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Processing and valorisation of *Mucuna* seeds in poultry feed

Rakotomanana OR[1], Razafinarivo TD[2], Rapatsalahy S[3], Michelle LM[4], Rasoanomenjanahary A[5] and Rafarasoa LS[6]

[1-5] DRZVP/ FOFIFA Ampandrianomby Antananarivo BP 04; 101, Madagascar

[6] Universite D'antananarivo/Faculty of Sciences/Entomology: Crops, Livestock and Health, Madagascar

Abstract

Mucuna seeds have been undertaken in the supplementation of *Gallus* feed. Locally available, rich in protein, they do not compete with human food. However, they have a high level of L-dopa, which disturbs digestion, thus requiring prior treatment before consumption. Seven different treatments are tried: untreated; soaking in water; boiling; soaking followed by boiling; depelleted; added with sodium bicarbonate and roasted. They are analyzed by NIRS and bromatological analysis, their L-dopa content is determined.

Two feed types are considered: incorporation of depelleted and bicarbonated seeds at different feeding rates. Feeding is carried out to different categories of *Gallus*. The weight evolution is monitored. Laying rate is considered for layers.

The nitrogenous content is particularly high and that in mineral elements and fat are not negligible. The antinutritional factors are very reduced in the depelleted seeds (0,79%) and decrease by half for the bicarbonated seeds (6,61 to 2,96%) by affecting little the nutritional value.

Chickens fed with *Mucuna* seeds show weight growth even for local breed chickens. A 20% incorporation rate of depelleted seeds is effective for local chicks and 10% for broilers and layers. The entry in laying is favoured whether these rates are 10% or 20%.

Keywords: *Mucuna*, *Gallus*, L-dopa, weight evolution and egg laying rate

Introduction

In the world of livestock farming, poultry farming has occupied an important place for decades. It presents two types of breeding: on the one hand, the intensive breeding calling upon elaborate techniques and requiring important investments and on the other hand, the traditional extensive breeding of chicken of local race called "Akoho Gasy" which remains the most practised in the country.

Akoho Gasy live and breed almost in the wild, looking for their meagre food around the huts and surrounding fields. Their growth rate is slow, so their expected market weight of 900g to 1 kg is only reached after five months of rearing or more. The hen lays late (Raoeliarisoa, 2004).

The supplementation of *Gallus* feed with *Mucuna* seeds was undertaken to improve the performance of this farm (Del Carmen and *et al*. 1999) [4]. *Mucuna pruriens is a* leguminous plant belonging to the Fabaceae family, subfamily Faboidae. It is one of the plants used in direct seeding under plant cover (DSC) within the framework of the GSDM Support Project for the Dissemination of Agroecological Techniques in Madagascar.

It is a natural raw material, available locally (Dahouda and al, 2009) [2], not yet used in Madagascar, yet rich in proteins and not in competition with human food (Farougou *et al*. 2006) [6]. It is a thermophilic, creeping and fast growing plant. *Mucuna pruriens* seeds have a high protein content and a relatively high proportion of amino acid (Josephine and Janardhanan, 1992; Ravindran V and Ravindran G, 1988) [11, 13]. Thus, the use of these seeds in animal feed will certainly alleviate the investment cost of feeding animals in intensive breeding and accelerate the growth of Akoho gasy. Despite its richness in amino acid and protein, *Mucuna pruriens* seeds are known to contain high levels of L-dopa (3,4-dihydroxyphenylalanine is a non-protein amino acid) (Siddhuraju, Becker and Makkar, 2000) [15] and other anti-nutritional factors that affect the animal by disrupting nutrient digestion and metabolism (Bell and Janzen, 1971; Daxenbichler *et al*. 1971) [1]. Therefore, the use of these seeds in animal feed requires precautions beforehand by the application of treatments likely to reduce these anti-nutritional factors.

Studies on the nutritional value of seeds and their use as a supplement in chick feed have been conducted as a substitute for certain expensive raw materials.

Materials and methods

Raw and processed *Mucuna* seeds are analyzed bromatologically and by SPIR. Their L-Dopa content is determined.

The effects of the different treatments of *Mucuna* seeds are observed on different categories of *Gallus* (broiler, layer and "akoho gasy"). The different treatments of seeds consist in : *Mucuna* treated by soaking in water; *Mucuna* treated by boiling; *Mucuna* soaked followed by boiling; *Mucuna* depelleted; *Mucuna* treated with sodium bicarbonate and *Mucuna* roasted. Untreated *Mucuna* seeds will be used as a control and the other treatments are conducted according to the following different modalities:

- T0: Untreated *Mucuna pruriens var. utilis* seeds.
- T1: *Mucuna pruriens var. utilis* seeds soaked for 24 hours.
- T2: *Mucuna pruriens var. utilis* seeds soaked for 48 hours.
- T3: *Mucuna pruriens var. utilis* seeds soaked for 72 hours.

- E1: *Mucuna pruriens var. utilis* seeds boiled for 30 minutes.
- E2: *Mucuna pruriens var. utilis* seeds boiled for 60 minutes.
- T.E.: *Mucuna pruriens var. utilis* seeds treated by "Soak and Boil".
- T.E.T.: *Mucuna pruriens var. utilis* seeds treated by "Soaking-Boiling Depelliculation-Treating" or "*Mucuna* depelleted ".
- TBic: *Mucuna pruriens var. utilis* seeds treated by "Boiling in 0.2% sodium bicarbonate water, 30 minutes + 24 hours soaking" or "Bicarbonated *Mucuna*".

As for the feeding of the different categories of *Gallus*, two cases of feeds are considered and which differ by their rate of administration. These are the incorporation of seeds treated with 0.2% sodium bicarbonate (TBic or bicarbonated *Mucuna*) and seeds after soaking, dehulled and boiled (TET or depelleted *Mucuna*). The water is distributed *ad libitum.*
The weight development of the different categories of animals shall be monitored. In addition, the laying rate is considered for laying hens.

Table 1: Feeding methods for Gallus

Categories of *Gallus*	***Mucuna* " depelleted ".**		**Bicarbonated" *Mucuna***	
	Number of *Gallus*	**Administration rate**	**Number of *Gallus***	**Administration rate**
Broilers 60 day-old chicks	10	0%	10	0%
	10	10%	10	10%
	10	20%	10	20%
Local chickens 60 chicks of 45 days old "manara-penitra" with an average weight of 387,5 ± 62,3 g	10	0%	10	0%
	10	15%	10	15%
	10	30%	10	30%
Laying hens 60 ready-to-lay pullets, 18 weeks old and intensively reared before the experiment	10	0%	10	0%
	10	10%	10	10%
	10	20%	10	20%

Results and discussion

The averages of the chemical composition in nutrients of the studied seeds are represented in table 2. From a statistical treatment T test, at each nutrient, significant differences ($p<0.001$) are presented between each type of treatment.

Table 2: Chemical composition of the studied *Mucuna* seeds

	T0	**T1**	**T2**	**T3**	**E1**	**E2**	**TE**	**TET**	**TBic**
Dry matter	93,8	94,9	95,2	95,9	94,5	94,4	98,4	99,5	93,9
Fats	4,2	4,4	4,2	4,5	5,0	4,2	4,8	5,0	5,2
Crude Protein	26,3	24,2	23,5	22,6	25,7	23,8	21,4	21,7	24,2
Mineral materials	3,5	4,2	3,8	4,0	4,2	3,9	4,1	2,7	4,1
Calcium	0,40	0,50	0,50	0,40	0,20	0,30	0,20	0,20	0,30
Phosphorus	0,70	0,80	0,70	0,70	0,80	0,70	0,80	0,70	0,70
Insoluble Ash	0,1	0,1	0,1	0	0,1	0,1	0,1	0,1	0,1
L-dopa	6,6	5,95	5,23	2,91	3,15	2,02	2,2	0,79	3,0

The protein content is high and varies from 21,4 to 26,3 % DM (dry matter). For fat, the contents are between 4.2 and 5.2% of DM. The mineral contents are between 2.7 and 4.2% of DM, with Calcium contents of 0.20 to 0.50 % of DM and Phosphorus contents of 0.70 to 0.80 % of DM.
L-Dopa levels are highly significant between the different treatments and vary from 0.79 to 6.6%.
As high L-Dopa content disrupts digestion, the *Mucuna* TET ("depelleted" *Mucuna*) seeds with the lowest L-Dopa content were tested for their effect on the weight development of the *Gallus*. As TBic (*Mucuna* "bicarbonated") is an additive treatment, this modality was considered and tested during the feeding of the different categories of *Gallus*.
Of all the treatments, the Gross Protein content (figure 1) is particularly high while the mineral (figure 2) and fat (figure 1) content is not negligible.

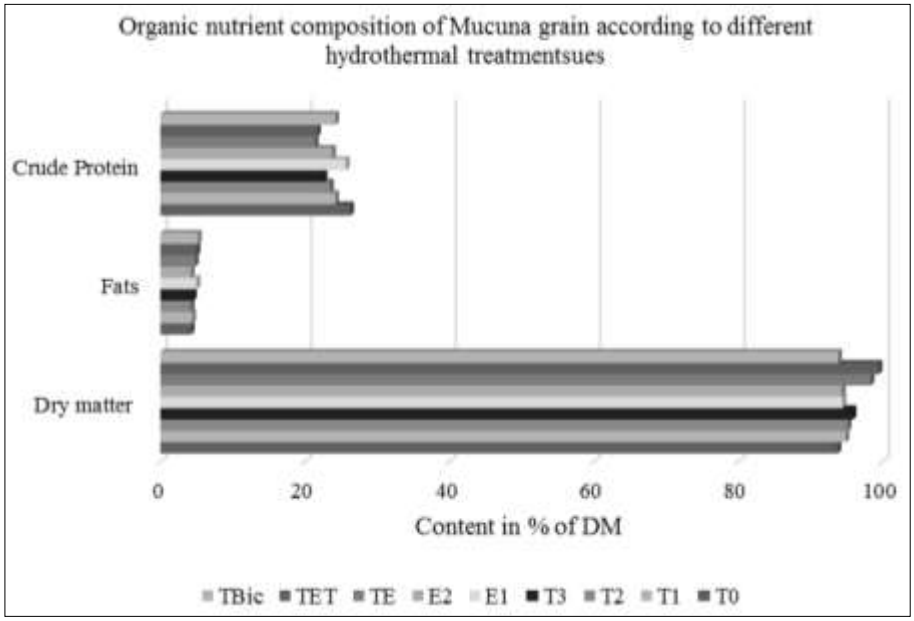


Fig 1: Organic matter content of *Mucuna* seeds from different types of treatment

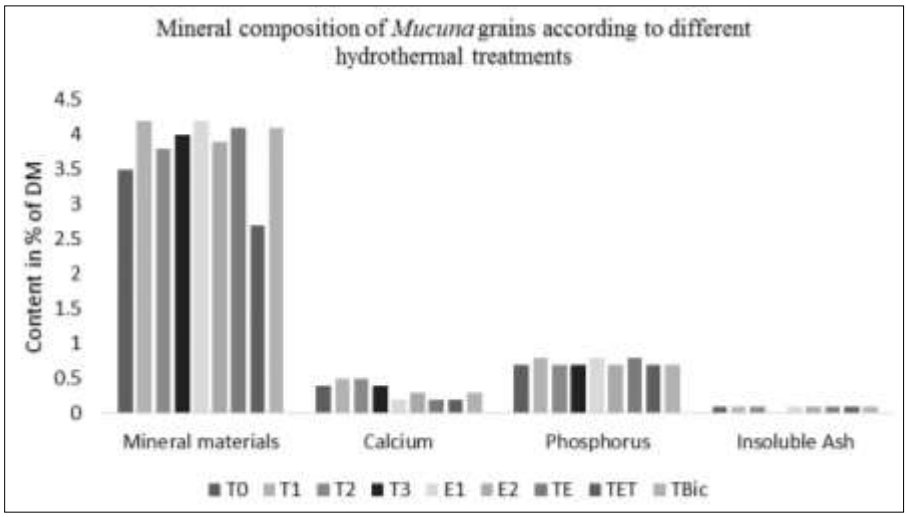


Fig 2: Mineral content of *Mucuna* seeds from different types of treatments

The antinutritional factors (figure 3) are very reduced in the depelleted *Mucuna* seeds. But on those treated with sodium bicarbonate 0.2%, they are higher than those treated by "boiling for 60 min" and "soaking-boiling".

The initial L-Dopa content of bicarbonated *Mucuna* seeds decreases by half, from 6.61 to 2.96%, with little effect on nutritional value.

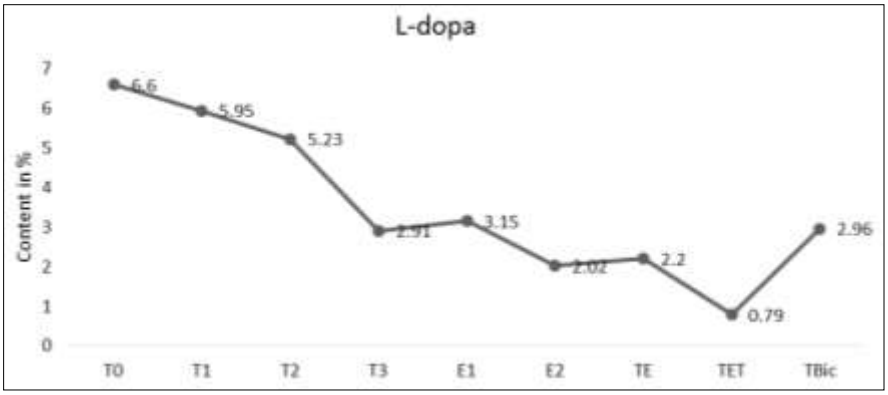


Fig 3: L-dopa content of *Mucuna* seeds from different treatments

L-dopa, or 3,4- dihydroxyphenylalanine, a non-protein amino acid, intermediate in the synthesis of catecholamines, has two optical isomers, L-dopa and D-dopa. Only the levoisomeric form is metabolizable by the body. L-dopa is either synthesized in the body (endogenous), or can be of exogenous origin, as in the case of L-dopa contained in the seeds of *Mucuna* (DAHOUDA *et al*. 2009) [2].

- However, despite an interesting protein content of *Mucuna*, its biological value is reduced by the presence of L-dopa. The oxidation products of L-dopase conjugate with the sulfhydryl residues of proteins to form the 5-S-cysteinyldopa complex leading to protein polymerization. The 5-S-cysteinyldopa complex may be one of the factors limiting the digestibility of *Mucuna* proteins and starch (DOSSA, 1999).
- L-dopa is also a toxic substance, causing nausea and headaches (PARDO *et al*. 1995). In birds, it leads to a slowing of growth and a decrease in food consumption (DEL CARMEN *et al*. 1999) [4].
- The different treatments decrease the L-dopa content of *Mucuna*. However, these treatments affect the nutritional and feeding value of *Mucuna*. Thus, the purpose of this experiment is to determine which treatment decreases the L-dopa content the most but does not change the initial nutritional value of *Mucuna*. All treatments applied to the samples affected both the L-dopa content and the nutritional value of *Mucuna* seeds.

They can all be a source of feed for animals. They can be combined with cereals and byproducts (rice bran, wheat bran, etc.) which are grasses, thus making it possible to obtain a balanced diet. Moreover, they are available locally and even in abundance at low cost and, moreover, they do not compete with human food.
The results of these two feeding treatments are shown by *Gallus* category. The experimentation on each treatment lasted 11 weeks.

Broilers

The average weekly weights of broilers fed with bicarbonated *Mucuna* seeds are given in Table 3.

Table 3: Evolution of weekly average weights of broilers fed with bicarbonated *Mucuna* seeds at different incorporation rates

Weeks	Weight in g		
	T0=0% *Mucuna*	**T1= 10% *Mucuna***	**T2= 20% *Mucuna***
0	46	45,9	45,8
1	89,1	90,6	95,4
2	101	91	96
3	255	209	214
4	436	326	303
5	598	443	366
6	686	576	424
7	803	719	505
8	961	767	557
9	1010	852	621
10	1294	1097	828
11	1300	1100	850
Average	631,6	526,4	408,8
Standard deviation	454,2	383,3	274,0

For all three experiments, an increase in broiler weight was observed. However, the incorporation of bicarbonated *Mucuna* decreases the average weight production of broilers by 631.6g, 526.4g and 408.8g for the 3 respective batches at 0%, 10% and 20%. Despite the interesting protein and amino acid content in *Mucuna*, its biological value is reduced by the presence of L-dopamine (3,4-dihydroxyphenylalanine which is a nonprotein amino acid). This is due to the formation of 5-S-cysteinyldopa complex which limits the digestibility of protein and starch in *Mucuna* (DOSSA, 1999).
In addition, between 10 and 20% of *Mucuna* seeds, the lower incorporation rate attributes a better effect on growth.
As with the bicarbonated *Mucuna* feeds, the weekly average weights of chickens fed depelleted *Mucuna* are recorded in Table 4.

Table 4: Evolution of weekly average weights of broilers fed depelleted *Mucuna* seeds at different incorporation rates

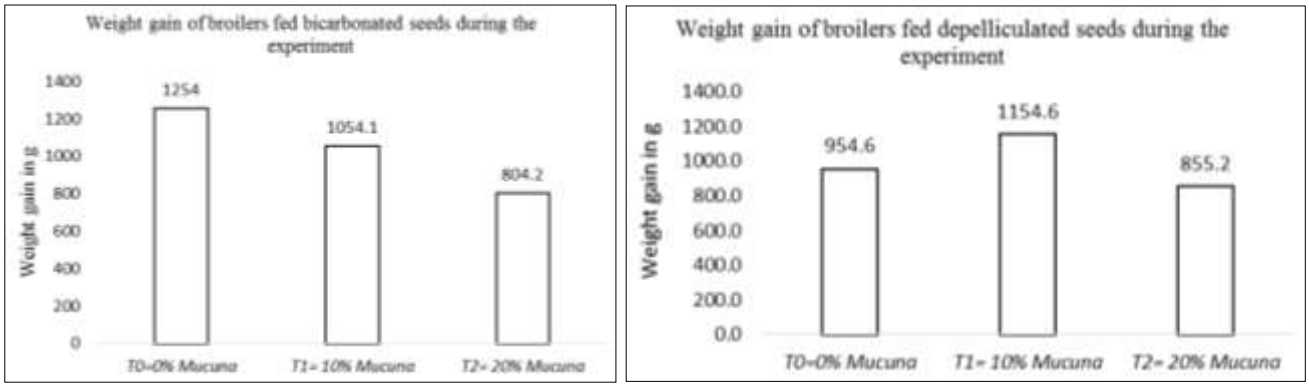
Weeks	Weight in g		
	T0 = 0 % *Mucuna*	**T1 = 10 % *Mucuna***	**T2 = 20 % *Mucuna***
0	45,8	45,7	45,7
1	90,0	91,1	91,7
2	123,9	132,9	123,0
3	170,6	193,9	176,4
4	255,4	282,8	219,6
5	313,0	320,8	282,9
6	370,7	391,0	357,9
7	485,6	488,8	410,3
8	523,3	548,0	446,6
9	556,1	601,0	494,7
10	680,0	724,0	660,5

11	1000,4	1200,3	900,9
Average	384,6	418,4	350,9
Standard deviation	280,0	325,6	251,6

Broilers fed depelleted seeds showed an increase in weight. Nevertheless, the incorporation of 10% dehulled *Mucuna* offers a distinct result among the 3 batches.

The average weights obtained from broilers fed bicarbonated seeds of 631.6g, 526.4g and 408.8g for the 3 respective batches at 0%, 10% and 20% are higher against those fed depelleted seeds of 384.6g, 418.4g and 350.9g.

NaHCO3 sodium bicarbonate helps to improve digestibility in broilers and leads to good weight growth (Mercier, Nuffer, Geraert, 2005) [12].



a b

Fig 4: Weight gain of broilers fed 2 types of *Mucuna* seeds at different incorporation rates

The weight gain of broilers fed bicarbonated *Mucuna* seeds during the experiment decreased inversely with increasing incorporation rate (Figure 4, a).

While the weight gain perceived by the lot of the ration with 10% dehulled *Mucuna* seeds is higher among the 2 rations (0% and 20% *Mucuna*) (Figure 4, b).

Thus, feeding *Mucuna* seed to broilers has a significant effect on weight gain.

Local chickens

The average weekly weights of local breed chickens fed with bicarbonated and depelleted *Mucuna* seeds are presented in Table 5 and Table 6 respectively.

Table 5: Evolution of weekly average weights of local breed chickens fed with bicarbonated *Mucuna* seeds at different incorporation rates

Weeks	Weight in g		
	T1:0% *Mucuna*	**T2: 15% *Mucuna***	**T3: 30% *Mucuna***
0	374	394	395
1	467	460	445
2	547	533	524
3	617	607	603
4	694	670	691
5	758	708	749
6	861	789	805
7	949	878	935
8	1023	966	1002
9	1087	1022	1076
10	1177	1116	1156
11	1286	1208	1296
Average	820	779	806
Standard deviation	291	262	290

A weight evolution of each batch is recorded. The average weight of the chickens obtained with a feed without *Mucuna* (820g) is the highest, preceded by batch 3 incorporated with 30% bicarbonated *Mucuna* seeds (806g).

Table 6: Evolution of weekly average weights of local breed chickens fed depelleted *Mucuna* seeds at different incorporation rates

Weeks	Weight in g		
	T1:0% *Mucuna*	**T2: 15% *Mucuna***	**T3: 30% *Mucuna***
0	482,5	372,2	354,4
1	499,6	421,5	368,7
2	546,1	441,6	395,4
3	584,4	477,7	427,7
4	583,5	555,6	488,9

5	686,0	610,0	536,6
6	729,7	665,3	575,2
7	771,8	722,2	614,1
8	819,0	780,4	654,9
9	867,1	841,7	706,6
10	928,3	902,9	758,6
11	1002,3	991,3	817,9
Average	708,4	648,5	558,3
Standard deviation	173,0	202,9	156,3

The evolution of the weight of the "Akoho Gasy" chickens in the three batches receiving different rations of dehulled *Mucuna* seeds indicates a significant difference between each batch. The average weight of the local chickens decreased proportionally with the increase of the rate of incorporation of depelleted *Mucuna* seeds.

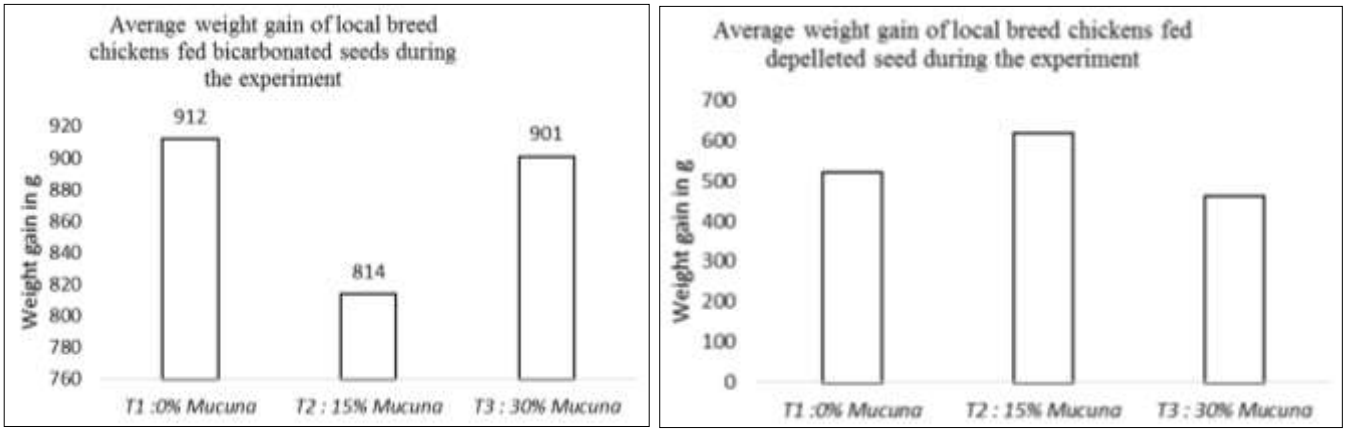


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Fig 5: Weight gain of local breed chickens fed 2 types of *Mucuna* seeds at different incorporation rates

During the experiment with sodium bicarbonate treated *Mucuna* seeds and depelleted seeds, weight gain on local breed chickens was recorded in all batches. The weights increased significantly ($p<0.05$).

The greatest gain during the experiment was observed in the batch of chickens receiving a ration containing 30% bicarbonate seeds apart from the batch without *Mucuna* (figure 5, a) but the difference between the 3 batches fed with these seeds was not significant.

The weight gain of local breed chickens at 15% dehulled seeds is the highest among the 3 incorporation rates (figure 5, b)

Laying hens

Laying hens are weighed only at the beginning and at the end of the trial, the results of which are shown in Table 7 and 8.

Table 7: Evolution of the average weights of laying hens fed with bicarbonated *Mucuna* seeds at different incorporation rates during the experiment

		Weight in g	
	T0=0% *Mucuna*	**T1= 10% *Mucuna***	**T2= 20% *Mucuna***
at the beginning of the test	1500.00	1561.00	1660.80
at the end of the test	1540,80	1602,90	1697,50

Table 8: Evolution of the average weights of laying hens fed with depelleted *Mucuna* seeds at different incorporation rates during the experiment

		Weight in g	
	T0=0% *Mucuna*	**T1= 10% *Mucuna***	**T2= 20% *Mucuna***
at the beginning of the test	1595	1529	1504
at the end of the test	1574	1616	1603

A weight evolution is observed for the three cases of experiments of the two types of incorporation of seeds of *Mucuna*.

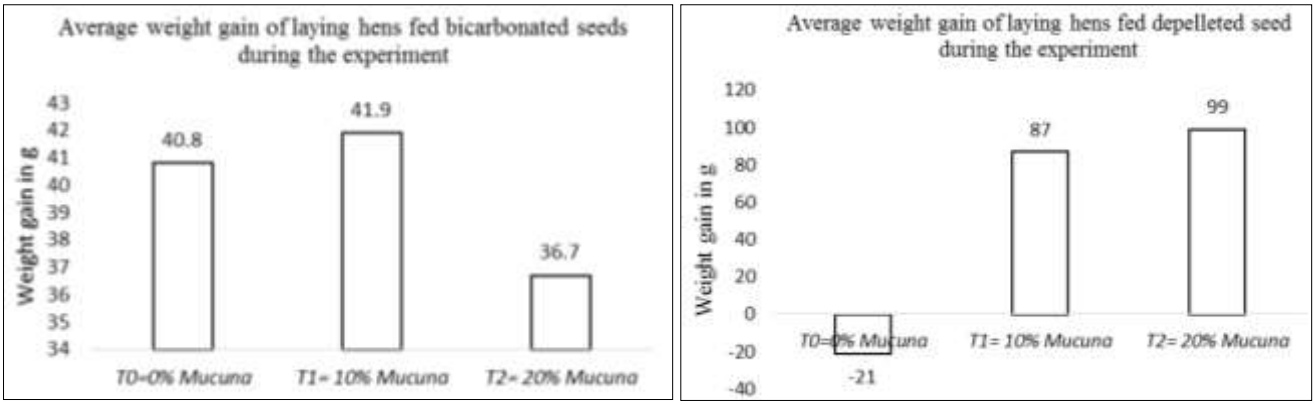

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Fig 6: Weight gain of laying hens

For laying hens, the ration with a 10% incorporation of bicarbonated *Mucuna* seeds showed a higher gain than the other two batches (without *Mucuna* and at a rate of 20%) (Figure 6, a).

For those fed depelleted seeds, the weight gain increases proportionally to the rate of incorporation of these seeds. (Figure 6, b)

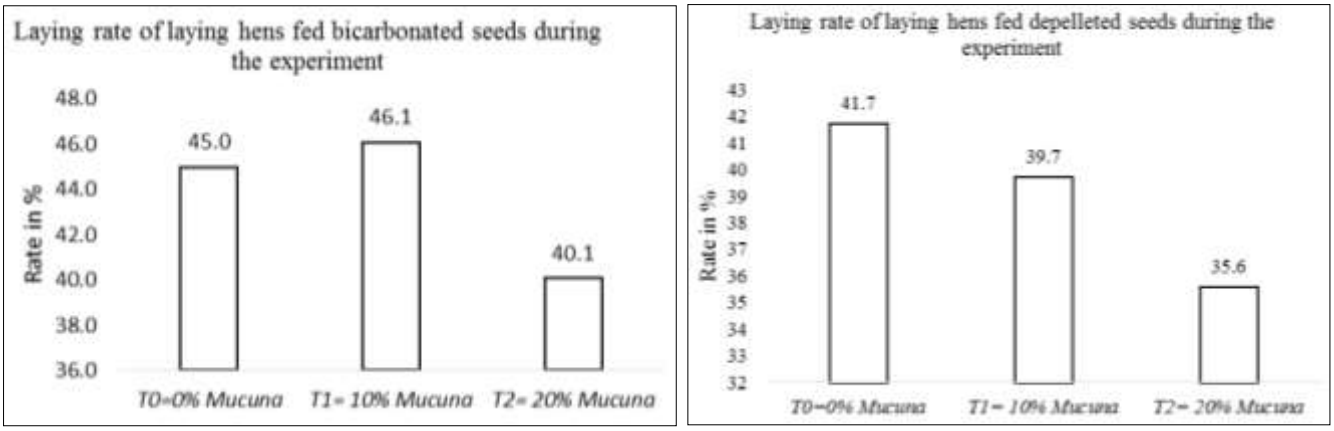

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Fig 7: Laying rate of laying hens

There was no significant difference between the percentage of egg laying rate of the batches receiving 0% and 10% *Mucuna* bicarbonate. The laying rate decreased inversely with the rates of incorporation of bicarbonated *Mucuna* seeds in the laying hen's diet (Figure 7, a). This is supported by a study in Florida which showed that a reduction in laying rate was observed during the experiment following an increase in the rate of incorporation of *Mucuna* seeds in the ration (Harms, Simpson, Waldroup, 1961) [8]. This decrease may be related to the existence of residual anti-nutritional factors (L-Dopa) in the ration even if the seeds were treated. This decrease is observed for the laying rate of hens fed depelleted seeds at 10% and 20% incorporation (Figure 7, b).

Conclusion

Treatment of depelleted *Mucuna* seeds at 15% incorporation is most effective for local chicks, at 10% for broilers and at 20% for layers.

The L-Dopa value of the depelleted seeds is the lowest. This shows that this factor is located in the skins.

The efficacy of adding bicarbonated *Mucuna* seeds for broilers and layers is at a 10% incorporation rate while for local breed chickens at 30%. The bicarbonate acts on the digestion, hence little effect of L-dopa.

The incorporation of *Mucuna* seed meal in the ration favours the laying of eggs by laying hens, whether at a rate of 10% or 20%, of which the 10% incorporation rate of bicarbonated and depelleted seeds is more effective.

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