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RESEARCH ARTICLE

USE OF AZOLLA PINATA IN THE RATIONING OF "POULET DE FASO" BROILERS IN BURKINA FASO: INFLUENCE ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, CUT PARTS AND ORGANS

Timbilfou Kiendrébéogo[1,2], Souleymane Ouédraogo[1,2], Epilou Baziémo[2], Zanbéwendin Isidor Ouédraogo[3] and Marie Chantal Valerie Bougouma-Yaméogo[4]

1. Institu de l'Environnement de l'Environnement et de NERA/épartement Productions Animales(DPA)Technologique, Laboratoire de de Recherches en Production et Santé Animales (LAREPSA), de l'Institut de l'Environnement et de Recherches Agricoles, Station de Farako-Bâ, Bobo-Dioulasso, Burkina Faso.
2. Laboratoire d'Etudes et de Recherches sur les Ressources Naturelles et les Sciences de l'Environnement(LERNSE), Université Nazi Boni, Bobo-Dioulasso, BurkinaFaso.
3. ECole National de Formation en Agriculture, Maturkou, Bobo-Dioulasso, Burkina Faso.
4. Laboraoire des Systèmes Naturels, Agrosystmes e de l'Ingénierie de l'Environnement (SyNAIE), Université Nazi Boni, Bobo-Dioulasso, BurkinaFaso.

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Abstract

The aim of the study was to evaluate the growth performance of chicken broilers "Poulet du Faso" fed rations incorporating Azzola pinata. Three growth-finishing diets were formulated and tested, including 02 experimental diets incorporating 5% (ED5) and 10% (ED10) azzola meal and a standard control without azzola (SCD). One hundred and five (105) chicks divided into batches of 35 chicks per diet were used for the experiment, which lasted 54 days (8 weeks). The results show that the growth rate of the chicks was significantly faster for ED5 and ED10 diets ($p<0.05$), comparable for all diets for the last 2 weeks, and overall average daily gain ($p>0.05$). The average daily feed intake (ADFI) of ED5 and ED10 were homogeneous($p>0.05$) and significantly higher than that of the SCD ration($p<0.05$) No significant difference in CI and FCPkgLW was noted between the 3 diets($p>0.05$).No significant differences in hot (RDTcc) and chilled (RDTcr) carcass yields and abdominal fat content (AFC) were observed between diets ED5, ED_{10} and SCD($p>0.05$). Among the organs and parts of the cut, only the average weight of the Thigh+Tail of diets SCD and ED5 were homogeneous($p>0.05$) and significantly higher than that of ED_{10}($p<0.05$). Incorporating Azolla meal into the diet had no adverse effect on chicken carcass characteristics. Azolla meal can be recommended for use as a source of vegetable protein in chicken rations, particularly for purebred mixed breeds.

Corresponding Author:- Timbilfou Kiendrébéogo
Address:- Institu de l'Environnement de l'Environnement et de NERA/épartement Productions Animales (DPA)Technologique, Laboratoire de de Recherches en Production et Santé Animales (LAREPSA), de l'Institut de l'Environnement et de Recherches Agricoles, Station de Farako-Bâ, Bobo-Dioulasso, Burkina Faso.

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Introduction:-

Livestock accounts for 40% of the world's agricultural production, and contributes to the livelihoods and food security of nearly a billion people (FAO, 2009). It is one of the fastest-growing sub-sectors in developing countries, where it already accounts for a third of agricultural GDP (Bruinsma, 2003). It accounts for 5% to 10% of exports from West African countries, particularly the landlocked Sahelian countries of Burkina Faso, Mali and Niger, which are the three major cattle, sheep and goat producers (RPCA and CILS, 2010). This sub-sector is the second largest productive sector in Burkina Faso, directly affecting the highest proportion of poor people in all regions (MRA, 2011). Moreover, in the national economy, it contributes 18.8% to wealth creation, 14.2% to exports and 38.8% to the monetary income of rural households (MRA and UNDP, 2011). Poultry farming occupies an important place in livestock production, especially in rural areas, where poultry are raised for local consumption, ritual, customary, religious and social practices, and above all to generate income through sales (Pousga, 2009). It is an activity that is easily accessible to the rural and poor households that practice it (MRA, 2007). Increasingly, poultry farming systems using chickens of improved strains for laying and meat production are being introduced (MRA, 2010). However, the supply of feed resources is the major constraint to the development of intensive poultry farming in Burkina Faso. Rearing improved breeds in modern poultry farming requires feed in terms of quality and quantity, which accounts for between 60 and 80% of production costs (Meffeja et al., 2006). The supply of feed inputs is a crucial issue these days. Indeed, we are witnessing a rise in the cost of conventional raw materials on the international market, in particular maize, the energy base of feed for monogastric pigs and poultry. The use of maize in biofuel production poses further problems in terms of the availability of this resource (Doumbia, 2002). The same applies to conventional protein raw materials such as soy, cotton and peanut cakes (plant proteins) and fishmeal (animal proteins). In Burkina Faso, the fish used in poultry feed is imported in its entirety, resulting in a loss of foreign currency. Faced with this situation, it is necessary to look for new protein sources that are more accessible, less expensive and non-competitive with human consumption. This is why species such as Moringa oleifera, Leucena leucocephalla and Azolla pinnata have been used in poultry feed (Dahouda et al., 2009). Azolla is a small aquatic fern that floats freely on the surface of freshwater ecosystems in tropical, subtropical and warm temperate regions of Africa, Asia and the Americas (Costa et al., 2009). It is abundant in Burkina Faso in aquatic ecosystems such as the Bala hippopotamus pond and the Bama dam. It is a plant that is rich in protein, essential amino acids, vitamins (A, B12, Beta Carotene) and whose chemical composition analysis has shown a protein content of up to 25%-35% (Kathiverlan et al., 2015). Despite its presence in Burkina Faso, very few studies have been devoted to its valorization in poultry feed, particularly broiler feed. The aim of the study is to assess the technical-economic effects of incorporating Azolla on the growth performance and carcass quality of "Poulet du Faso" broilers in Burkina Faso.

Materials and Methods:-

Study site

The study was conducted at INERA's Farako-Bâ research station over the period from July 19 to October 11, 2021. The Farako-Bâ station covers an area of 475 hectares and is located 10 km southwest of Bobo-Dioulasso on the Bobo-Banfora axis. Its geographical coordinates are: 04°20' west longitude, 11°06' latitude at an altitude of 405m (getamap.net, 2023). The Farako-Bâ station is characterized by two strongly contrasting seasons, including a relatively short rainy season lasting 5 to 6 months and a dry season lasting 6 to 7 months. The dry season comprises a cool dry season from December to February and a hot dry season from March to April. Rainfall is relatively high, ranging from 800 to 1100 mm depending on the year.

Hen house used for the study

A 10 m long by 4 m wide poultry house with six 3.75m² (2.5m X1.5m) stalls, three of which were used for the trial. The building is oriented perpendicular to the prevailing east-west winds. The concrete floor was covered with a 5cm layer of rice husk litter. The litter was changed once a week. At the entrance to the henhouse was a foot bath containing bleach (sodium hypochlorite) for sanitizing before entering the henhouse, for biosafety reasons. The henhouse was first cleaned with soapy water and bleach. It was then brushed with quicklime to kill any parasites that might be present. After these operations, a two-week sanitary vacuum was observed before introducing the chicks. Three days before the chicks arrived, the building was disinfected by spraying with VURINET® to kill any parasites that had escaped the quicklime. One of the boxes in the experimental hen house was converted into a chick house to house the chicks. Accessory equipment such as six-liter drinkers and three 1-m linear feeders were used to feed and drink the chicks. An electric chick heater was used to heat and light the henhouse. 2.3. Animal material and experimental set-up

Animal material

A total of one hundred and five (105) one-day-old "Poulet du Faso" chicks were used in the experiment (photo 1). They came from a hatchery in Bobo-Dioulasso, which is an annex of a Centre de promotion du pouletdu Faso in Boussé, Burkina Faso. The Chicken du Faso (photo 2) is a cross between a rooster of the local Burkina Faso breed and a traditional local French female named Sasso SA 51. The "Poulet du Faso" phenotypically resembles the "pouletbicyclette". However, it grows faster than the latter. Breeding conditions are the same as those observed in traditional farming, but to make the most of it, intensive breeding conditions must be respected. After 3 months of rearing, they can reach a weight of 1.5 kg, and are dual-purpose.

Figure 1: - Batch of 01-day-old "Poulet du Faso" chicks.

Figure 2: - Mature "Poulet du Faso" chickens (Credit photo Bazémo, 2021).

- The experimental set-up consisted of a six-box building, with each box measuring 2.5 m long by 1.5 m wide. Three boxes were used for the experiment. The chicks were divided into three batches of 35 chicks, each batch occupying one box. Each of the 3 batches received one of the three rations. The chicks were allocated to the different batches at random, considering the weight of the chicks in order to obtain balanced average weights for the three batches. After batching, the chicks underwent a four-day feed transition (Bello, 2010) (36th, 37th, 38th and 39th day) with 3/4 (of the usual feed), 2/4, 1/4 and zero share of the usual feed. On installation, the birds were fed a commercial GALDUS® starter feed from day 1 to day 13, then a chick feed from day 14 to day 35, purchased from a feed seller in Bobo-Dioulasso. The feed was served ad libitum morning, noon and evening. The chicks were ringed on day 28. From day 36 onwards, the feed was served twice a day, at 8 am and 2 pm. The quantity of feed consumed per chick per day was readjusted according to their demand. Water was served ad libitum to the chicks during feed distribution.

Formulation of chicken rations

- Production of incorporated Azolla pinnata used in chicken rationing

The second biological material is Azolla pinnata. It was produced in a pond measuring 19.60 m, 9.54 m wide and 1.24 m deep at the Farako-Bâ station (Figure 3). After inoculation of Azolla in the basin, a quantity of fertilizer (cow dung) was added to the water. Harvesting is carried out when Azolla pinnata has covered the entire surface of the water in the basin. Once harvested, A. pinnata was cleaned of impurities.

Figure 3:- Azolla production basin.

Figure 4:- Azolla drying on a tarpaulin.

Figure 5:- Dried Azolla flour.

It was then sun-dried for two to three days (Figure3), then ground into flour (Figure 4) for incorporation into experimental rations.

- Diet formulation: two experimental diets RAZ_5 incorporating 5% azolla flour and RAZ_{10} incorporating 10% azolla flour and 01 standard control (SCD) were formulated and fed to chickens in the growth-finishing phase. Table 2 shows the centesimal composition, energy and nutritional intakes of the diets. Diets were sampled for dry matter (DM), organic matter (OM), mineral matter (ash), crude protein, calcium, phosphorus, potassium, magnesium and sodium. Analyses were carried out at the soil-water-plant laboratory of the Natural Resources Management Program (GRN/SP) at the Farako-Bâ research station. Dry matter is obtained by oven-drying at 105°C for 24 hours. Mineral matter or ash is obtained by passing the dry sample through a muffle furnace at 550°C for 24 hours. Organic matter is thus obtained from the difference between dry matter and ash. Protein concentration is estimated from N content, based on an average nitrogen content of 16% in plant or animal proteins (N*6.25).

Table 1:- Centesimal composition, energy and nutritional content of diets.

Ingredients	**Distributed diets**		
	SCD	**RAZ_5**	**RAZ_{10}**
----------Centesimal composition----------			
Corn	66.8	65.5	66.8
Weath bran	10	6.8	0
Azolla pinnata	0	5	10
Fysh meal	5	5	5
Soya cake	15	14.5	15
Prémix	0.5	0.5	0.5
Oyster shell powder	1	1	1
Salt	1	1	1
Methionine	0.2	0.2	0.2
Lysine	0.5	0.5	0.5
Total	100	100	100
----------Energy (kacal/kgDM) and Nurients content (%)----------			
DM (%)	87.91	88.12	87.30
ME (Kcal/kg)	2932	2901	2927
CP	17.28	18.26	17.65
CF	9.19	9.76	10.03
Lysine	0.79	0.84	0.897
Methionine	0.50	0.51	0.51
Calcium	0.30	0.38	0.42
Phosphore	0.28	0.27	0.24
Potassium	0.98	1.30	1.47
Sodium	0.80	0.82	0.94
Magnésium	0.28	0.12	0.21
CPkgD(FCFA)	275.28	261.1	263.4

SCD=standard control ration without Azolla**; RAZ_5:** ration incorporating 5% Azolla flour; **RAZ_{10}=** ration incorporating 10% Azolla flour.

Data collection and analysis

- To assess chicken feed consumption. the quantities of feed rejected were collected and weighed by batch each morning before meal service;

- Growth assessment: Weekly weighing of chickens was carried out in the morning before meal service. using an electronic balance with a capacity of 10.000 g and accuracy of 1 g.

- Daily feed consumption (DFC) was calculated using the formula: DFC(g)=(QFD-RF)/n where QFD = quantity of feed distributed per day. FR= feed refusal and n= number of birds in the batch;
- Average daily gain (ADG) was calculated according to the formula:

- ADG(g)=(FW-IW)/nd where WF = subject's final weight; IW = subject initial weight and nd = number of collection days; subjects were weighed weekly in the morning before the day's meal service.
Conversion index (CI) was calculated using the formula:
- CI=DFC(g)/ADG(g) where DFC = daily food consumption and ADG = average daily gain:
Mortality rate (MR) was calculated according to the formula:

- MR (%)=NDS x100/NIS where NSM = number of dead subjects and NSI = number of initial subjects;
Economic parameters were calculated using the formulas in Kiendrébéogo et al. (2018):
- Production cost per kg of feed dry matter (CPkgDM) obtained by the formula CPkgDM (FCFA) = $\sum$ (PPi x Yi) in where PPi = the purchase price of one kgDM of the ingredient. Yi = the contribution by weight (kgDM) of the ingredient in one kgDM of feed produced and n = the number of ingredients in the ration;

-The feed cost of producing one kg of live chicken (FCPkgLW) is calculated by the formula: FCPkgLW (FCFA)=CI xCPkgDM where CI = conversion index and CPkgDM = the cost of producing one kg of diet.

- To assess carcass characteristics. 4 subjects/batch. i.e. 12 subjects in all. were slaughtered. plucked in hot water and partially eviscerated (crop. intestine). Carcasses still containing organs such as lungs. heart. liver. spleen and gizzard were weighed. These organs were then detached and weighed individually per subject (Bello. 2010). The empty carcasses were suspended head-down from wooden gallows in a ventilated PT room for 01 hour. At the end of this time. the carcasses were weighed again to obtain the weight of the penetrated carcass. The carcasses are then individually wrapped in aluminum foil and refrigerated for 24 hours. After chilling. they are weighed again. The various parts - legs. thighs+pillars. wings. head and neck - are then detached from each carcass and weighed individually.

- Hot carcass yield (HCY) was calculated according to the formula:

HCY (%) =(HCWx100)/PSW where HCW = carcass weight after evisceration and PSW= live weight before slaughter;

Refrigerated carcass yield (CCY) was calculated according to the formula

- CCF (%) =(CCWx100)/PVA where CCW=chilled carcass weight and PSW: hot carcass weight;

- Average weights of organs (heart. gizzard and liver). parts (thighs + drumstick. wings. legs) were calculated according to the following formula: Average weight (organ or part) = (Sum of organ weights / Number of animals slaughtered)

- Abdominal fat content (AF) was calculated according to the following formula: AF content (%) = (AFW*100/HCW).

Data were entered into an Excel spreadsheet. Statistical analyses were performed using XLSAT version 2016 software. Analyses of variance (ANOVA) using Fisher's least significant difference (LSD) model at the 5% threshold were used to statistically separate averages.

Results:-

A total of 01 deaths were recorded in RAZ_{10}, representing an overall rate of 0.95%, and 2.86% in RAZ_{10}.

Chemical composition of Azolla pinnata produced

Table 2 shows the results of the analysis of the chemical composition of Azolla pinnata. The concentrations of mineral matter and crude protein were good.

Table 2:- Chemical composition of Azolla pinnata.

Nutrients	**Content(%DM)**
Dry Matter	90.50
Crude Propteïn	20.31
Organic Matter	79.62
Ash	20.38
Calcium	0.74
Phosphorus	0.46
Potassium	2.16
Magnésium	0.14
Sodium	0.49

Effects of diets on growth parameters and production cost per kg live weight of "Poulet du Faso" broilers

The results in Figure 5 show that chicken growth was continuous from week 1 to week 9 for all diets. Growth was higher from week 3 onwards, first with the RAZ_5 ration, then with RAZ_{10}, compared with the SCD. Analysis of variance revealed no significant difference in average weekly weights between the 3 diets ($p>0.05$).

Table 3 shows the results for feed consumption, feed conversion ratio, ADG and feed cost per 01 kg liveweight (FCkgLW). The feed consumption of the RAZ_5 diet was significantly higher ($P=0.045$) than that of the RAZ_{10} and SCD homogeneous rations ($p>0.05$). No significant differences were observed for CI, ADG and FCkgLW between the 3 diets($p>0.05$).

Table 3:- Evolution of average weekly chicken weights according to rations distributed.

Weighing periods		**Distributed diets**		**Pr > F**	**Significave**
	RAZ_5	RAZ_{10}	RTS		
W1	215±6a	216±9a	215±6a	0,979	No
W2	234±8a	241±8a	234±7a	0,769	Non
W3	294±11a	290±11a	283±10a	0,771	Non
W4	411±16a	399±16a	375±16a	0,285	Non
W5	548±19a	526±21a	494±21a	0,172	Non
W6	690±23a	643±23ab	613±25b	0,075	Non
W7	810±25a	759±28a	753±29a	0,28	Non
W8	976±29a	913±33a	901±32a	0,197	Non
W9	1121±32a	1051±39a	1044±36a	0,244	Non

- SCD=standard control ration without Azolla; RAZ_5: ration incorporating 5% Azolla flour; RAZ10= ration incorporating 10% Azolla flour;

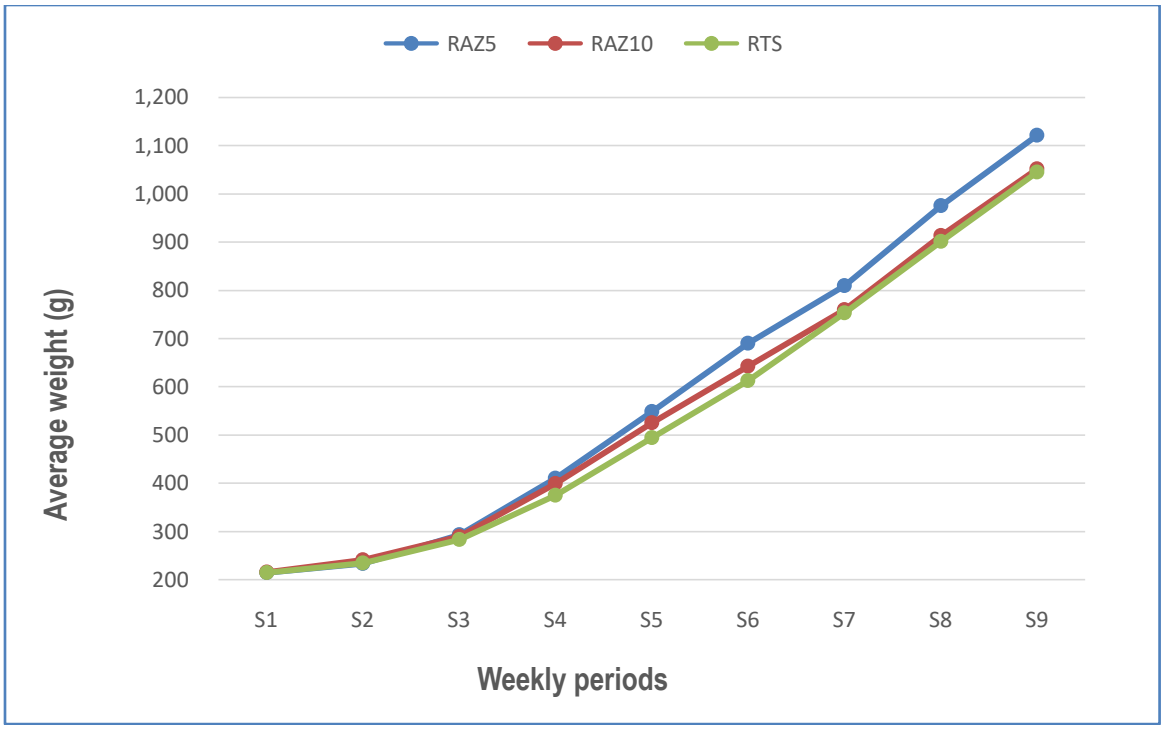

Figure 6:- Evolution of growth according to diet distributed.

Table 4:- Feed consumption, conversion index, daily weight gain and feed cost of producing 01 kg live chickens.

Distributed diets	DFC(g/sujbet)	CI	ADG(g)	FCkgLW (FCFA)
SCD(n=35)	56.95±2.67b	4.12±0.20a	14.82±0.56a	1133.94±54.18a
RAZ_5 (n=35)	66.47±2.67a	4.25±0.20a	16.18±0.56a	1118.26±54.18a
RAZ_{10}-(n=34)	61.37±2.67ab	4.40±0.21a	14.91±0.57a	1148.07±54.97a
P	0.045	0.63	0.16	0.72

- SCD=standard control ration without Azolla; RAZ_5: ration incorporating 5% Azolla flour; RAZ_{10}= ration incorporating 10% Azolla flour;
- Averages on the same line bearing the same letter are not significantly different at the 5% threshold.

Effects of diets on growth parameters as a function of sex in "Poulet du Faso" broilers

The results presented in Table 4 show that sex did not significantly influence average weights in the RAZ_5 ration ($P>0.085$), that the average weights of males were significantly higher than those of females from the 4th week to the end of the experiment in the RAZ_{10} ration ($p<0.05$) and that finally the average weights of males were significantly higher than those of females from the 5th week to the end of the experiment in the SCD diet ($p<0.05$). For all rations, the ADG of the males was significantly higher than that of the females ($p<0.05$). Growth surplus for males averaged 8.31%, 17.30% and 17.07% for the RAZ_5, RAZ_{10} and RTS diets respectively.

Table 4:-Average weight of chickens per ration, by sex.

Weighing period	RAZ_5				RAZ_{10}				SCD			
	F(n=17)	M(n=18)	Pr>F	Sig.	F(n=17)	M(n=18)	Pr>F	Sig.	F(n=17)	M(n=18)	Pr>F	Sig.
W1	200±8a	228±8b	0,02	Oui	200±7a	232±8b	0,005	Oui	201±6	228±9	0,015	Oui
W2	221±11a	245±11a	0,128	Non	224±10a	258±12b	0,04	Oui	221±9	247±11	0,071	Non
W3	279±15a	308±15a	0,19	Non	269±15a	311±16	0,061a	Non	265±13	300±14	0,079	Non
W4	401±22a	420±22a	0,547	Non	263±21a	436±21b	0,021	Oui	343±20	406±24	0,052	Non
W5	527±26a	568±26a	0,2	N	467±2	584±28	0,00	O	445±29	541±26	0,0	Le

			85	on	6a	b	4	ui			18	s
W6	667±31a	711±31a	0,337	Non	577±29a	708±29b	0,003	Oui	543±34	680±31	0,005	Oui
W7	776±34a	841±34a	0,208	Non	691±35a	827±36b	0,012	Oui	670±37	832±35	0,003	Oui
W8	925±37a	1023±37a	0,085	Non	814±37a	1013±44b	0,002	Oui	796±40	1000±37	0,001	Oui
W9	1049±40a	1189±40b	0,024	Oui	929±42a	1173±53b	0,001	Oui	920±43	1162±41	0,000	Oui
ADG(g)	15,15±0,64a	17,16±0,63b	0,033	oui	13±0,76a	16,81±0,76b	0,001	oui	12,84±0,68a	16,68±0,67b	0,000	oui

- SCD=standard control ration without Azolla; $RAZ_{5:}$ ration incorporating 5% Azolla flour; RAZ_{10}= ration incorporating 10% Azolla flour;

Diet effects on carcass characteristics, cut parts and organs

The results presented in Table 5 show that there were no significant differences in pre-slaughter live weight, near-slaughter and chilled carcass weight, hot and chilled carcass yields and abdominal fat levels between the experimental and control rations ($p>0.05$). For cuts, only the leg + drumstick of the RAZ_{10} diet was on average significantly heavier than those of the homogeneous RTS and RAZ_5 diets ($p>0.05$). In terms of organs, only the spleen was significantly heavier on average than that of the homogeneous RTS and RAZ_{10} rations($p>0.05$).

Table 5:- Carcass yields (%), average carcass, cut and organ weights according to rations fed.

Parameters	**Distributed diets**			**Pr>F**
	RTS (n=35)	RAZ_5 (n=35)	RAZ_{10} (n=34)	
----------Carcasse----------				
HCW(g)	757.25±23.82a	802.50±23.82a	738.50±23.82a	0.2
CCW(g)	724.75±30.28a	793.75±30.28a	734.00±30.28a	0.27
RHCY(%)	74.98±0.49a	74.35±0.49a	73.80±0.49a	0.28
CCY (%)	71.70±1.72a	73.54±1.72a	73.34±1.72a	0.72
AF(%)	1.69±0.46a	2.08±0.46a	1.46±0.46a	0.64
----------Poids moyens des pièces de la découpe de la carcasse----------				
Legs	33.50±1.67a	35.00±1.67a	33.25±1.67a	0.73
Thighs + drumsticks	199.00±6.64ab	216.75±6.64b	194.75±6.64a	0.1
Wing	95.00±2.95a	100.25±2.95a	98.00±2.95a	0.48
Head	40.00±2.39a	36.50±2.39a	36.50±2.39a	0.52
Neck	61.50±3.22a	59.75±3.22a	56.50±3.22a	0.56
----------Poids moyens des organes----------				
Liver(g)	18.50±0.85a	19.50±0.85a	21.00±0.85a	0.17
Heart (g)	4.75±0.39a	4.25±0.39a	5.00±0.39a	0.42
Splen(g)	1.25±0.20a	2.00±0.20b	1.25±0.20a	0.04
Gizzard(g)	32.50±1.90a	31.00±1.90a	30.50±1.90a	0.75

- SCD=standard control ration without Azolla; RA_{Z5}: ration incorporating 5% Azolla flour; RAZ_{10}= ration incorporating 10% Azolla flour;
- Averages on the same line bearing the same letter are not significantly different at the 5% threshold.

Discussion:-

Effect of diets on chicken mortality

The mortalities recorded in this study are not attributable to the incorporation of Azolla flour in the diet, as they are due to the onset of coccidiosis during the third week of age. This clearly shows that the diet incorporating Azolla biomass does not have a deleterious effect on chickens. This same finding was made by Kumar et al. (2018) who reported that the inclusion of Azolla biomass at a rate of 10% in the chickens' diet had no influence on the viability of the birds. They are also similar to those of Basak et al. (2002) and Paudel et al,. (2015) who by incorporating Azolla biomass into the poultry ration at rates of 5%, 10% and 15% recorded no mortality during the period of their experimentation. They concluded that the Azolla-based diet had no toxic effects.

Effects of diets on growth parameters of "Poulet du Faso" broilers

Weight development of chickens: Our results show that the incorporation of A. pinnata flour did not have a depressive effect on the weight development of the subjects compared with the control ration. Our results agree with those of Bhattacharryya et al. (2016) and Ouédraogo et al. (2021). Indeed, Bhattacharryya et al. (2016) in India used rations incorporating Azolla flour at rates of 4.5% and 5% in the feed of COBB400 breed broilers. Ouédraogo et al. (2021) in Burkina Faso on the other hand used rations containing 3% and 6% Azolla pinnata in the Isa Brown breed ration. Authors such as Basak et al. (2002) in Bangladesh and Paudel et al. (2015) in Nepal had obtained better results from the 6th week of age, using a diet of containing 5% and 10% Azolla in broiler feed. Growth of the chickens was almost identical between the sexes from week 5 to week 9, with the average weights of the males being significantly higher than those of the females (Table 5). This is explained by ADGs that were highly significantly higher for males than females in all rations, but much higher in RAZ_{10} RTS rations. This trend was reported by Ouédraogo (2017) who said that sex had a significant influence of greater growth of males compared to females ranging between 10% and 20%. Our results for the RAZ_{10} (+17.30%) and RTS (+17.07%) rations confirm this assertion. Feed consumption and weight gains: Our results show that the daily feed consumption of subjects on the experimental diets (RAZ_5 and RAZ_{10}) was significantly higher than that of subjects on the SCD, and that the DFC of RAZ_5 was significantly higher than that of the other diets. Cambel (1984) and Rout et al. (2017) reported results contrary to ours, demonstrating that diets incorporating 10% Azolla were better consumed than diets that did not. The level of feed consumption had no significantly differential effects on GMQs and CIss between diets. Work carried out on the same "Poulet du Faso" mixed breed by Ouédraogo et al. (222) and on the same issue of finding new sources of protein in poultry feed reported higher DFCs (73.1g and 73.5g) and CIs (5.4 and 5.3) for subjects fed diets incorporating maggot concentrate as a source of protein and mango feed as a partial source of energy inmaize replacement. Apart from the need to investigate certain diet parameters such as NDF and ADF fiber content, these poor performances could be explained by the Faso chicken's limited intrinsic capacity to make good use of diets, due to the fact that it is a mixed breed, one of whose parents is known to be slow-growing. Our results show that the diets had the same level of utilization by the "Poulet du Faso" broiler. However, our CIs are higher than the reference index for fast-growing broilers reported by Hubbard (2012), ranging from 1.8 to 2.2. They are also higher than those of 2.49 to 2.60 reported by Atakoun (2012), 2.70 to 3.55 reported by Sourokou (2014), 3.55 to 3.78 by Ouédraogo et al., (2020) and finally 3.75 to 3.87 by Ouédraogo et al. (2021). However, our values are better than those for local chickens reported byOuattara (2008) in Burkina Faso (4.4 to 4.9) and by Bello (2010) in Senegal (5.8 to 7.7). The same observation was made by Alalade and Iyayi (2006), who showed that incorporating Azolla flour into the chicken ration improved the feed consumption index compared with the control. Despite all the above, our results clearly show the ability of the birds to value diets incorporating Azolla flour in the same way as diets incorporating only conventional feed resources.

Feed production costs:

Feed production costs for 01 kg of live chicken were statistically comparable between diets. This further demonstrates that Azolla is a competitive protein source with soybean meal, for which it has been substituted at lower levels of incorporation. In general, non-conventional feed sources that are less or not at all competitive with human food sources such as maize and soybean have the advantage of contributing to lower formula costs and feed production costs. Kiendrébéogo t al., (2018); Kiendrébéogo et al., (2019), Zagré et al. (2019) have reported this trend. substituting maize or maize bran respectively with mango flour, feeds based on cassava by-products and peelings from pineapple marketing in the feed of growing pigs in Burkina Faso. Our results corroborate those of Islam (2017), who found that RAZ_5% contributed to reducing production costs. Better results had been found by Basak et al. (2002). Indeed, these researchers obtained a significantly ($P < 0.05$) better cost per kg of broiler chicken when feeding 5% Azolla flour. The incorporation of Azolla biomass in chicken rations is therefore an alternative way of reducing broiler production costs.

Effects of diets on carcass characteristics, carcass weights and organs

The incorporation of Azolla meal into the ration did not adversely affect carcass characteristics. In agreement with the observations of the present study, Bhattacharyya et al. (2016) and Ouédraogo et al. (2021) found no difference in carcass characteristics when feeding poultry with rations containing 4.5% and 5% Azolla; 3% and 6% Azolla, respectively. Carcass yields for Faso chickens were 74.98%, 74.35% and 73.80% respectively for subjects fed SCD, RAZ_5 and RAZ_{10}. Ouédraogo et al. (2021) also found no difference between carcass characteristics and obtained carcass yields of around 76.66% for the ration with 3% Azolla and 76.30% for the ration with 6% Azolla. The same observation was made by Sourokou Sabi (2014) in Senegal, who also found no difference between the carcass yields of COBB500 broilers when formulating rations based on Hibiscus sadariffa seed flour. However, better results were found by Naghshi et al. (2014). Indeed, these authors found that rations incorporating Azolla flour at a rate of 5% improved chicken carcass yield. The results also showed that RAZ_5 recorded the best average chicken thigh + drumstick weight. Naghshi et al. (2014) and Bhattacharrya et al, (2016) in their studies reported that rations incorporating 5% and 5.5% Azolla respectively increased the relative thigh weight of chickens. This is a good thing, all the more so as thighs and drumsticks are highly prized in the kitchen for their tender, juicy flesh, which lends itself to being prepared in a variety of ways and can even be boned (FINEDININGLOVERS, 2022). We note, however, that there was no significant differencebetween the other parts of the subjects in the three diets. This same finding was made by Bhattacharrya et al. (2016). Rana et al. (2017) obtained a higher average gizzard weight in rations incorporating 2.5% and 5% Azolla flour. Our results show that only the spleen of subjects on the RAZ_5 ration had a higher spleen weight than the other rations. The weight of the spleen represented 0.12% of the average body weight of subjects on RAZ_{10} and RTS rations, and 0.18% of that on RAZ_5. The results obtained for RAZ_{10} and RTS corroborate the norm of 0.12% for the Hubbard Flex broiler strain reported by Kokoszyński et al. (2017). This could be attributable to underlying infectious causes that may warrant splenomegaly as reported by Harry (2023).

Conclusion:-

Soaring prices for raw materials used in poultry feed are a major obstacle to intensive breeding. In Burkina Faso, the study demonstrated that Azolla pinata had a good nitrogen content and could be produced for incorporation into broiler diets as a source of vegetable protein. The performances achieved in terms of feed consumption, feed conversion, weight gains and production costs showed that the incorporation of Azzola pinata enabled good growth at competitive costs compared with the control diet. In terms of carcass quality, the carcasses of chickens fed experimental diets incorporating Azzola pinata were statistically identical. However, the absolute abdominal fat content of RAZ_5 was one point higher than that of the RAZ_{10} experimental ration and the SCD dietl. Finally, in terms of cut pieces, the RAZ_5 ration produced heavier thigh+pillow pieces than the RAZ_{10} and RTS control rations. In conclusion, Azzola pinata can be promoted in poultry diets as a low-cost source of vegetable protein. In addition, the RAZ_5 and RAZ_{10} experimental rations can be recommended for the rational feeding of broilers.

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