropriate technical skills in the field [22].

The 75% of factories surveyed were Limited Liability Companies (LLCs), compared with 25% that were Anonymous Societies (ASs). In Burkina Faso, the status of aLimited Liability Company (LLCs) requires a minimum social capital of one hundred thousand (100,000) CFA francs[23], whilethe status ofanAnonymous Societies (ASs) requires the owner to have a share capital of one hundred million(100,000,000) CFA francs in the case of a public offering, or ten million (10,000,000) CFA francs otherwise[24] . The fact that it is relatively easier to raise share capital for the creation of limited liability companies (LLCs) could partly explain their predominance compared with Anonymous Societies (ASs).

The results show a degree of professionalism among the feed mill operators surveyed, through the use of ration/feed formulation software and the expertise of animal nutrition and feed technology specialists. The actors surveyed are well aware of the importance of a quality feed supply. To this end, they determine and control the chemical composition of their feeds in the laboratory. Some of them have even set up "pseudo laboratories" to control the quality of their products. Such is the case of the “Société de Fabrique d'Aliments pour Bétail (SOFAB)”company.

In addition, most of these feed mills try to produce feed to the best possible satisfaction of their customers (breeders), taking into account the three critical phases of broiler physiological needs: start-up, growth and finishing. The feeds produced also have a good level of dry matter content, making them easy to store for healthy poultry feeding.

The CP levels obtained from the present study are slightly close to the recommended standards for starter feed, which range from 21 to 23.7%, and finishing feed, which vary from 16 to 20% [19,25]. On the other hand, the values of this parameter for the growth phase (17.61% on average) remain slightly below those recommended in the literature, which vary from 18 to 21%. It is recognized that the reduction in protein content in broiler chicken feed is a major issue affecting the performance of the birds and the sustainability of poultry farming[26–28].

The metabolizable energy (ME) values obtained from the present study are higher than those usually recommended, which average 2,750 to 3,200 kcal/kg DM for starter feed, 2,900 to 3,200 kcal/kg DM for grower feed and 2,700 to 3,200 kcal/kg DM for finisher feed[19,25,29]. However, in tropical zones where temperatures are high, poultry still have lower energy requirements than those living in temperate environments [30]. To achieve this, they limit their feed and energy intake, in order to maintain their body temperature at a normal 42°C[31]. In addition, a high-energy diet can induce greater fat deposition and limit the quality of chicken carcasses produced for consumers. In the tropics, 3000 kcal/kg would appear to be the ideal energy level for good growth performance [32]

The results of chemical analyses show that, overall, the phosphorus and calcium content of the feed studied is inappropriate. However, an excessive or insufficient intake of either of these two minerals generally inhibits the effective use of the other, which can cause nutritional problems in chickens [33].Calcium and phosphorus are the most important minerals in poultry nutrition, especially for broilers (rapid growth) where good skeletal mineralization is important to avoid problems of lameness or joint deformities [34]. They are involved in humoral balance and bone formation during growth. For this reason, it is recommended to have a calcium-phosphorus ratio that is favorable to good bone retention, which should be between 2 and 3[19,35,36]. However, the results obtained from our study also show

unattractive calcium-phosphorus ratios, especially those for the growth and finishing phases, which are 1.64 and 1.89 respectively.

The levels of trace elements measured in this study (Zn, Cu and Fe) exceeded the recommended values, i.e. they were in excess of these values. These results could be the consequence of excessive or abusive use of mineral supplements by feed mills, particularly iron sulfate and premixes, as the results showed. Trace elements play an important role in the life and metabolism of birds, and their deficiencies or excesses are the cause of many diseases and abnormalities[37,38]. It should also be noted that most of the trace elements ingested, in quantities generally in excess of the animal's requirements, are excreted and may pose a risk to the environment [12].

5. Conclusion

The results of the study show that the factories that produce feed for poultry in Burkina Faso are almost exclusively run by men who are trying to professionalize in their own way in order to best satisfy their customers, who are mainly poultry farms. In fact, they produce and take into account the physiological phases of broiler poultries.

Apart from crude protein (CP) content, most of the feed from the factories studied had chemical compositions that were either deficient or excessive in relation to the required standards.This requires paying particular attention to the actors involved in order to help them adjust their diets and make them more balanced and high-performance.To achieve this, research could contribute its expertise by studying and optimizing the effectiveness of these feeds from the feed mills studied. In the meantime, the results obtained from this study could serve as a reference for the animalfeed industry and for Burkinabe Government officials responsible for monitoring and inspecting feed quality at the national scale.

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Data Availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' Contributions

Conceptualization, data curation, methodology, writing-original draft, writing-review and editing: ZAMPOU Yasmine Jessica Irène, GNANDA Bila Isidore. For the formal analysis ZARE Yacouba, KY Inoussawere responsible. For the investigation, supervision, validation and visualization TRAORE Boureima, ZONGO Moussa were responsible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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