UNIVERSITY OF BURUNDI

Analysis of effect of incorporating processed Mucuna pruriens as source of protein and energy in home–mixed rations on performance of growing pigs and determination of optimal quantity

FACULTY OF ECONOMICS AND MANAGEMENT SCIENCES

Department of Rural Economy and Management of Agri-business Companies

ANALYSIS OF EFFECT OF INCORPORATING PROCESSED MUCUNA PRURIENS AS SOURCE OF PROTEIN AND ENERGY IN HOME–MIXED RATIONS ON PERFORMANCE OF GROWING PIGS AND DETERMINATION OF OPTIMAL QUANTITY

By

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THESIS

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DEDICATIONS

To almighty God;

To my parents, Sisters and brothers;

To the late Dr Emmanuel MACUMI family;

To Hon. NZIGAMASABO Révérien family;

To Tonton Gratien KARANGWA, Odette KAYITESI and Léonce NGAYINDIKA family;

To the International Institute for Tropical Agriculture (IITA);

To all of my friends and to the first graduating master’s class of the University of Burundi in the Faculty of Economics and Management Sciences.

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ACRONYMS AND ABBREVIATIONS

ADISCO	: Appui au Développement Intégral et à la Solidarité sur les Collines
ADWG	: Average Daily Weight Gain
ANOVA	: Analysis of Variance
BWG	: Body Weight Gain
Ca	: Calcium
CBA	: Cost-Benefit Analysis
CEA	: Cost Effectiveness Analysis
CLiP	: Crop and Livestock Integration Project
DM	: Dry Matter
ECVMB	: Enquête sur les Conditions de Vie des Ménages au Burundi
EU-IFAD	: European Union-International Fund for Agricultural Development
FAO	: Food Agriculture Organization
FBW	: Final Body Weight
IBW	: Initial Body Weight
IITA	: International Institute for Tropical Agriculture
INERA	: Institut National de l'Environnement et de la Recherche Agricole
INRS	: Institut National de Recherche et de Sécurité pour la prévention des accidents de travail et des maladies professionnelles
IRR	: Internal Rate of Return
ISABU	: Institut des Sciences Agronomiques du Burundi
K	: Potassium
LASPA	: Laboratoire d'Analyse des Sols et des Produits Agro-alimentaires
MD	: Man Day
Mg	: Magnesium
MJ	: Mega Joule
MS	: Mean Square
Na	: Sodium
P	: Phosphorus
PCDC	: Plan Communal de Développement Communautaire
PDI	: Protein Digestible in the Intestine
SS	: Sum of Square

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ABSTRACT

Cost-Benefit Analysis (CBA) and Analysis of Variance (ANOVA) were used in this study to analyze the economic and performance effect of incorporating *Mucuna pruriens* in home-mixed rations on growing pigs. The grains of *Mucuna pruriens* were first detoxified by soaking, boiling and drying before being milled. Detoxified Mucuna grain flour has been incorporated into the 4 different treatment diets to replace cotton cake, palm cake and rice bran depending on the bromatological value of the raw material to be replaced almost equivalent to that contained in the *Mucuna pruriens* flour to use which led us to use 0% of the *Mucuna pruriens* flour for the T1 treatment diet (control group), 20% for the T2 treatment, 30% for the T3 treatment and 40% for the T4 treatment diet in order to assess which of the treatments is more capable of ensuring good growth of pigs than other treatment diets at a lower production cost. The ANOVA model, correlation analysis and Pairwise Comparisons of Equal Variance Means (Tukey's post-hoc test) proved that regardless of the type of treatment, the average daily body weight gain of young pigs is greater than that of older pigs, so these statistical analyzes have shown that the T3 treatment diet is the best at ensuring good performance of pigs with an average daily body weight gain of 0.798 kg versus 0.744 kg of T4 treatment, 0.625 kg of T2 treatment and finally 0.625kg of T1 treatment which does not contain Mucuna flour. The Cost-Benefit Analysis was revealed that only the T3 treatment which contains 30% of the flour of *Mucuna pruriens* cultivated by the breeders could be profitable with a gross profit of 0.275 F generated by 1F invested in 3 weeks by the time that use of Mucuna valued at market price only results in losses regardless of the treatment adopted to feed the pigs. 1F invested in T1 treatment to feed pigs that do not contain Mucuna grown by association members, would have a negative yield of 0.05052F over a 3 weeks period and a loss of .40884 F, 0.30113 F and 0.6424F respectively for T2, T3 and T4 treatment diets.

Key words: Treatment diet, feed cost, profit margin, *Mucuna pruriens,* optimal treatment diet.

RESUME

L'Analyse Coût-Bénéfice (ACB) et l'Analyse de Variance (ANOVA) ont été utilisées dans cette étude pour analyser l'effet économique et la performance d'incorporer la farine des grains de *Mucuna pruriens* dans des mélanges de rations-maisons des porcs en croissance. Les grains de *Mucuna pruriens* ont été premièrement détoxiqués via le trempage, l'ébullition et le séchage avant de les transformer en farine. La farine des grains de Mucuna détoxiqués a été incorporée dans les 4 régimes alimentaires différents en remplaçant les tourteaux de coton, le palmiste et le son de riz en fonction de la valeur bromatologique de la matière première à remplacer presque équivalente à celle de la farine de *Mucuna Pruriens* à utiliser ce qui nous a poussé d'utiliser 0% de la farine de *Mucuna pruriens* pour le traitement T1 (groupe de contrôle), 20% pour traitement T2, 30% pour traitement T3 et 40% de la farine de *Mucuna pruriens* pour traitement T4 pour évaluer lequel de ces traitements est capable d'assurer la bonne croissance des porcs que les autres à un coût de production moins élevé. Le modèle ANOVA, l'analyse de la régression, de la corrélation et le test de comparaison des paires du post-hoc test de Tukey ont monté que quel que soit le type de traitement, la moyenne du gain de poids corporel quotidien des porcs de bas âge est supérieur à celui de porcs de l'âge avancé ainsi ces analyses statistiques ont prouvé que le traitement T3 est le meilleur à assurer une bonne performance des porcs avec une

Mots clés : Régime alimentaire, coût alimentaire, bénéfice brut, *Mucuna pruriens*, régime

traitement T4, 0,625kg pour le traitement T2 et en fin 0,625kg pour le traitement T1 qui ne contient pas de la farine de *Mucuna pruriens.* L'analyse des coûts-avantages a été révélée que seul le traitement T3 qui contient 30% de la farine de *Mucuna pruriens* cultivé par les éleveurs pourrait être rentable avec un bénéfice brut de 0,275756 F généré par 1F investi dans 3 semaines au moment où l'utilisation de Mucuna comptabilisé au prix du marché n'engendre que des pertes quel que soit le traitement adopté pour nourrir les porcs. 1F investi dans l'alimentation de porcs en utilisant le traitement T1 qui ne contient pas de la farine de Mucuna qui n'est pas cultivé par les éleveurs engendre une perte de 0,05052F dans une période de 3 semaines. L'utilisation des traitements T2, T3 et T4 engendrent respectivement une perte de 0,40884 F ; 0,30113 F and 0,6424F dans une période de 3 semaines pour 1F investi.

Mots clés : Régime alimentaire, coût alimentaire, bénéfice brut, *Mucuna pruriens*, régime alimentaire optimal.

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CHAPTER 1. GENERAL INTRODUCTION

1.1. Background Information

The reduction of poverty and malnutrition in developing countries cannot be achieved without taking into account the development of income-generating activities, including those of small farmers in rural areas. Pig farming is a secondary activity providing additional income to almost all socio-professional strata of the population of Africa (Nonfon, 2005; Youssao et al., 2008; Mopate et al., 2010, 2011a). Pig production is distributed worldwide, except in regions where, for cultural or religious reasons, pork is not consumed.

According to the FAO meat market review (2018), world pork production in 2018 is estimated at 120.5 million tonnes, recording a marginal growth of 0.6% compared to 2017. In a report published recently by the FAO found that the production of pig in African countries has undergone a positive development of 4.8% between 2000-2010 when the world evolution was 2%.

In order to meet the needs of its galloping population of 11 million people with a density estimated at 435 inhabitants per km^2 in 2015 according to the survey on the living conditions of households in Burundi (ECVMB, 2014), Burundi adopts the agriculture of development that goes hand in hand with animal husbandry. This breeding is essentially of traditional type. Larger scale of pig, extensive or intensive, are almost non-existent and are mainly raised from cattle, goats, sheep and poultry.

The local animal production chains are particularly focused on the processing of dairy products, the sale of meat or even the production of organic manure, but this production is however very insufficient in view of national demand and needs which are growing rapidly with the population. Among all domestic animals, pig farming is one of the major agricultural enterprises in which the vast majority of the poorest segment of the rural population in Burundi, particularly in landless rural areas, can benefit from their income and a certain amount of meat to consume, due to its adaptability to different environmental conditions. Pigs have a great capacity for survival and often develop on vegetation unfit for the consumption of other animals because it is omnivorous.

Thus, when the conditions of accommodation, reproduction, feeding, health and technical and economic management of the animal are well controlled, only the pig is the very prolific animal capable of calving 7 to 12 piglets and with 2 births per year, it can wean 14 to 18 piglets per sow per year.

Pig is thus the only domestic animal to present a high carcass yield of 73 to 80% (Costantino et al., 2016) à after poultry (broiler) which provides 64 to 65% of its carcass (Fanatico et al., 2005). Pig farming provides income for farmers with poor subsistence resources in tropical regions (FAO, 2012) and, therefore, may be well suited for poverty alleviation (Mopate et al., 2010). According to FAO Statistical Yearbook 2012), Burundi recorded an evolution of 11.2% between 2009-2010.

In Burundi, as elsewhere in Africa, one method that has often been overlooked to reduce poverty and malnutrition is the use of underutilized sources such as the case of *Mucuna pruriens.* According to Afolabi et al. (1985), the seeds of *Mucuna pruriens* seem to be a rich source of minerals, especially calcium. The chemical score is generally low; however, lysine and phenylalanine are high, 198.66% and 270.77% respectively.

Our present study entitled: **"Analysis of the effect of incorporating processed *Mucuna pruriens* as a source of protein and energy in home-mixed rations on the performance of growing pigs and determination of the optimal quantity"** will analyze the effects of incorporating the seeds of *Mucuna pruriens* in home-mixed rations on the performance of growing pigs by also determining an optimal level of rationing allowing to obtain the best margin on feed cost in order to control the consumption index and the quality of the carcass to achieve the highest possible margin.

1.2. Problem statement

Pig is the most consumed meat in the world due to changes in eating habits following the increase in incomes of certain developed countries which offers sector investment opportunities, not only in the meat and dairy processing industry, but also in developing the infrastructure necessary for local and international distribution (FAO, 2012). The pig sector is a profitable economic activity provided that a certain number of parameters are well controlled, in particular the housing, reproduction, feed, health and especially the technical and economic management of the animals. Each feed ration must therefore be adapted to the nutritional needs of the animal according to its physiological stage (Gilbert et al 2017). Burundi faces a food deficit (or severity of hunger), which has increased in recent years

(FAO, 2018), as much influenced by the low availability of food as by limited access and the insufficient use of available food. It is therefore very difficult for the Burundian pig farmers to get the feeds of the pigs when they cannot even find theirs.

In Burundi, pig farming is not well developed, most breeders practice traditional farming systems where animals roam the wilderness in search of feed which could be a source of disease transmission. In reality, fed with poor quality fibers that cannot ensure their performance (Average daily body weight gain). These animals become less competitive on the market and therefore unproductive in the life of breeders. All this is due to the fact that the concentrates capable of ensuring the good growth of the pigs are more expensive and on top of that they are derived from products which are consumed by the human being such as cereals (maize, rice, corn, etc.), oilseeds (rapeseed, peas, sunflowers, etc.).

These crops represent an important part of feed cost and constitute a major stake in the evolution of the pig sector towards production systems meeting various criteria of sustainability (economic, environmental and social). As there is little literature that tells us about the use of *Mucuna pruriens* in animal feed, we were conducted this study focusing on the use of *Mucuna pruriens* in pig feed to supplement what others have done. This study analyzed how the very expensive pork feed crops could be replaced by *Mucuna pruriens* produced by farmers at a very low production cost while respecting environmental, social and economic sustainability. Therefore, our study has the following research questions:

- Does the incorporation of transformed *Mucuna pruriens* as a source of energy and protein in the diet of growing pigs have significant effects on their growth?
- Do the substituting certain ingredients in the pig ration for processed *Mucuna pruriens* as a source of energy and protein increase the profit margin for pig farmers?

1.3. Objectives of the study

1.3.1. Overall objective

Overall objective focuses to determining a practical way to reduce the anti-nutritional factors in Mucuna grains in order to transform it into a protein and energy-generating feed that must be economically incorporated into home-mixed rations of growing pig capable of ensuring its good performances and so that become competitive at the market.

1.3.2. Specific objectives

More specifically, our thesis work has the following specific objectives:

- Advice smallholders' livestock farmers of Carire on suitable options of incorporating *Mucuna pruriens* in their pig feed rations;
- determine the optimal treatment diet that can give pig farmers of Carire a better profit margin on the feed cost;
- Determine an effective, economic and practicable way to reduce concentration of L.Dopa and other anti-nutritional factors in Mucuna grain through soaking and boiling procedures;
- Evaluate the feeding value of different pig rations constituted with processed Mucuna grain as protein and energy source;

1.4. Hypothesis of study

Our study was conducted on eight pigs that are fed four different treatments and was built around following assumptions:

- There is no significant difference between the weight of pigs fed with rations T1 treatment diet which does not contain *Mucuna pruriens* flour, T2 treatment diet which contains 20% of the *Mucuna pruriens* flour, T3 treatment diet which contains 30% of the *Mucuna pruriens* flour and T4 treatment diet which contains 40% of the *Mucuna pruriens* flour
- There is no significant difference between the profit margin generated by pigs fed a ration T1 treatment diet which does not contain *Mucuna pruriens* flour, T2 treatment diet which contains 20% of the *Mucuna pruriens* flour, T3 treatment diet which contains 30% of the *Mucuna pruriens* flour and T4 treatment diet which contains 40% of the *Mucuna pruriens* flour.

1.5. Significance of the study

Many pig breeders only use less nutrient rich feed sources and others use concentrates which are very expensive leading them to realize losses. The present study which aims at the analysis of the effects of incorporation of *Mucuna pruriens* in the home rations of the growing piglets and the determination of the optimal level of rationing able to generate the highest profit margin to the pig breeders has for effects:

- In the short term, pig breeders are learning that it is good to grow *Mucuna pruriens* themselves to substitute the more expensive ingredients at the market with flour from the Mucuna grains that they themselves produce more cheaply.

- In the medium term, the breeders of neighboring localities will also learn from these breeders of the association about the use of Mucuna grains in their breeding.
- In the long term, this study would allow breeders to make better rational decisions in the feeding of their pigs as well as in the breeding of other animals by using less expensive feeds likely to improve their economic performance as much as possible through the additional information received on the cost-benefit analysis which allows them to know if they are working while losing or not and therefore reducing malnutrition because the feed they share with the pigs would be intended for humans.

1.6. Organization of the study

Our work revolves around five chapter namely the first chapter entitled introduction which presents background information, the research problem, the questions, the objectives, the hypotheses and the relevance of the study. The second chapter is a review of the literature which provides us with a summary of what others have done on similar empirical research. The third presents the methodology and the tools necessary to carry out our study well. The fourth is that of the presentation, interpretation and discussion of the results and finally the recommendations.

1.7. Conclusion of the first chapter

This first chapter presents the general idea of the research by identifying the problem which is the use of non-nutritious or expensive feeds in pig feed when there are under-used sources capable of validly replacing or even more validly expensive food ingredients like palm cake, cotton cake and rice bran. *Mucuna pruriens* grains are underutilized in pig feed as it was not known that they are very good at improving the performance of pigs and that they can be produced easily by the breeders themselves. This chapter therefore shows the genesis of this research work through the research questions, the objectives and the hypotheses which were verified by using statistical tests to give a contribution to the resolution of this problem. He gets the reader into the swing of the research by presenting him the whole plan of the research and the researcher's involvement.

CHAPTER 2. LITERATURE REVIEW

Each scientific study is developed around a conceptual and theoretical framework which guarantee the consistency of the approach used, it is therefore important to specify the theoretical foundations and the meaning of the concepts used in order to clarify our research. This chapter presents the review of the literature on the model of objective determination of a treatment diet which has an optimal quantity of the flour of the grains of transformed *Mucuna pruriens* as a source of energy and proteins which must be mixed in rations of growing pigs allowing pig farmers to get the best profit margin over feed cost. The chapter uses also the cost-benefit analysis model that can allow farmers to analyze the profitability of pig farming.

2. 1. Theoretical literature

2.1.1. Crossbred Large White pigs

The crossbred Large White pigs have a good adaptation to high temperatures (FAO, 2012). The pigs of the crossbred "Large white" are white-coated animals; they are of improved breed of English origin. These pigs are hardy and their ears are erect. They adapt easily to tropical environments. Sows of this breed have good maternal quality (10 to 13 piglets at birth and 9 to 10 piglets at weaning) their adult weights are higher, sows and boars can weigh between 100 and 150 kg at the age of the slaughtered (Labroue, 2000).

2.1.2. Growing pigs

Running a pig farm consists of three main periods, which are farrowing, post-weaning and fattening. Piglets are said to be in the growth phase when they reach weaning age. In intensive production units, piglets are weaned at the age of 3 to 4 weeks. Attention must also be paid to the age and genetic diversity of the strains of animals used (Mennella and Beauchamp, 1998) and of the saccharin (Glaser et al., 2000).

At each stage of animal development there is a space adapted to their specific needs. According to Chesworth al. (1996), the main nutritional requirements for feeding growing pigs are digestible energy (13.0MJ / kg), crude protein (16.0%), calcium (0.7%) and phosphorus (0.55%). The breeder must ensure the health and comfort of his animals on a daily basis.

2.1.3. Feeding pigs

At all times, in a more or less empirical way, man has sought to improve the diet of his livestock, particularly from the time when he cultivated crops whose products were intended for the feeding of his animals breeding. It is likely that specific and increasingly rational dietary practices are brought into play from the start of domestication. The hierarchies achieved between the nutritional values of food have been refined over the centuries and have led to the creation of feeding unit systems, essential tools for rationally reasoning the feeding of animals. The feed units were created to ensure that the various nutrients are provided in sufficient quantity to cover the needs of the animal and allow it to enhance its production potential.

According to Sauvant (2005), to be operational, the power supply units must comply with seven essential principles or characteristics:

1. Each unit is specific to a nutritive component likely to be a factor limiting performance (energy, protein, amino acid, mineral element ...).
2. Each unit translates a flow of organic or mineral matter or energy measured at a given level of its use by the animal. The place where this reference flow is appreciated in the animal organism differs according to the nutritive component considered. It is, for example, the amount ingested in the case of mineral elements, the flow of amino acids absorbed through the intestinal wall in the case of P.D.I. ruminants, net expenditure for maintenance and production in the case of energy.
3. Each unit must be able to quantify both a component of the food or nutritional value of food and the same component of the food or nutritional requirements of animals. In this regard, it should be noted that the term "food" is broader than "nutritious" insofar as it also incorporates the parameters related to ingestion, that is to say the ingestion for food and the ingestion capacity for animals.
4. Power units must be additive. Additivity is expressed by the fact that a mixture of n raw materials i of nutritional value U_{ij} (for the nutrient j) incorporated in proportions P_i into the mixture, has a nutritional value U_j (for the nutrient j) calculable by the expression: $U_j = \sum_i P_i U_i$ with $\sum_i P_i = 1$

This property makes it possible in particular to make combinations and substitutions between foods on the basis of the different units and to formulate regimes by linear programming and by automatic calculation.

5. A power unit must be reliable and precise. This principle means that, in the supply zone where the nutrient considered is the primary limiting factor, variations in animal performance levels must be predicted and explained with maximum precision by variations in the quantities of units of food provided by the ration. This amounts to minimizing the residual variation around an average response.
6. The practical implementation of power supply systems should be done at the lowest cost. This implies in particular the use of simple and inexpensive methods of food analysis to estimate their nutritional value.
7. The power supply units must be scalable, that is to say they must be able to integrate, in stages and, if possible, without major modification of practical use, the new knowledge updated by Research.

Studies have been done to ensure that feeding practices are rational in order to control the consumption index and the quality of the carcass.

Thus, the food choices of the animal therefore depend on many parameters related to the animal and to the food in a spatio-temporal dimension (Emmans 1991). Eating is a voluntary act which depends on the desires and tastes of each individual. It also depends on the amount of nutrients present in the food and the amount of energy ingested by the animal.

According to the pig feeding technical sheet (Sheet n ° 3), the needs of a pig are among others those which provide:

- Energy (starch or fat) cereals, tubers, vegetables (millet, corn) between 2,400 and 2,600 kcl / kg of food;
- Proteins: important (15 to 20% of the ration), it is often necessary to add proteins of animal origin (fish meal, blood);
- Minerals and vitamins: Calcium (0.9%), phosphorus (0.3%), copper, zinc, iron… (shell, salt)

Indeed, it is certain that a large animal eats more than a small one. However, the relationship between height (determined by weight) and food intake is not as straightforward as one might imagine. As a general rule, the intake is determined by the "metabolic size" of the animal and is proportional to its metabolic weight.

Roy (2011) on two consecutive strips of 96 pigs each, he took 4 daily feed cap levels to determine the level of ad libitum rationing of a fattening pig and found, on a 45 g of feed per kg of live weight at the time of fattening, that 2.5 kg / day / 65 kg pig is needed, i.e. around 4% of its live weight.

It is also reported that the possibility of wet food allows animals to eat more quickly. (Gonyou and Lou, 2000). Deprez et al (1987) reported the positive effect of liquid foods on the length of the intestinal villi. In practice, for fattening pigs using a feed trough equipped with a water source rather than dry flour, recorded a 17-36% reduction in daily feeding time (Gonyou and Lou, 2000; McDonald and Gonyou, 2001). From a zootechnical point of view, the use of feeders with integrated drinkers in engraving allows performance at least as good as conventional feeders (Walker, 1990; Maton and Daelemans, 1991; Gonyou and Lou, 2000).

Maton and Daelemans (1991) reported that a reduction in water consumption leads to a reduction in effluent production.

2.2. Empirical literature

2.2.1. General information about Mucuna grain

Velvet bean (*Mucuna pruriens*) is a tropical legume with high productivity in grain and foliage (Afolabi et al., 1985). The chemical legume composition and nutritive value of the Mucuna beans were investigated by Siddhurraju et al. (1996) and Udedibie and Carlini (2000), and the legume seems to have a greet nutritional potential as components of livestock feed, most especially monogastric animals. In spite of the high protein (25.5-35.75%) content of this promising legume, the nutritive value of Mucuna bean is marked by the occurrence of trypsin inhibitors, haemagglutinin, tannin, saponin, L-dopa and hydrogen cyanide (siddhurraju et al., 1996; Emiola, 2004). Severe inhibitions in feed intake, growth rate and incidence of high of high mortality in broiler chicks fed raw Mucuna beans have been reported by Afolabi et al. (1985). Similar observations have been reported (D”mello et al., 1983) in chicks fed raw winged beans and Jack bean. These negative effects have been attributed to the anti-nutritional factors in the beans. Few data are available on the use of velvet bean in pig nutrition.

David (1986) reported that the raw seeds are not utilized by poultry but can comprise up to 25% of a ration for pigs. EDN (1997), in contrast, observed that while the seeds usually give good results with cattle and sheep even when fed up to 70% of the diet, they are generally unsatisfactory for pigs when forming up to 5% of the ration and even cause severe vomiting and diarrhoea at 25% dietary level.

Studies with poultry have shown that the raw bean in toxic to broilers (Emelalom and Udedibie 1998; Carmen et al., 1999; Esonu 2001) and that cooking the bean ((Emelalom and Udedibie, 1998) only gave indications of partial detoxification hence its dietary inclusions could not exceed 10%. Soaking the bean in water before cooking (Udedibie et al., 2001) allowed for a successful use of the bean at 20% for broilers. Emenalom et al. (2002) observed that cracking the bean into 2 to 4 pieces soaking in water and cooking was more effective in improving the performance of broilers. This procedure has not been used for pig rations.

Resultat from recent investigations by CLiP Project in Burundi show that the most effective methods to reduce total phenolics, tannin and oxalate contents is to soak the seed for 18hrs in water and thereafter, boil the seed for 1 hour. Using this method, total phenolics, tannins and oxalates were reduced by 32.6%, 37.0% and 63.5%, respectively. When used alone, imbibitions increases the contents of total phenolics and tannins by 32% and 9% respectively. However, boiling imbibed seed eliminates the total phenolics and tannin contents that increased during the process of imbibitions. Researchers are now waiting for L-Dopa results to finalize this research.

If successful, this work will enable farmers to rapidly expand the use of *Mucuna pruriens*, since Mucuna fits well in cereal-legume rotations under mixed crop-livestock systems and is a high producer of high protein grain, as well as fodder. Therefore, the EU-IFAD funded CLiP Project in Burundi, is understanding the following experiment to evaluate the growth of cross-bred Large White pigs fed rations containing different levels of processed Mucuna grain.

2.2.2. The association of *Mucuna pruriens* with other cultures

Mucuna pruriens is a heliophilic and thermophilic plant. It therefore requires hot and humid conditions and significant light requirements. This is why the plant is found in the tropics and subtropics including Burundi, in Asia (mainly in India and southern China), in Central America, South America and Africa (Gichet, 2017).

Indeed, it does not require any special conditions to ensure its growth. A temperature varying from 15 to 35 ° C and a pluviometry between 650 to more than 1200mm allow them to adapt well because it presents a great tolerance to the adverse environmental conditions such as drought, low soil fertility and the high acidity of the soil, that is to say a pH varying from 4.5 to 7.5 (INERA technical files).

Mucuna pruriens is sown at the start of the rainy season, as a pure crop or in combination with other crops such as maize, sorghum, yam or other food crops. But since it is a climbing and creeping plant with a length ranging from 0.30 m to 0.80 m when cultivated in combination with other crops, it is sown one month after sowing these crops, at a density of 0.80 mx 0.80 m or 0.80 mx 0.40 m with a port high enough to escape smothering by Mucuna because it can take advantage of these cultures to use it as a tutor (Badou, 1992; Codjia, 1996). It is also sown at the rate of one seed per bag (i.e. 15 kg of seeds per hectare) or two seeds per bag (i.e. 30 kg of seeds per hectare), (Skerman, 1982; Badou, 1992; Kanninkpo, 1992).

The yield of Mucuna seeds is 3 to 4 tons per hectare in pure cultivation and 200 to 600 kg per hectare in combined cultivation, for example, with maize or sorghum. Growing Mucuna not only avoids long fallows but also helps to maintain the fertility of cultivated fields. This better performance is justified by the fact that Mucuna is able to mobilize and recycle soil elements, especially allowing nitrogen fixation of up to 170 kg / ha and a production of nitrogen returned by residents ranging up to 200 kg / ha (Lessaint, 1998) hence the increase in the productivity of other crops in association with M*ucuna pruriens*. The study of the production possibilities of maize (*Zea mays* L.) and soya (Glycine max (L.) Merr.) On a blanket of *Mucuna pruriens* (L.) DC. in the ecological conditions of Kikwit in the Democratic Republic of the Congo showed that the association of maize with Mucuna and soybeans significantly influenced production, and the maize yield from 1041.7 kg / ha to 2233.3 kg / ha, i.e. twice as high as that obtained in pure maize cultivation.

2.2.3. Use of *Mucuna pruriens* as animal feed

Muinga, Saha and Mureithi (2003) studied the effect of *Mucuna pruriens* forage on the performance of lactating cows Tropical and Subtropical Agroecosystems and they concluded that Mucuna forage at the daily rate of 2 kg DM can be used to supplement dairy cows fed a grass-based diet and so that farmers have the option of either using Mucuna for soil fertility improvement or for livestock feeding and use the manure for crop production.

Farougou, S., et al (2006) passed Mucuna seeds through two types of processing T1 (*Mucuna pruriens* seeds soaked, shelled, boiled and dried) and T2 (dry shelled *Mucuna pruriens* seeds , soaked, boiled, re-soaked and dried) before transforming them into flour to divide them into 6 rations composed of corn, wheat bran, soybean meal, *Mucuna pruriens* flour, three of which should be 07.50% (batch A1), 10.62% (batch B1) and 13.75% (batch C1) of Mucuna seeds treated with T1 while the other three regimes contained Mucuna seeds treated with T2 were incorporated in the same proportions 7 , 50% (batch A2), 10.62% (batch B2) and 13.75% (batch C2) compared to the control feed, whose composition respects that used by local breeders, containing 11% soybean meal and did not undergo any treatment (T0) so analyzer its effects on pentad growth and found that despite a lower protein supply, the soybean cake substitution by 10.62 % of soaked, shelled then boiled *Mucuna pruriens* seeds or by 13.75 % of shelled then boiled *Mucuna pruriens* seeds allows a normal or improved growth for lower food production costs.

Chakoma, I. et al., (2016), analyzed the economic and performance effect of supplementation by replacing commercial foods with iso-nitrogenous and iso-energetic diets based on alternative sources of protein from two trials, which trial 1, was composed by three regimes (commercial concentrate, commercial concentrate partially substituted by Mucuna and commercial concentrate partially substituted by lablab - cowpea) compared to grass veld attributed to 12 cattle in a complete random block design and trial 2 was performed under a complete double randomized block design with 40 cattle assigned to four forage legume-based diets, a poultry-based diet and a commercial beef concentrate. Diets were offered at 1.5% body weight per day for 56 days and found that in trial 1 ADWG was significantly ($p < 0.05$) higher for animals taking supplements compared to non-supplemented cattle. In trial 2, the average daily weight gain (ADWG) was significantly highest on peanut stems diet and less on the poultry litter diet. They ended up concluding that the substitution of commercial concentrates with alternative diet sources of reduced protein costs and a significant improvement in gross margins.

2.2.4. Theoretical Framework

2.2.4.1. Analysis of variance test: ANOVA

The ANOVA test is an extremely useful technique concerning researches in the fields of economics, biology, education, psychology, sociology, business /industry and in researches of several other disciplines. Professor R.A. Fisher was the first man to use the term "Variance" and, in fact, it was he who has developed a very elaborate theory regarding ANOVA, explaining its usefulness in the practical field.

This technique is used when several samples are involved in the search to test the significance of the difference between the means of these samples. The significance of the difference between the means of two samples can be judged by z-test or t-test, but when the samples are greater than two these tests are not capable, other tests must be used.

By using the ANOVA technique, we can carry out this simultaneous test and can draw inferences as to whether the samples were drawn from populations having the same mean or not.

The ANOVA technique is important in the context of all those situations where to compare more than two populations, for example in comparing the crop yield of several varieties of seeds, the gasoline mileage of four automobiles, the smoking habits of five groups and so on. In such circumstances, one generally does not want to consider all combinations of two populations at once as this would require a large number of tests before being able to reach a final decision. It would also consume a lot of time and money, and even then, certain relationships may be left unidentified especially interaction effects.

2.2.4.2. Decision conditions

The ANOVA test is used when the samples involved in the study are greater than two. This test aims to highlight the existence or not of significant differences between the means of the groups studied and is built around the following hypotheses:

- The null hypothesis H0: $\mathcal{M}1 = \mathcal{M}2 = \ldots\ldots = \mathcal{M}k$ (always supposes the equality of means of the k groups) and
- The alternative hypothesis H1: $\mathcal{M}1 \neq \mathcal{M}2 \neq \ldots\ldots \neq \mathcal{M}n$ (supposes that at least one of the means is different from the others).

To verify the null hypothesis H0 (all the means of the groups are identical), we seek to know the probability p that a value F read in the table according to a Fisher-Snedecor law (k-1, n-k) degree of freedom exceeds the value F calculated using the following formula:

$$F = \frac{Estimate\ of\ \ population\ \mathrm{var}iance\ \ based\ on\ between\ samples\ \mathrm{var}iance}{Estimate\ of\ \ population\ \mathrm{var}iance\ based\ on\ within\ samples\ \mathrm{var}iance}$$

at the risk of making a mistake, noted α set more generally at the threshold of 5% (significant conclusions) or 1% (very significant conclusions).

If the probability of F is less than the threshold α, the model is globally good, in this case a comparison is made between F calculated and F tabulated.

If F calculated ≥ F read in the table at the degree of freedom (k-1, n-k), the difference between the groups is said to be significant and if F calculated < F read in the table at the degree of freedom (k-1, n-k), the difference between the groups is said to be insignificant.

Briefly, once the p-value is greater than the significance level α, you cannot reject the null hypothesis because you are not able to conclude that the population means are equal, we accept the alternative hypothesis.

2.2.4.3. Cost-benefit analysis

The history of CBA dates back at least to Jules Dupuit in the middle of the 19th century, when he looked into the problem of the construction of bridges and their location. But the real birth of the CBA in its ability to influence public decisions dates back to 1930 with major work on water and flood control in the United States, then later to the Green Paper in the 1950s laying down rules for compare and aggregate the benefits (Nicolas Treich, December 2005).

It is important to distinguish between Cost Benefit Analysis (CBA) and Cost Effectiveness Analysis (CEA). CEA can be seen as a particular form of CBA. In a CEA, it's about setting a goal and minimizing the costs to achieve that goal. It is then a question of deciding to do everything possible to achieve this objective by increasing expenses as much as possible. More generally, a CEA determines the policy which leads to a specific objective while inducing a minimal loss in terms of social welfare and allows to consult the conversion into monetary units of the efficiency indices while the CBA is, unlike CEA, indicates how the lens is chosen. CBA is therefore preferable to CEA as it is more transparent in the decision-making process and its consequences are measured in monetary units.

Each project requires estimates of the forecast production costs for economic and financial studies allowing the price decisions in relation to probable changes in selling prices, changes in market position and changes in the composition of supplies. It is therefore an economic evaluation which can be defined as a process involving analytical techniques in the field of allowing an optimal choice of resource allocation. Cost-benefit analysis is one of the most widely used methods that provide decision-makers with the various elements to enable them to choose between several programs or projects. It makes it possible to estimate the value of the goods and / or services that it will be necessary to acquire for each project as well as the advantages in terms of efficiency or benefit that can be expected from them.

CBA can therefore serve as a support for deliberation between different social actors, without being a sufficient condition or a necessary condition for the decision to implement a prevention plan.

Formally, the cost-benefit analysis has many analogies with the investment choice techniques used by private firms. But, as G. Terny points out, “while the decision rules of firm theory tend towards maximizing private profit, the decision rules of cost-benefit analysis seek to maximize collective benefits or profit. general welfare. This means that it would be utopian to consider cost-benefit analysis as the instrument of an “objective” rationality, similar to that which guides the private entrepreneur in the search for maximum profit.

There are many others who have written literature focusing on the definition and practical cases of the cost-benefit analysis model in different areas of analysis of projects or various programs whether in the private sector as public.

Florio M. (2006) in the cost-benefit analysis and the EU Cohesion Fund on the social cost of capital and labor, he specifies that the cost-benefit analysis is a legal obligation prior to projects of evaluation supported by the Cohesion Fund, which raises the need to calculate shadow prices. It concludes that the prices observed in developing regions of the EU do not reflect the social opportunity cost, neither of labor nor of capital, due to market distortion and political constraints. He focused on the discussion of simple rules for calculating the opportunity costs of capital and labor, as part of the assessment of financial equipment financed in part under the aegis of the Cohesion Fund, admitting that for the 2007-2013 programming period, the Commission should adopt a single financial discount rate of 3.5% in real terms, social discount rates of 5.5% for convergence regions and 3.5% % for regions with the “competitiveness” objective, and a virtual wage rate specific to each zone.

INRS (2009) performed a cost-benefit analysis at two hospitals, which implemented programs to prevent the risks of manual handling and found that in one case, the assessment reveals a 3.3-year return period on investment in prevention, based on an assumed 60% reduction in occupational accidents. In the second case, expected benefits will be compensate for 80% of the prevention cost over the 10-year period used, based on a 42% reduction in occupational accidents related to handling risk.

Goldbach and Alban (2006) carried out a cost-benefit analysis of the four strategic control alternatives of salmonella control in the existing Danish pig farm by comparing the hot-water decontamination of all pigs at slaughter, sanitary slaughter of pigs from herds with high levels of Salmonella, use of home-mixed feed in herds with slaughter pigs and use of acidified feed for slaughter pigs and found that for all alternatives, hot-water decontamination was socio-economically profitable with a net present value over 15 years of 3.5 million euros compared to -43.6 sanitary slaughter of pigs from herds with high levels of Salmonella, - 262.3 million euros for home mixed feed, and - 79.9 million euros for acidified foods for slaughter pigs.

Based on a cost-benefit analysis, Itty and al. (1994), studied the economic profitability of 7 village herds infested by tsetse flies by evaluating the purchases, the drug costs, the milk and the outputs (sales, slaughter) of cattle which represent income as well as the devaluation of the FCFA and have found that the variation in results between herds is very considerable. The Internal Rate of Return (IRR) varying from 21% to 47% with herd 2 which is distinguished by superior results, herds 1, 4, 6 and 7 have modest financial performances, while that these are clearly insufficient for herds 3 and 5.

CHAPTER 3. MATERIALS AND METHODS

3.1. Location of study area

The study was carried out in the area of Bitare on Carire hill in a pigsty of the TERIMBERE association supported by the CLiP project. Carire hill is one of the 22 hills of the Bugendana commune divided into 4 zones including Bitare, Bugendana, Mugera and Mutoyi.

The commune of Bugendana is one of the 11 communes which make up the Gitega province and shares its limits in the North with the communes Mutaho and Gihogazi (from Karusi Province), in the South with the commune of Giheta, in the West with the Communes of Rutegama and Mbuye both from Muramvya province, and to the east with the commune of Shombo from Karusi province. The Mubarazi river forms the western border, while the Ruvyironza river forms the southern border of the municipality. The Bugendana commune totals an area of 274 km^2, corresponding to approximately 14% of the area of Gitega province.

The commune of Bugendana is located at 29 ° 48 'and 30 ° 2' East longitude, and between 3 ° 9' and 3 ° 21' South latitude. It is crossed by the 30 ° meridian which passes near the confluence of the Ruvubu-Ruvyironza rivers, limiting the Mugera and Mutoyi zones respectively to the border of the municipalities of Giheta and Shombo. Its relief is formed by rounded or slightly steep hills. Its eastern part which includes the areas of Mutoyi and Mugera gradually rises to reach higher altitudes at 1900 m. The average ambient temperature hovers around 20° C, with average lows of 12.6° C and average highs of 25.3° C.

This commune is connected to other bordering communes thanks to the national road RN15 which links Gitega to Ngozi by crossing the Bugendana commune. It also has a few interior tracks which can be used in vehicles connected by numerous culverts but which are unfortunately in poor condition for the most part. Only the three centers which are Mutoyi, Mugera and the capital of the commune are supplied with electricity from the Ruvyironza hydroelectric plant. The fields of animal husbandry and agriculture appear to be the most attractive for the population of Bugendana, especially those who operate around the center of Mutoyi a cooperative which is made up of several activity sectors namely modern pottery, carpentry, food and livestock. But in addition to production activities, it also oversees private producers. This study area has been shown on the following figure in pink coulor:

Figure 1: The map of the Bugenda commune and its hills

*S*ource*:* Communal community development plan of Bugendana (PCDC, 2013*)*

3.2. Processing Mucuna grain

For a ration to be well optimized, care must be taken to ensure that its nutritional characteristics best meet the needs of the piglets. Even if the legume Mucuna has a great nutritional potential as a component of livestock feed, especially monogastric animals, he also has the anti-nutritional toxic factors (D"mello et al., 1983) which limit its use in animal feed, namely the L-Dopo. In our research, we went through the technique of detoxifying its grains by soaking, boiling and drying before transforming them into flour that we incorporated in the rations of growing pigs to replace cotton cake, palm cake and rice bran in a proportion determined in the order of 0% of the *Mucuna pruriens* flour for T1 treatment diet (control group), 20% for T2 treatment, 30% for T3 treatment diet and 40% for T4 treatment to assess which of the treatments is able to ensure good growth of pigs more than the other treatments at a lower production cost. The processing of the *Mucuna pruriens* grains was done by the two technical assistants under supervision. One who was responsible for feeding the pigs and maintaining their pens during the day and the other who was responsible for their surveillance at night.

The one who worked during the night also did the soaking and boiling of the Mucuna grains and the one who worked during the day was also responsible for drying the Mucuna grains and grinding them. The stages of transformation of *Mucuna pruriens* grains are as follows:

a. Cleaning and soaking grain in water

The Mucuna grains (*Mucuna pruriens* var. Cochichennensis) were first cleaned with water to remove all the dirt which it can contain before being soaked in cold water for 48 hours. The cleaning was done before the soaking to remove the dirt from the grains and after to remove the remaining soaking water (figure 2).

Figure 2: Soaking Mucuna beans

Source: Photo taken by the author in Cibitoke (Mparambo) during the first experiment

b. Cooking and drying

After soaking, the remaining soaking water was discarded before being cooked for three hours. After cooking the beans were rinsed in a single flush of flesh water and dried in the sun (figures 3 and 4).

Figures 3 & 4: Cooking and drying Mucuna grains

Source: Photo taken by the author in Cibitoke (Mparambo) during the first experiment.

c. Milling Mucuna grain

After being cooked for three hours, rinsed in a single flush of fresh water, and dried in the sun, the grain of Mucuna was milled through a 5.0 mm screen. This meal was incorporated in the diet of growing Large White piglets at the different proportions depending on the desired treatment (figure 5).

Figure 5: Milling Mucuna grains

Source: Photo taken by the author in Carire (Mparambo) during the second experiment

3.3. The composition of experimental diets

The treatments provided to the pigs constituted of 33.7% rice bran, 30% maize, 20% palm cake, 10% cotton cake, 5% molasses, 1% bone meal, 0 , 3% salt and 0% flour *Mucuna pruriens* for T1 treatment; 33.7% rice bran, 30% maize, 10% palm cake, 0% cotton cake, 5% molasses, 1% bone meal, 0.3% salt and 20% of *Mucuna pruriens* flour for T2 treatment; of 33.7% rice bran, 30% maize, 0% palm cake, 0% cotton cake, 5% molasses, 1% bone meal, 0.3% salt and 30% *Mucuna pruriens* flour for the T3 treatment and 23.7% rice bran, 30% maize, 20% palm cake, 10% cotton cake meal, 5% molasses, 1% flour of bone, 0.3% salt and 0% *Mucuna pruriens* flour for the treatment of T4.
Analyze nutritional characteristics including percentage of dry matter (DM), total ash, protein, fat, fiber, sugars and mg / kg of calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K) and sodium (Na) resulting from these 4 treatments, they were transmitted to the soil analysis and agro-food products laboratory of ISABU (LASPA).

3.4. Study design and sampling

The research has been reported on the transformation of *Mucuna pruriens* which has been incorporated into the 4 different feed treatment diets and each of the piglets should pass on all 4 different treatments. The responses to the different treatments were recorded. The prices linked to the ingredients constituting the treatments to better analyze the performance and profitability of these piglets were also recorded.

The main objective of the investigation was to find the optimal quantity of *Mucuna pruriens* transformed as source of energy and protein which it is necessary to incorporate in home-mixed rations of growing piglets having positive effects on the performance of these and allowing getting the best margin on food cost. The materials and methods adopted to carry out all of the research were prescribed by pure scientific approach. To conduct the present study, various research results from similar or related works were studied and analyzed.

To carry out the work, the study had took 10 large white crossbred growing piglets, whose experiments carried 8 piglets numbered from 1 to 8 and each confined in its cage, but the other 2 piglets of them were put in reserve in order to replace any piglet that could get sick or die.The feed to these piglets was offered at 4% of the animal's body weight, while water was provided *ad libitum* i.e., 2% in the morning and 2% in the afternoon. Weights were taken each time at the onset of the experimental period and after 7 days using the Brecknell brand electric scale (Max = 300kg, d = 0.2kkg) to calculate the body weight gain for each period of experimentation and adjusting the feed to the current weights of the pigs.

The experiment was constituted of two 4X4 Latin Square trials (term first used by Euler, 1782) conducted simultaneously which allowed us to obtain the estimates of the mean unconfused effects synthesized as follows in the below tables 1 and 2.

Table 1 et 2 : Latin Square trials

	Pig			
Period	**1**	**3**	**5**	**7**
1	T1	T2	T3	T4
2	T4	T1	T2	T3
3	T3	T4	T1	T2
4	T2	T3	T4	T1

	Pig			
Period	**2**	**4**	**6**	**8**
1	T1	T2	T3	T4
2	T4	T1	T2	T3
3	T3	T4	T1	T2
4	T2	T3	T4	T1

The first Latin square includes 4 crossbred Large White male growers' pigs (37 kg, 32 kg, 39 kg, 41kg) that have odd numbers (1, 3, 5 and 7) and the second Latin square includes also 4 crossbred Large White male growers' pigs (37 kg, 34 kg, 37 kg, 40 kg) that are even numbers (2, 4, 6 and 8). The arrangements of each 4X4 Latin Square trial gave us 16 observations for a complete plan, therefore 32 observations in total.

From the first period, pigs n ° 1 and n° 2, were fed the T1 treatment diet containing 33.7% of rice bran, 30% of maize, 20% of palm cake, 10% of cotton cake, 5% of molasses, 1% of bone meal, 0, 3% of salt without the *Mucuna pruriens* flour, but each piglet was in its cage. Piglets n ° 3 and n° 4 were fed the T2 treatment diet containing 33.7% of rice bran, 30% of maize, 10% of palm cake, 5% of molasses, 1% of bone meal, 0, 3% of salt and 20% of flour *Mucuna pruriens* flour without cotton cake but separately. Piglets n° 5 and n° 6 were fed the T3 treatment diet which included 33.7% of rice bran, 30% of maize, 5% of molasses, 1% of bone meal, 0, 3% of salt and 30% of flour *Mucuna pruriens* flour without palm cake and cotton cake, but each piglet in its cage and piglets n ° 7 and n° 8 were fed the T4 treatment diet was constituted with 23.7% of rice bran, 30% of maize, 5% of molasses, 1% of bone meal, 0.3% of salt and 40% of flour *Mucuna pruriens* flour without palm cake and cotton cake also separately.

At the end of the first period, pigs fed T1 treatment diet were moved to T2 treatment diet, those from T2 treatment diet to T3 treatment diet, those from T3 treatment diet to T4 treatment diet and those fed from T4 treatment diet to T1 treatment diet and so on until the pigs were passed on all 4 treatments. The experiment had taken 12 weeks, i.e. 3 weeks for each period.

3.5. Food distribution and cage cleanliness

All the pigs except the 2 which are kept aside were numbered using the markings attached to their ears and then confined in a pigsty divided into 9 cages to prevent them from eating excrement from the outside which can be contemned. Each of the 8 experimental piglets was put in its own cage and the other two which were in reserve in the same remaining cage. Each pig was weighed individually just at the onset and end of the experimental period to calculate the weight gain for the entire experimental period. Food was offered at four percent (4%) of body weight per day, i.e. 2% in the morning and the other 2% in the afternoon while water was provided *ad libitum* and was adjusted weekly to suit their body weight gain. It should be noted that the water was supplied ad libitum. Pig body weight gain is obtained by simple subtraction of the final weight and the initial weight found during the experiment (figure 6).

Figure 6: Pig weighing

Source: Photo taken by the author at Carire during the second experiment

3.6. Source and types of data

3.6.1. Primary data

The primary data that we used in our research study are the data collected on the ground in Bugendana commune on the hill carire of the Bitare zone in Gitega province. These data were observed over a period of three months during the experiment with the 8 pigs subjected to the 4 different types of feed treatment. The data were recorded in a table period by period and treatment by treatment for each pig. The cost of food was also calculated and recorded during the adjustment period as well as during the data collection period.

3.6.2. Secondary data

In order to carry out our work well, the collection of secondary data was first based on documentary research, which involved the consultation of certain works which deal with subjects similar to ours found on the Internet, in the central library of the University of Burundi. We have also read various reports and publications which relate to the issue of our subject. Other additional information is collected from IITA and ISABU staff.

3.7. Specification of ANOVA model

The ANOVA (or Analysis of Variance) test is used to compare the mean of several groups. The term ANOVA is a bit misleading. Although the name of the technique refers to variances, the main purpose of ANOVA is to study differences in means. To compare the independent groups. They are the different types of ANOVA, in particular:

- One-way ANOVA: an extension of the independent sample t-test comparing means in a situation where there are more than two groups. This is the simplest case of the ANOVA test where the data is organized into several groups based on a single grouping variable (also called a factor)
- Two-way ANOVA (two-way-between-subjects ANOVA): used to simultaneously assess the effect of two different grouping variables on a continuous response variable.
- Three-way ANOVA (three-way inter-subject ANOVA): used to simultaneously assess the effect of three different grouping variables on a continuous response variable.

Thus, through ANOVA technique one can, in general, investigate any number of factors which are hypothesized or said to influence the dependent variable. One may as well investigate the differences amongst various categories within each of these factors which may have a large number of possible values.

In a two or more-way ANOVA, the interaction (i.e., inter-relation between two independent variables / factors), if any, between two independent variables affecting a dependent variable can as well be studied for better decisions.

One-way ANOVA corresponds well to this study to answer the first hypothesis which was as follows "There is no significant difference between the weight of pigs fed with T1 rations which do not contain *Mucuna pruriens* flour, T2 which contains 20% flour. of *Mucuna pruriens*, T3 which contains 30% *Mucuna pruriens* flour and T4 which contains 40% Mucuna pruriens flour", we used the ANOVA analysis model which enabled us to test the differences between the means of these 4 treatments to see the amount of variation within each of these treatments.

In terms of variation within the given population, it is assumed that the values of T_{ij} differ from the mean of this population only because of random effects i.e., there are influences on T_{ij} which are unexplainable, whereas in examining differences between treatments we assume that the difference between the mean of the j^{th} treatment and the grand mean is attributable to what is called a '**specific factor**' or what is technically described as treatment effect.

Thus, while using ANOVA, we assume that each of the treatments is drawn from a normal treatment and that each of these treatments has the same variance. We also assume that all factors other than the one or more being tested are effectively controlled. This, in other words, means that we assume the absence of many factors that might affect our conclusions concerning the factor(s) to be studied.

In short, we have to make two estimates of population variance, one based on between samples variance and the other based on within samples variance. Then, the said two estimates of population variance are compared with *F*-test, wherein we work out.

$$\text{F} = \frac{Estimate\ of\ population\ variance\ based\ on\ between\ samples\ variance}{Estimate\ of\ population\ variance\ based\ on\ within\ samples\ variance}$$

This value of *F* is to be compared to the *F*-limit for given degrees of freedom. If the *F* value we work out is equal or exceeds the *F*-limit value (to be seen from *F* table), we may say that there are significant differences between the sample means. The technique involves the following steps in order to work out F:

1. Obtain the mean of each sample i.e., obtain $\bar{X}_1, \bar{X}_2, \bar{X}_3, \ldots, \bar{X}_k$ when there are *k* samples.
2. Work out the mean of the sample means as follows: $\bar{\bar{X}} = \frac{\bar{X}_1+\bar{X}_2+\bar{X}_3+\cdots+\bar{X}_k}{N°\ of\ samples}$

3. Take the deviations of the sample means from the mean of the sample means and calculate the square of such deviations which may be multiplied by the number of items in the corresponding sample, and then obtain their total. This is known as the sum of squares for variance between the samples (or *SS* between). Symbolically, this can be written:

$$SS\ between = n_1\left(\bar{X}_1 - \bar{\bar{X}}\right)^2 + n_2\left(\bar{X}_2 - \bar{\bar{X}}\right)^2 + n_3\left(\bar{X}_3 - \bar{\bar{X}}\right)^2 + \cdots + n_k\left(X_k - \bar{\bar{X}}\right)^2$$

4. Divide the result of the (3) step by the degrees of freedom between the samples to obtain variance or mean square (*MS*) between samples. Symbolically, this can be written:

$MS\ between = \frac{SS\ between}{(k-1)}$ where (k – 1) represents degrees of freedom(d.f.) between samples.

5. Obtain the deviations of the values of the sample items for all the samples from corresponding means of the samples and calculate the squares of such deviations and then obtain their total. This total is known as the sum of squares for variance within samples (or *SS* within). Symbolically this can be written:

$$SS\ within = \sum(X_{1i} - \bar{X}_1)^2 + \sum(X_{2i} - \bar{X}_2)^2 + \sum(X_{3i} - \bar{X}_3)^2 + \cdots + \sum(X_{ki} - \bar{X}_k)^2$$

i = 1, 2, 3, …

6. Divide the result of (5) step by the degrees of freedom within samples to obtain the variance or mean square (*MS*) within samples. Symbolically, this can be written:

$$MS\ within = \frac{SS\ within}{(n-k)}$$

where (n – k) represents degrees of freedom within samples,

n = total number of items in all the samples i.e., $n_1 + n_2 + n_3 + \cdots + n_k$

k = number of samples.

7. For a check, the sum of squares of deviations for total variance can also be worked out by adding the squares of deviations when the deviations for the individual items in all the samples have been taken from the mean of the sample means. Symbolically, this can be written:

$SS\ for\ total\ variance = \sum\left(X_{ij} - \bar{\bar{X}}\right)^2$ i = 1, 2, 3, …j = 1, 2, 3, …

This total should be equal to the total of the result of the (3) and (5) steps explained above i.e., *SS* for total variance = *SS* between + *SS* within.

The degrees of freedom for total variance will be equal to the number of items in all samples minus one i.e., (n – 1).

The degrees of freedom for between and within must add up to the degrees of freedom for total variance i.e., (n - 1) = (k - 1) + (n - k)

This fact explains the additive property of the ANOVA technique.

8. Finally, F-ratio may be worked out as under:

$$F - ratio = \frac{MS\ between}{MS\ within}$$

This ratio is used to judge whether the difference between the T1, T2, T3 and T4 treatments is statistically significant or if it is just a matter of sampling fluctuations. For this, we look in the table at the value of F (4-1, 32-4) degree of freedom at a significance level of 5%.

If the calculated value of F, as indicated above, is less than the value read from the table of F, the difference is considered insignificant, i.e. due to chance and the null hypothesis of no difference between the treatment averages is accepted. In the event that the calculated value of F is found to be equal to or greater than its value read from the table, the difference is considered significant which means that the treatments have different means and therefore the conclusion can be drawn. The more the calculated value of F is greater than the value read in the table, the more we can be precise and sure to conclude in favor of the alternative hypothesis which says that there is a statistically significant difference between the means of the treatments at the threshold of significance that we have set for ourselves.

3.8. Profitability analysis

3.8.1. Profitability of pig farming

The profitability of a farm is determined by the profit from the farm. The gross margin per pig is an indicator defined by the difference between two factors which are linked, namely the gross product of the operation and the expenses allocated to this operation. It is also called gross profit. In unit terms, the latter is equal to the selling price minus the cost price. Pig farming is an activity whose products depend on the category of pig farm: cattlemen, fatteners and fattening fattening farms. Manure is the only by-product of pig farms. The DOUMANA study (2011) showed that the gross monetary income per animal fattened and sold at 8 months is 29,866.67 F CFA in well-appointed buildings in the locality of Jagoo (Dakar) in Senegal.

3.8.2. Specification of the cost-benefit analysis model

It is not enough to measure the impact of a development project to know whether it is effective or not. Indeed, a project can only be considered effective if all of its benefits outweigh all of its total costs recorded during its execution.

To evaluate our second objective which said that there is no significant difference between the profit margin generated by pigs fed a diet containing *Mucuna pruriens* and that generated by pigs fed a diet containing no *Mucuna pruriens,* we used the cost-benefit analysis model.

This cost-benefit analysis model involves assigning a monetary value to these two components which are costs and benefits, in order to calculate the net value of this pig farming project. The charges taken into account are among others the purchase of feed, the processing of grains of *Mucuna pruriens* (firewood, rental of cooking pots), the costs of guarding and feeding the pigs and the purchase of antibiotics which are considered as factors of production while for the benefits we have taken into account the monetary value of the body weight gained and the organic manure received during the whole period of experimentation on any treatment.

The formula used in order to calculate the pig breeding gross margin was as follows:

$GM_T = \sum_{i=1}^{n} TI_i - \sum_{i=1}^{n} TC_i$, where:

- GM_T is gross margin (T = treatment diet),
- $\sum_{i=1}^{n} TI_i$ is summation of the total income (TI) for each animal (i = 1,2…) and
- $\sum_{i=1}^{n} TC_i$ is summation of the total costs (TC) for each animal (i = 1, 2…).

The return per unit of money invested was also calculated on the basis of the following formulas:

$Pp = \frac{Tmp}{T.C}$ where:

- Pp: Project profitability
- Tmp: Turnover at market price (Monetary value of the body weight of pigs gained increased by organic manure)
- T.C: Total costs recorded throughout the experimentation period for treatment t.

When this ratio $\frac{Tmp}{T.C}$ is:

- $\frac{Tmp}{T.C}$ =1, The project is neither profitable nor unprofitable. We are at a Break even, that is to say that the profits made simply cover the costs
- $\frac{Tmp}{T.C}$ >1, the project is profitable.
- $\frac{Tmp}{T.C}$ <1, the project is not profitable.

The cost-benefit ratio is a measure of the total expected return per unit of money spent. To determine what to commit for each monetary unit spent, we used the following formula: 1-$\frac{T.C}{Tmp}$

3.9. Statistical analysis of data recorded

The data were collected in 4 periods and according to the 4 different treatments during an experimental period of 12 weeks. To analyze their effects on the growth of pigs, the data were processed using the Rstudio software. The statistical test for analyzing the difference between treatments was performed using the stata 13 software, while the feed costs of the different feed ingredients were calculated using the MS Excel software.

CHAPTER 4. PRESENTATION AND DISCUSSION OF THE RESULTS

4.1. Introduction

This study aims to determine the optimal level of Mucuna flour to be incorporated into pig home-mixed rations which is likely to ensure good performance and growth of pigs and at lower cost so that Carire pig farmers can derive a satisfactory benefit from it if they properly adjust to the use of this Mucuna flour.

Therefore, the 3 levels of Mucuna flour mixed with other ingredients such as rice bran, maize, palm cake, molasses, salt, bone meal to constitute 3 different treatments were examined via different software to compare them to a treatment which does not contain Mucuna flour.

This chapter therefore presents the results found on each of our 4 specific objectives of this study. It also presents the empirical results of the analytical process described in chapter three. The results are tabulated and interpreted individually against each specific objective. A descriptive analysis of the socio-economic aspect comes before the discussion of the results.

4.2. Socio-economic aspect of Carire pig farmers

Carire pig breeders have come together in an association called "TERIMBERE" men, women, young and old so that they can develop together. After coming together in association, the government has supported them by giving them around 10 hectares of land where they cultivate some of the crops that they give to their pigs. The International Institute for Tropical Agriculture through his Crop Livestock project has helped them to cultivate plants including *Mucuna pruriens* which can replace the foods they buy at the market at a very high price and which are likely to guarantee the economic profitability and performance of pigs.

4.3. Nutrients requirements for pigs

Usually carbohydrates make-up approximately 70% of the total pig ration. Protein requirements vary, depending on the size/ category of the pigs. Growing pigs need approximately 220g/kg protein during the suckling period and 180-200 g/kg during weaning. The level of protein requirements reduces as the pigs mature. Hence, protein requirement of a breeding boar and pregnant female would be approximately 150 g/kg. Mineral and vitamins are also required in trace amounts, being added at the rate of approximately 1.0 kg/100kg of feed. Samples of different categories of ration were subjected to chemical analysis before mixing to ensure that diets are mixed correctly**.**

4.4. The ingredients of the experimental treatments

The detoxified Mucuna grain flour has been incorporated into the 4 different treatment diets (T1, T2, T3 and T4) to replace cotton cake, palm cake and rice bran depending on the bromatological value of the raw material to be replaced almost equivalent to that contained in the *Mucuna pruriens* flour to use (figure 7,8,9 and 10).

- **The T1 treatment diet (control group)** contained 7 ingredients which were 33.7% of rice bran, 30% of maize, 20% of palm cake, 10% of cotton cake, 5% of molasse, 1% of bone meal and 0.3% of salt

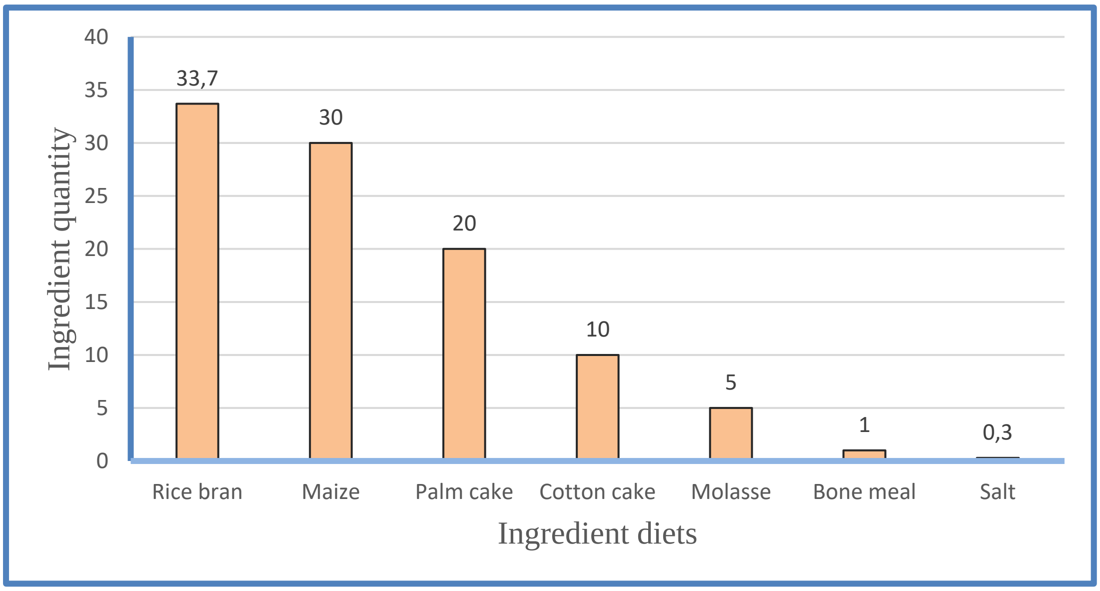

Figure 7: The ingredients of T1 treatment diet which does not contain Mucuna

- **In the T2 treatment diet**, the cotton cake and 10% of palm cake were replaced with 20% of *Mucuna pruriens* flour. The other ingredients were maintained (33.7% of rice bran, 30% of maize, 10% of palm cake, 5% of molasse, 1% of bone meal and 0.3% of salt)

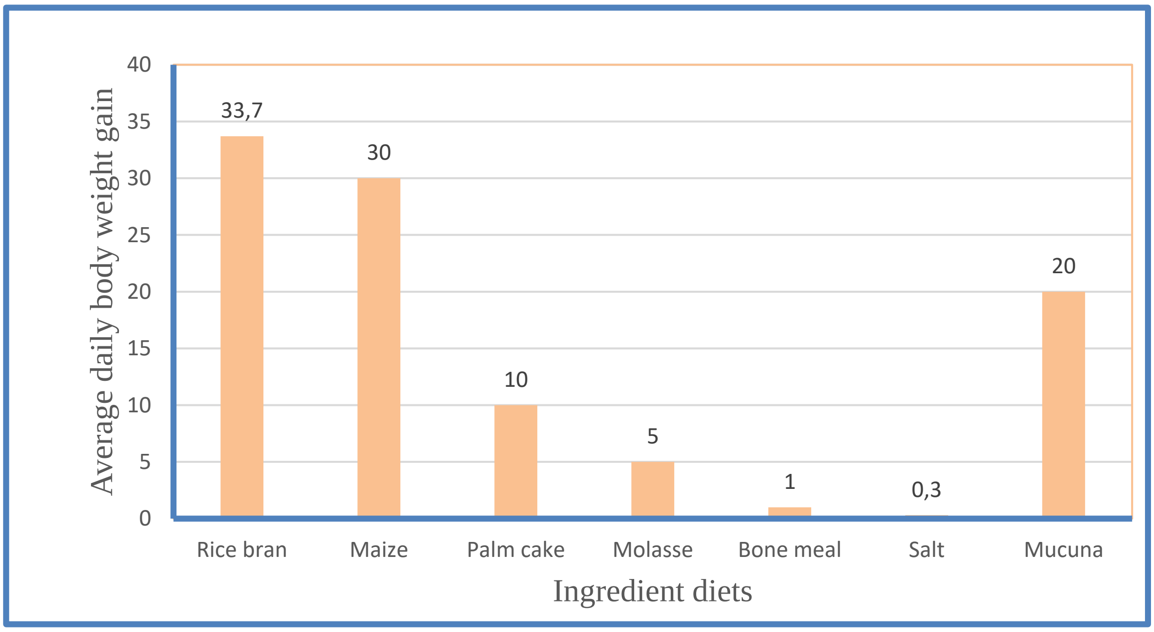

Figure 8: The ingredients of T2 treatment diet which contain 20% of Mucuna

- **In the T3 treatment diet** we used 30% of *Mucuna pruriens* flour and so that all palm cake and cotton cake quantities were removed, the other ingredients were maintained (33.7% of rice bran, 30% of maize, 5% of molasse, 1% of bone meal and 0.3% of salt

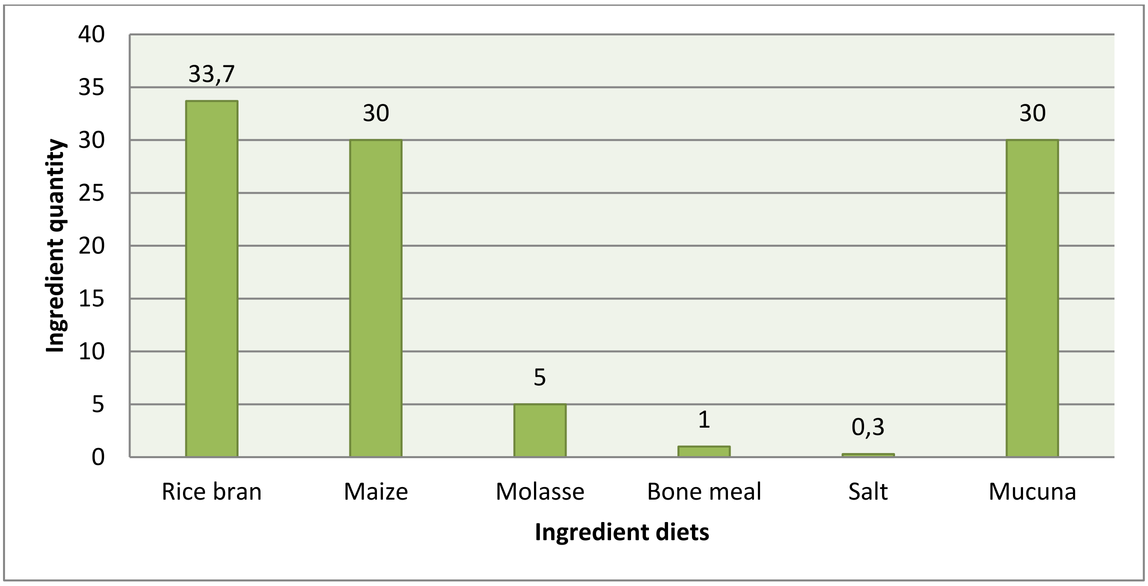

Figure 9: Ingredients of T2 treatment diet which contain 30% of Mucuna

- **In the T4 treatment diet**, all palm cake and cotton cake quantities and 10% of rice bran were replaced with 40% of *Mucuna pruriens* flour. The T4 treatment diet was contained 23.7% of rice bran, 30% of maize, 5% of molasse, 1% of bone meal and 0.3% of salt and 40% of *Mucuna pruriens* flour.

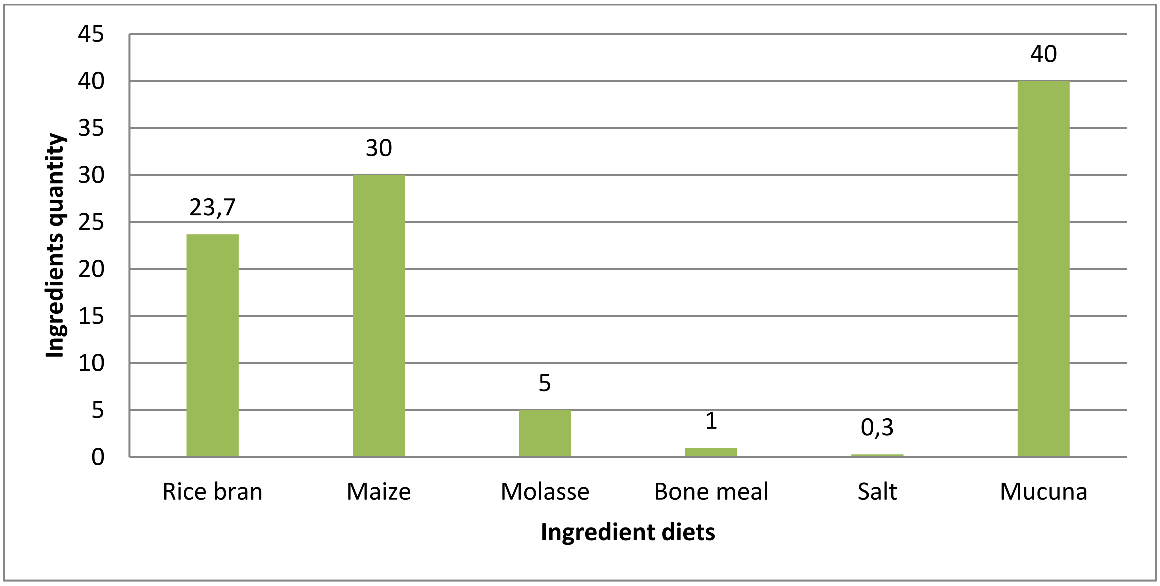

Figure 10: Ingredients of T4 treatment diet which contain 40% of Mucuna

NB: In order to optimize the growth, zootechnical performance and reproduction of pigs, there are micro-ingredients (mineral and vitamin supplements that adapt to the precise needs of animals) dedicated to animal production in the best conditions of welfare. Each 100 kg mix of each type of treatment diet includes 1kg of premix

4.5. Laboratory results of the 4 experimental treatments

Samples of the 4 different categories of treatments were subjected to chemical analysis before mixing to ensure that diets are mixed correctly. The chemical compositions of the constituent ingredients of our 4 experimental treatments are distributed as follows as shown in the following table.

Table 3: Composition of experimental diets

Prortion of Mucuna	**T1 (0%)**	**T2(20%)**	**T3 (30%)**	**T4(40%)**
Chemical composition of treatment used in the experiment.				
Dry Matter (%)	88.97	87.73	87.87	87.**79**
Ash (%)	12.7	10.4	10.9	9.04
Crude Protein (%)	19.7	10.6	22.6	20.5
Crude Fat (%)	9.11	8.45	8.32	6.24
Crude Fibers (%)	9.07	5.13	4.57	4.27
P (mg/kg)	9891	8191	9308	7550
Total suger (%)	4.47	5.60	5.55	5.61
Ca (mg/kg)	32327	13778	39913	42507
Mg (mg/kg)	4481	2818	2026	4784
Na (mg/kg)	1308	2796	1900	4207
K(mg/kg)	5697	5001	6862	8174

N.B: For each treatment, a mixture of 100 kg contains 1 kg of vitamin premix

4.6. Results of the test of significance of the period and the treatment effect on pig performance

This study was carried out on 4 treatments and in 4 different periods. To analyze whether these 2 factors (period and treatment) had a significant influence on the increase in the live weight of pigs, we used the Rstudio software.

Table 4: Significance test of the period and the treatment on the live weight of the pig

> anova(lm1)
Analysis of Variance
Response: Weight.gain

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Treatment	1	65.025	65.025	8.3814	0.007270
Period	1	84.100	84.100	10.8401	0.002692
Treatment: Period	1	11.520	11.520	1.4849	0.233181
Residuals	28	217.230	7.758		

The results which were output from the Rstudio software showed us that the period and treatment factors were all significant (p value is less than 5%). Therefore, the treatment diets and the period during which the animal feeds this or that other treatment diet have a very great significance on the animal's body weight gain.

The determination of the treatment and the period likely to influence the increase in weight of the pig more than the others were found using the software stata13.

4.6.1. Choice of the period very significant to the improvement of the pig's live weight

The data that made it possible to carry out this analysis were collected in the field from April 18 to July 11, 2020 in 4 different periods of 3 weeks each and were calculated using the stata13 software. We collected the initial live weight of the animal as well as the final live weight of the animal in order to determine the animal's live weight gain by simple subtraction as shown in the following table:

Table 5. Calculation of live weight gain of pigs per period

P1				P2			P3			P4		
N° of pig	IBW	FBW	BWG	IBW	FBW	BWG	IBW	FBW	BWG	IBW	FBW	BWG
1	37	53	16	53	67	14	67	80	13	80	94	14
2	**40**	**57**	**17**	**57**	**74**	**17**	**74**	**88**	**14**	**88**	**107**	**19**
3	37	57	20	57	71	14	71	87	16	87	100	13
4	32	44	12	44	58	14	58	70	12	70	80	10
5	34	48	14	48	62	14	62	77	15	77	83	6
6	39	60	21	60	77	17	77	88	11	88	104	16
7	37	56	19	56	75	19	75	83	8	83	95	12
8	41	59	18	59	71	12	71	80	9	80	98	18
Total			**137**			**121**			**98**			**108**
ADWG			**0.815**			**0.72**			**0.583**			**0.643**

4.6.1.1. Analysis of the significance of the difference between the averages of the periods

By simply observing the data, we can say that the results of these different periods differ, but this difference can result from simple fluctuations between the periods. To make sure that there was a statistically significant difference between the means we proceeded by the ANOVA model.

Table 6: Significance test of variations between periodic means

	Summary of Body weight gain		
Period	Mean	Std.Dev.	Freq.
P1	17.125	3.0443155	8
P2	15.125	2.2951813	8
P3	12.25	2.8157719	8
P4	13.5	4.2761799	8
Total	14.5	3.5560036	32

Analysis of Variance

Source	SS	df	MS	F	Prob>F
Between groups	106.75	3	35.5833	3.49	0.0286
Within groups	285.25	28	10.1875		
Total	**392**	**31**	**12.6451**		

First, the ANOVA model displayed the averages of the 4 periods. Then, the results of this same model proved that the difference between the means of these periods is statistically significant. From the results obtained above, we knew that at least one of the means of the periods is different from the other means. The p value (0.0286) was less than the level of significance α (5%).

The first row of the table showed us that the sum of squares (partial SS) for the model was 106.75 with 3 degrees of freedom (df) and with a mean square (MS) of 106.75/ 3 ≈ 35.5833.

The corresponding statistical value of F was 3.49 which was greater than F (3, 28) degrees of freedom read from table (2.95). Then, the model was appeared to be significant at the 2.86% level. Hence the difference between the means of these 4 periods was statistically significant ($p = 0.0286<5\%$). Although that finding is interesting, we next want to know which period appears to improve the pig body weight than the others. One way to find out One way to find out is to use the Tukey post hoc test called Pairwise Comparisons of Equal Variance Means.

Table 7: Tukey post-hoc test

Pairwise comparisons of means with equal variances

Over : Period

Number of comparrisons

period : 6

bodyweight~n	Contrast	Tukey Std. Err.	T	Tukey P>|t|	[95% Conf. Interval]	
Period						
2 vs 1	-2	1.595893	-1.25	0.599	-6.357286	2.357286
3 vs 1	-4.875	1.595893	-3.05	0.024	-9.232286	-.5177145
4 vs 1	-3.625	1.595893	-2.27	0.129	-7.982286	.7322855
3 vs 2	-2.875	1.595893	-1.80	0.294	-7.232286	1.482286
4 vs 2	-1.625	1.595893	-1.02	0.740	-5.982286	2.732286
4 vs 3	1.25	1.595893	0.78	0.861	-3.107286	5.607286

From the results obtained from the one-way ANOVA, we know so far that at least one of the period means is different from the other means (F3.49) = 3.10, p = 0.0286. The post-hoc test of Tukey was used to find this period. The data were the mean ± standard error and the periods were classified into four groups: P1 period, P2 period, P3 period and P4 period.

Looking at the p-value (i.e. the row P> | t | under the Tukey column), the Tukey post-hoc test revealed that the pig body weight gain was statistically significantly higher for pigs on the first period compared to that of pigs on the third period (-4.875 ± 1.595893kg, p = 0.024).

However, there was no statistically significant difference between the second period and the first period (-2 ± 1.595893 kg, p=0.599), between the fourth and the first period (-3.625 ± 1.595893 kg, p=0.129), between the third and the second period (-2.875 ± 1.595893 kg, p= 0.294), between the fourth and the second period (-1.625 ± 1.595893 kg , p= 0.740) or between the fourth and the third period (1.25 ± 1.595893 kg, p=0.861).

4.6.1.2. Analysis of the average daily body weight gain per period

The average daily body weight gain was calculated based on the results we had over a 3-week period using MS Excel software. The results have shown that the average daily body weight gain was very high in the first period P1 than other periods: 0.8154 kg/d versus 0.7202 kg/d, 0.5833 kg/d and 0.6429 kg/d respectively for P2, P3 and P4 period (figure 11).

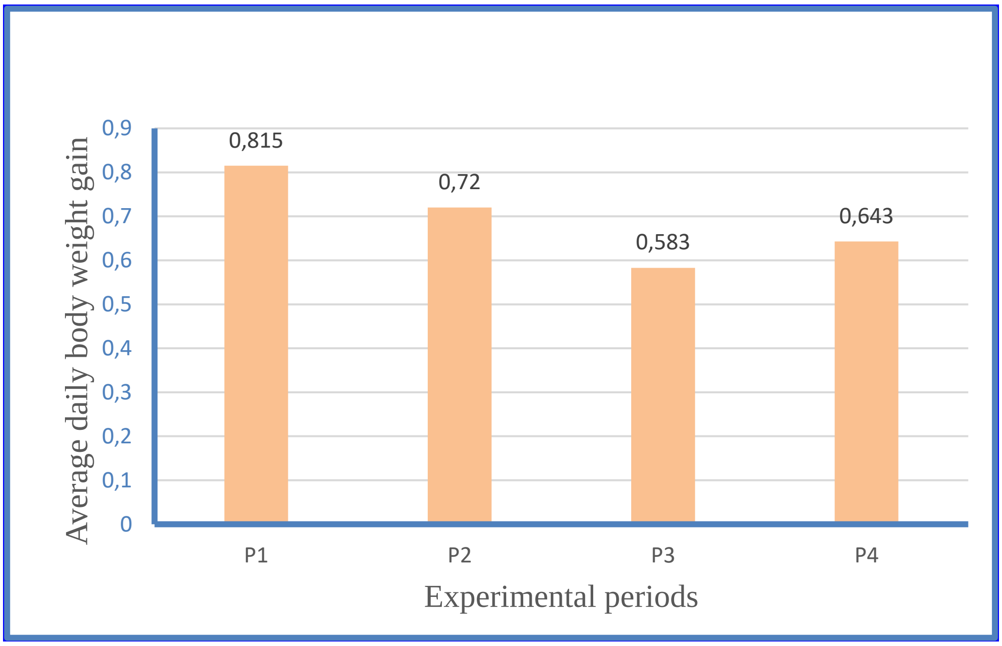

Figure 11: Average daily body weight gain per period

4.6.1.3. Discussion between the periods

The experiment was divided into four periods of three weeks each. At the start, all the pigs were almost the same age and almost the same weight varying between 32 kg to 41 kg and were fed separately with 4 different treatment diets. For each treatment diet we had two pigs of almost the same weight but each pig in its cage. At the end of each period the pigs which fed the T1 treatment diet move to the T2 treatment diet and those which fed the T2 treatment diet move to T3, those which fed the T3 treatment diet start to feed the T4 treatment diet and lastly those which fed T4 treatment diet feed T1 and so on until that they would go through all the treatment diets in the fourth period.

Regardless of the treatment diet used to feed the pigs, the period factor has a significant influence on the good performance of the pigs. The results showed that the Average Daily Body Weight Gain of Pig is significantly higher in the first period, meaning that at young age pigs are more likely to gain weight very rapidly than at older age. But in the third period, the average daily body weight gain of the pigs had decreased to increase in the fourth period from 0.583kg / d in the third period to 0.643 kg / d in the fourth period to say that the feed may not to be effective at that period to be effective at the following period.

4.6.2. Choice of the treatment very significant to the improvement of the pig's live weight

The data collections that we analyzed were collected in the field from April 18 to July 11, 2020 in 4 different periods. The live weights of the pigs at start and at the end of the experimental period for each treatment were recorded in order to determine the body weight gain of each pig and at each treatment. Note that we had 4 treatments in each period and 2 observations per treatment, therefore 8 observations per period. The results generated by stata13 were as follows (table 8):

Table 8: Calculation of the live weight gain of pigs per treatment

	T1			T2			T3			T4		
N° of pig	IBW	FBW	BWG	IBW	FBW	BWG	IBW	FBW	BWG	IBW	FBW	BWG
1	37	53	16	53	67	14	67	80	13	80	94	14
2	37	57	20	57	71	14	71	87	16	87	100	13
3	70	80	10	32	44	12	44	58	14	58	70	12
4	77	83	6	34	48	14	48	62	14	62	77	15
5	77	88	11	88	104	16	39	60	21	60	77	17
6	75	83	8	83	95	12	37	56	19	56	75	19
7	59	71	12	71	80	9	80	98	18	41	59	18
8	57	74	17	74	88	14	88	107	19	40	57	17
Total			**100**			**105**			**134**			**125**

4.6.2.1. Analysis of the significance of the difference between the averages of the treatments

Table 9. Significance of the difference between the averages of the treatments

(2 variables, 32 observations pasted into data editor)
oneway bwg treatment,tabulate

	summary of BWG		
Treatment	**Mean**	**Std. Dev.**	**Freq.**
T1	12.5	4.7809144	8
T2	13.125	2.1001701	8
T3	16.75	2.9154759	8
T4	15.625	2.5035689	8
Total	**14.5**	**3.5560036**	**32**

	Analysis of Variance				
Source	**SS**	**df**	**MS**	**F**	**Prob>F**
Between groups	97.75	3	32.5833333	3.10	0.0426
Within groups	294.25	28	10.5089286		
Total	**392**	**31**			

Bartlett's test for equal variances: chi2(3) =5.4182 Prob>chi2 = 0.144

The ANOVA model first presented with the means of these 4treatment. Looking at these averages we could perhaps say that T3 is the better treatment to ensure good pig performance than the T1, T2 and T4 treatments, but as it could be due to simple random fluctuations it was necessary to proceed by the most reliable statistical tests to give conclusions as certain at a precise significance level (i.e. 5%).

From the results obtained above, we knew that at least one of the means of the treatments is different from the other means because by examining the value of p, we saw that it is 0.0426 < at the significance level α (5%). So, the first row of the table showed that the sum of squares (partial SS) for the model was 97.75 with 3 degrees of freedom (df) and with a mean square (MS) of 97.75 / 3 ≈32.5833. The corresponding statistical value of F was 3.10 which was greater than F (3, 28) degrees of freedom read from table (2.95). Then, the model was appeared to be significant at the 4.26% level. Hence the difference between the means of these 4 treatments was statistically significant (p = 0.0426 <5%).

Although the difference between the means of these 4 treatments was found to be significant, we were not able to determine which treatment had a better influence on pig performance than the other treatments. To determine this treatment, we proceeded by using Tukey post-hoc test.

In order to find the treatment which was the best indicated to improve the live weight of pigs than other treatments (table 10).

Table 10: Pairwise comparisons on the treatments

Pairwise comparisons of means with equal variances

over: treatment

Number of comparisons

Treatment: 6

bwg	Contrast	Tukey Std. Err.	T	Tukey P>|t|	[95% Conf. Interval]	
treatment						
2 vs 1	.625	1.620874	0.39	0.980	-3.800491	5.050491
3 vs 1	4.25	1.620874	2.62	0.063	-.1754906	8.675491
4 vs 1	3.125	1.620874	1.93	0.240	-1.300491	7.550491
3 vs 2	3.625	1.620874	2.24	0.138	-.8004906	8.050491
4 vs 2	2.5	1.620874	1.54	0.427	-1.925491	6.925491
4 vs 3	-1.125	1.620874	0.69	0.898	-5.550491	3.300491

By looking at the p-value (i.e. the row P> | t | under the Tukey column), we see that there is a statistically significant difference in pig body weight gain at least at a threshold of 7% between the third treatment and the first treatment (p = 0.063). The difference between other pairwise comparisons is not even at 10% statistically significant.

One-way ANOVA was conducted to determine whether treatments with different levels of Mucuna flour offered to pigs improve their body weight gain in different ways. Data are the mean ± standard error.

The treatments were classified into four groups: T1: No Mucuna flour (control group, n = 8), T2: 20% of Mucuna flour (n = 8), T3: 30% of Mucuna flour (n = 8) and T4: 40% of Mucuna flour (n = 8).

There was a statistically significant difference between the groups as determined by one-way ANOVA (F3.28) = 3.10, p = 0.0426. The Tukey post-hoc test revealed that pig body weight gain was statistically significantly higher for pigs fed the T3 treatment which contained 30% of the Mucuna flour compared to compared to that of pigs feeding with T1 (control group) which doesn't contain Mucuna flour 4.25 ± 1.620874 kg, p = 0.063). However, there was no statistically significant difference between the T1 control group which doesn't contain Mucuna flour and T2 treatment which contained 20% of Mucuna flour (0.625 ± 1.620874kg, p = 0.980); between the T1 control group which does not contain Mucuna flour and T4 treatment which contains 40% of the Mucuna flour (3.125 ± 1.620874kg, p = 0.240); between T3 treatment which contains 30% of the Mucuna flour and T2 treatment which contains 20% of the Mucuna flour (3.625 ± 1.620874kg, p = 0.138), between T4 treatment which contains 40% of the Mucuna flour and T2 treatment which contains 20% of the Mucuna flour (2.5 ± 1.620874 kg, p=0.427) or between T4 treatment which contains 40% of the Mucuna flour and T3 treatment which contains 30% of the Mucuna flour (-1.125 ± 1.620874 kg, p=0.898).

4.6.2.2. Analysis of the average daily body weight gain per treatment

The average daily body weight gain was calculated based on the results we had over a 3-week period using MS Excel software. Our results have shown that the T3 treatment composed by 33.7% of rice bran, 30% of maize, 5% of molasses, 1% of bone meal, 0.3% of salt and 30% of *Mucuna pruriens* flour is the best treatment to have increase pig weight than other treatments with an average daily gain of 0.798kg / day (figure 12).

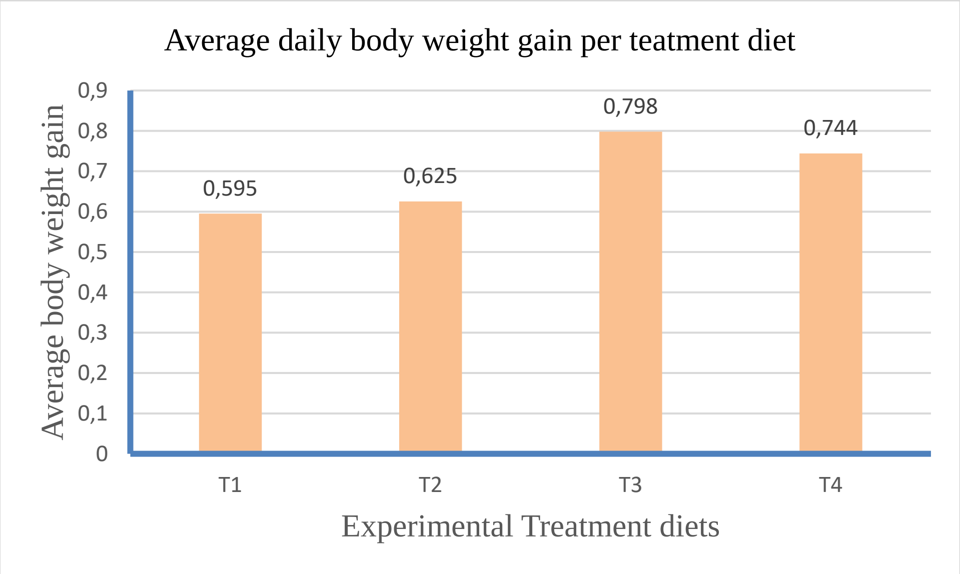

Figure 12: Average daily body weight gain per treatment

4.6.2.3. Discussion between the treatment diets

All the treatment diets did not have the same effects on the performance of the pigs, in fact by analyzing the average daily body weight gain for each pig and by each treatment diet, the results showed that the treatment diets were significant. Thus, the T3 treatment diet, which contains 30% of the Mucuna flour gave the pigs a good performance than the other treatment diets.

The incorporation of Mucuna flour into the pig home-mixed rations has an effect on the performance of pigs. Any treatment diet containing an amount of Mucuna flour gave a higher average daily body weight gain of the pigs than T1 treatment diet (control group) which did not contain Mucuna flour.

The 40% of the Mucuna flour incorporated in the ingredients constituting the T4 treatment diet can be considered a waste because the average daily body weight gain of the pigs resulting from this treatment is lower than that of the T3 treatment which contains only 30% of Mucuna flour.

4.7. Costs allocated to the purchase of feed

Generally speaking, in the process of calculating the ration, we cannot do it independently of the economic context. The considerations that have taken into account are the detailed costs of the constituent ingredients of each of the 4 treatments. Indeed, in the infinity of several possible technical solutions, it is advisable to choose the one which makes it possible to minimize the cost, at the same level of performance and product quality, or to maximize the margin of transformation of food into animal products for ensure optimal profit for breeders. It is certain that in due form, a large animal eats more than a small animal, the rations on which we calculated the costs are administered to the pigs according to their live body weight (i.e. 4% of the live body weight of the pigs) except the Premix (vitamin supplements that adapt to the precise needs of animals) which we used 1kg/100 kg of all the ingredients constituting the whole treatment. The prices retained for the various constituent ingredients of the said rations are those which we found on the central market of the economic policy of Burundi (Gitega). The 8 experimental pigs must resume all treatments, the costs of these rations were calculated by taking the 4% of the weight sum of these 8 experimental pigs and as the rations were adjusted weekly to the weight of the pigs, the costs were calculated per week.

4.7.1. Feed cost with *Mucuna pruriens* grains purchased on the market

Feed costs were calculated on the basis of the total amount of feed that the pigs could ingest during a period considered which was equal to 4% of the live weight of the animal per day.

4.7.1.1. Feed costs of T1 treatment (control group)

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment without Mucuna (Control group) were respectively 489 kg, 520 kg and 551 kg.

The weekly rations (4% of 489 kg, 520 kg and 551 kg) were respectively 136.92 kg, 145,6 kg, 154.28 kg and the corresponding costs were displayed in the following table:

Table 11: Total feed cost of T1 treatment

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Week quantity	**100**	**136,92**	**145,6**	**154,28**	**441,168**		**282,653**
Palm cake	**20**	27.384	29.12	30.856	87.36	600	52,416
Cotton cake	**10**	13.692	14.56	15.428	43.68	1,500	65,520
Rice bran	**33.7**	46.142	49.0672	51.9924	147.202	300	44,160.5
Maize	**30**	41.076	43.68	46.284	131.04	650	85,176
Molasses	**5**	6.846	7.28	7.714	21.84	400	8,736
Salt	**0.3**	0.41076	0.4368	0.46284	1.3104	1,000	1,310.4
Bone meal	**1**	1.3692	1.456	1.5428	4.368	800	3,494.4
Premix	**0.01**	1.3692	1.456	1.5428	4.68	5,000	21,840

By applying each price to the corresponding ingredient, the total feed costs of the 8 pigs having passed on this treatment for the whole period of the experiment were 282,653 BIF

4.7.1.2. Feed costs of T2 treatment

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 20% of *Mucuna pruriens* flour were respectively 492 kg, 527 kg and 559 kg. The weekly rations (4% of 492 kg, 527 kg and 559 kg) were respectively 137.76 kg, 147.56 kg, 156.25838 kg and the corresponding costs were displayed in the following table:

Table 12: Total feed cost of T2 treatment

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total of week	**100**	**137.76**	**147.56**	**156.52**	**446.2583**		**458232**
Palm cake	**10**	13.776	14.756	15.652	44.184	600	26,510.4
Cotton cake	**0**	0	0	0	0	1,500	0
Rice bran	**33.7**	46.4251	49.7277	52.7472	148.9	300	44,670
Maize	**30**	41.328	44.268	46.956	132.552	650	86,158.8
Melasses	**5**	6.888	7.378	7.826	22.092	400	8,836.8
Salt	**0.3**	0.41328	0.44268	0.46956	1.32552	1,000	1,325.52
bone meal	**1**	1.3776	1.4756	1.5652	4.4184	800	3,534.72
Mucuna	**20**	27.552	29.512	31.304	88.368	3,000	265,104
Premix	**0.01**	1.3776	1.4756	1.5652	4.4184	5,000	22,092

By applying each price to the corresponding ingredient, the total feed costs of the 8 pigs having passed on this treatment for the whole period of the experiment were 458,232 BIF.

4.7.1.3. Feed costs of T3 treatment

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 30% of *Mucuna pruriens* flour were respectively 474 kg, 516 kg and 572 kg. The weekly rations (4% of 474 kg, 516 kg and 572 kg) were respectively 132.72 kg, 144.48 kg, 160.16kgand the corresponding costs were displayed in the following table:

Table 13: Total feed cost of T3 treatment

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total of week	**100**	**132,72**	**144,48**	**160,16**	**441,7336**		**558552,46**
Palm cake	**0**	0	0	0	0	600	0
Cotton cake	**0**	0	0	0	0	1,500	0
Rice bran	**33.7**	44.72664	48.68976	53.97392	147.3903	300	44,217.096
Maize	**30**	39.816	43.344	48.048	131.208	650	85,285.2
Molasses	**5**	6.636	7.224	8.008	21.868	400	8,747.2
Salt	**0.3**	0.39816	0.43344	0.48048	1.31208	1,000	1,312.08
bone meal	**1**	1.3272	1.4448	1.6016	4.3736	800	3,498.88
Mucuna	**30**	39.816	43.344	48.048	131.208	3,000	393,624
Premix	**0.01**	1.3272	1.4448	1.6016	4.3736	5,000	21,868

By applying each price to the corresponding ingredient, the total feed costs of the 8 pigs having passed on this treatment for the whole period of the experiment were **558,552.46** BIF

4.7.1.4. Feed costs of T4 treatment

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 40% of *Mucuna pruriens* flour were respectively 484 kg, 528 kg, and 575 kg. The weekly rations (4% of 484 kg, 528 kg, and 575 kg) were respectively 135.52kg; 147.84 kg, 161kg and the corresponding costs were displayed in the following table:

Table 14: Total feed cost of T4 treatment

Treatment	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total of week	**100**	**135,52**	**147,84**	**161**	**448,8036**		**687469,36**
Palm cake	**0**	0	0	0	0	600	0
Cotton cake	**0**	0	0	0	0	1,500	0
Rice bran	**23.7**	32.11824	35.03808	38.157	105.3133	300	31,593.996
Maize	**30**	40.656	44.352	48.3	133.308	650	86,650.2
Molasses	**5**	6.776	7.392	8.05	22.218	400	8,887.2
Salt	**0.3**	0.40656	0.44352	0.483	1.33308	1,000	1,333.08
bone meal	**1**	1.3552	1.4784	1.61	4.4436	800	3,554.88
Mucuna	**40**	54.208	59.136	64.4	177.744	3,000	533,232
Premix	**0.01**	1.3552	1.4784	1.61	4.4436	5,000	22,218

By applying each price to the corresponding ingredient, the total feed costs of the 8 pigs having passed on this treatment for the whole period of the experiment were 687,469.36 BIF.

4.7.2. Feed cost with the grains of *Mucuna pruriens* cultivated by the associated

The kg of *Mucuna pruriens* grains cost 3000 BIF at the market and we felt that the pig associated breeders of carire must make losses by using the *Mucuna pruriens* bought in the market. As the pig breeders of the TERIMBERE association have benefited from their government a cultivable land, we therefore wanted to analyze whether the costs allocated to the purchase of feed could be reduced and ensure better economic profitability for these breeders via the exploitation of this land in comparison with the use of Mucuna bought to feed their animals.

4.7.2.1. Estimation of cost producing of *Mucuna pruriens* seeds per hectare

The culture of *Mucuna pruriens*, like other varieties of dry beans, requires only one weeding or pulling up tall grass. The only difference in the factors of production is that the *Mucuna pruriens* has its capacity to regenerate degraded soil which means that it is not necessary to add fertilizer or phytosanitary treatment. By this we mean that the means of production of *Mucuna pruriens* are almost almost the same as those of beans. Referring to the ADISCO report n ° 15-16 "LA VOIX DES COLLINES", the production costs of beans on one hectare assimilated to those of *Mucuna pruriens* are linked to the activities which are visible in the table below, but the land rent of the land was not taken into consideration because the Carire breeders received it free of charge from their local administration.

Table 15: The estimates of cost of producing *Mucuna pruriens*

N°	Designation	Unit	Quantity	U.C	Total
1	Land rent	Ha	1	500,000	500,000
1	Brush clearing	M.D	100	2,000	200,000
2	Labor	M.D	200	2,000	400,000
3	Harrowing	M.D	150	2,000	300,000
4	Sowing	M.D	200	2,000	400,000
5	Seeds	Kg	30	3,000	90,000
6	Weeding	M.D	200	2,000	400,000
7	Harvest	Man Day	100	2,000	200,000
8	Empty bags	Bags	40	1,000	40,000
9	Packaging	100kg bag	40	1,000	40,000
	Total charges				**2, 570,000**

Since the yield of *Mucuna pruriens* on 1ha in tropical regions is estimated between 3 and 4 tonnes in pure culture, we can say with total production costs of 2,570,000, the unit cost of production of Mucuna would be 642 to 857 BIF / kg, or an average of 750 BIB in pure culture. It is this production cost that we applied to the total amount of *Mucuna pruriens* used to estimate the amount allocated to feed the pigs.

4.7.2.2. Feed costs of T1 treatment (control group)

Following to the non-use of Mucuna flour in this T1 treatment, the costs allocated to this treatment remain unchanged. The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment without Mucuna (Control group) were respectively 489 kg, 520 and 551 kg. The weekly rations (4% of 489kg, 520kg and 551kg) were respectively 136.92kg, 145,6kg, 154.28kg and the corresponding costs were displayed in the following table:

Table 16: Feed cost for T1 treatment with *Mucuna pruriens* grains cultivated by associated

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Week quantity	**100**	**136.92**	**145.6**	**154.28**	**441.168**		**282,653**
Palm cake	20	27.384	29.12	30.856	87.36	600	52,416
Cotton cake	10	13.692	14.56	15.428	43.68	1,500	65520
Rice bran	33.7	46.142	49.0672	51.9924	147.202	300	44,160.5
Maize	30	41.076	43.68	46.284	131.04	650	85,176
Molasses	5	6.846	7.28	7.714	21.84	400	8,736
Salt	0.3	0.41076	0.4368	0.46284	1.3104	1,000	1,310.4
Bone meal	1	1.3692	1.456	1.5428	4.368	800	3,494.4
Premix	0.01	1.3692	1.456	1.5428	4.368	5,000	21,840

The cost of the ingredients composing this T2 treatment could not change because it did not contain Mucuna flour. we would still have 282,653 BIF.

4.7.2.3. Feed cost for T2 treatment with *Mucuna pruriens* grains cultivated by associated

The price of the Mucuna grains would mark the difference between the cost of the T1 treatment containing the Mucuna cultivated by the members of the association from that which could contain the Mucuna bought in the market.

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 20% of *Mucuna pruriens* flour were respectively 492 kg, 527kg and 559 kg. The weekly rations (4% of 492 kg, 527 and 559 kg) were respectively 137.76kg, 147.56kg, 156.25838kg and the corresponding costs were displayed in the following table:

Table 17: Feed cost of Treatment T2

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total	**100**	**137.76**	**147.56**	**156.52**	**446.2583**		**259,404.24**
Palm cake	10	13.776	14.756	15.652	44.184	600	26,510.4
Cotton cake	0	0	0	0	0	1500	0
Rice bran	33.7	46.4251	49.7277	52.7472	148.9	300	44,670
Maize	30	41.328	44.268	46.956	132.552	650	86,158.8
Molasses	5	6.888	7.378	7.826	22.092	400	8,836.8
Salt	0.3	0.41328	0.44268	0.46956	1.32552	1000	1,325.52
bone meal	1	1.3776	1.4756	1.5652	4.4184	800	3,534.72
Mucuna	20	27.552	29.512	31.304	88.368	750	66,270
Premix	0.01	1.3776	1.4756	1.5652	4.4184	5000	22,092

As breeders could obtain Mucuna at a lower cost production than at the market, the total amount allocated to purchase the ingredients for T2 treatment may also decrease. The amount could go from 458,232 BIF to 259,404.24 BIF.

4.7.2.4. Feed cost for T3 treatment with *Mucuna pruriens* grains cultivated by associated

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 30% of *Mucuna pruriens* flour were respectively 474 kg, 516 kg and 572 kg. The weekly rations (4% of 474 kg, 516 kg and 572 kg) were respectively 132.72kg, 144.48kg, 160.16kgand the corresponding costs were displayed in the following table:

Table 18: Total amount of treatment T3

ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total	**100**	**132.72**	**144.48**	**160.16**	**441.7336**		**263,334.456**
Palm cake	0	0	0	0	0	600	0
Cotton cake	0	0	0	0	0	1,500	0
Rice bran	33.7	44.72664	48.68976	53.97392	147.3903	300	44,217.096
Maize	30	39.816	43.344	48.048	131.208	650	85,285.2
Molasses	5	6.636	7.224	8.008	21.868	400	8,747.2
Salt	0.3	0.39816	0.43344	0.48048	1.31208	1,000	1,312.08
bone meal	1	1.3272	1.4448	1.6016	4.3736	800	3,498.88
Mucuna	30	39.816	43.344	48.048	131.208	750	98,406
Premix	0.01	1.3272	1.4448	1.6016	4.3736	5,000	21,868

The amount of Mucuna represents 30% of the entire T3 treatment. once the cost of Mucuna drops from 3,000 francs to 718 francs, the total amount of T3 could also decrease. Once the cost of Mucuna drops from 3000 Fr to 718 Fr, the total cost of the T3 treatment could also decrease from 558,552.46 to 263,334.456 Francs.

4.7.2.5. Feed cost for T4 treatment with *Mucuna pruriens* grains cultivated by associated

The live weights of the 8 pigs for the first, second and third week of the experimental period of treatment with 40% of *Mucuna pruriens* flour were respectively 484 kg, 528 kg, and 575 kg. The weekly rations (4% of 484 kg, 528 kg, and 575 kg) were respectively 135.52 kg, 147.84 kg, 161kg and the corresponding costs were displayed in the following table:

Table 19: Total amount of treatment T4

Ingredient	%	Week 1	Week 2	Week 3	Total	U.C	Feed Cost (BIF)
Total	**100**	**135.52**	**147.84**	**161**	**448,8036**		**287,403.36**
Palm cake	0	0	0	0	0	600	0
Cotton cake	0	0	0	0	0	1,500	0
Rice bran	23.7	32.11824	35.03808	38.157	105.3133	300	31,593.996
Maize	30	40.656	44.352	48.3	133.308	650	86,650.2
Molasses	5	6.776	7.392	8.05	22.218	400	8,887.2
Salt	0.3	0.40656	0.44352	0.483	1.33308	1,000	1,333.08
bone meal	1	1.3552	1.4784	1.61	4.4436	800	3,554.88
Mucuna	40	54.208	59.136	64.4	177.744	750	133,308
Premix	0.01	1.3552	1.4784	1.61	4.4436	5,000	22,218

The proportion of Mucuna was 40% of the total amount of the T4 treatment and it was the most expensive ingredient of all the other ingredients. The reduction in its cost could result in a reduction of more than 50% of the amount allocated to this T4 treatment. The T4 treatment could go from 687,469.36 to 287,403.36 Francs.

4.8. Other production costs relating to each treatment

Apart from the costs related to food, there were also the costs allocated to the preparation of *Mucuna pruriens* for its detoxification in order to transform it into flour. The other charges were those related to feeding the pigs, pigsty cleanliness, guarding the pig's day and night, buying antibiotics that were calculated at each treatment period and summarized in the following table:

Table 20: Common charges for the eight pigs for a period of 3 weeks

N°	Description of the activity	Mount
1	Payment of night watch, cooking Mucuna for 3 weeks	42,000
2	Pigsty cleanliness, feeding the pigs, drying and milling cooked Mucuna seeds for 3 weeks	63,000
3	Purchase of firewood and rental pot	20,500
4	Purchase of antibiotics (oxy 20)	12,000
5	Pigsty depreciation	13,200
6	**Total charges**	**150,700**

N.B: The pigsty was amortized over a period of 10 years. Each treatment took a period of 21 days, the amount allocated for the depreciation of the pigsty, was calculated from the total sum of the construction of the pigsty which was 2.26.3000 BIF. So, the pigsty depreciation was calculated over 21 days which corresponds to the period that the experiment of each treatment lasted.

4.9. Comparative analysis of the profitability of the project according to the type of treatment

The profitability analysis of a project constitutes an inventory of all the investments made in this project in order to compare them with the benefits they generate (the products). The cost-benefit analysis model was used to evaluate among the 4 treatments, T1 treatment (control group) which contains 33.7% rice bran, 30% maize, 20% palm cake, 10% cotton cake, 5% molasses, 1% bone meal, 0.3% salt and 0% *Mucuna pruriens* flour, T2 which contains 33.7% rice bran, 30% maize, 10% palm cake, 5% molasses, 1% rice flour bone, 0.3% salt and 20% *Mucuna pruriens* flour, T3 with 33.7% rice bran, 30% maize, 5% molasses, 1% bone meal, 0.3% salt and 30% *Mucuna pruriens* flour and the T4 treatment which contains 23.7% rice bran, 30% maize, 5% molasses, 1% bone meal, 0.3% salt and 40 % of *Mucuna pruriens* flour which could be able to give good economic returns to the breeders of Carire.

This BCA model allowed us to assign a monetary value to the factors that came into play in meeting the needs and increasing body weight of the pigs.

The production factors that we have taken into account in our model are the feed cost, the costs related to the transformation of Mucuna for its detoxification, the costs of guarding, the depreciation of the pigsty and the purchase of antibiotics which were analyzed in parallel with the results that we expected from pigs.

That is to say, as they are only males, the products we expected were only the meat and the amount of organic manure. The amount of meat was estimated from the body weight gain obtained by subtracting the initial body weight from the final body weight of the pig assessed at a market price which was 3,900 BIF / kg and the organic manure was found using the estimates for the 3rd period.

4.10. Estimates of organic manure produced at each treatment period

The amount of organic manure produced during each period of experimentation was estimated from the food ingested by the animal. All pigs should be fed all 4 treatments, but at very different times. For example, there were those who were on the T1 treatment from April 18 to May 9, 2020 (start of the experiment) and others who were there 9 weeks after the start of the experiment that is to say from June 20 to July 11, 2020 (end of the experiment) and the other pigs right in the middle of the experiment. To find the amount of manure that might be available, we gathered the manure from the 3rd period pig by pig and period by period and we compared it to the amount of feed taken during this entire period.

Table 21: Estimate of average organic manure per pig

N° of pig	Treatment	Feed quantity	Munure	Munure in %	Average
1	3	59.08	31	52	**50.60%**
2	3	64.12	33	51.466	
3	4	52.36	24	45.83652	
4	4	57.68	27	46.80999	
5	1	67.48	35	51.86722	
6	1	65.52	37	56.47131	
7	2	62.72	33	52.6148	
8	2	50.4	24	47.61905	
Total		**479.36**	**244**		

Estimates showed that each pig was ready to produce manure equivalent to 50.60% of its feed.

Table 22: Estimates of total manure at each treatment and for the 8 experimental pigs

	Feed quantity	Manure
T1	441.168	223.231
T2	446.25832	225.8067
T3	441.73358	223.5172
T4	448.8036	227.0946

The amounts of organic manure were calculated by referring to the average of 50.6% of the food supplied to the animal. The results were showed us that at each treatment the animals had almost the same average. This caused the amount of food we fed to the animals and the manure they got also almost around the same average for all 4 treatments.

4.11. Profitability analysis of pigs fed on purchased Mucuna

Like producers of goods and services, meat producers seek to maximize their profit. It is quite obvious that this or that other treatment improves the increase in live weight of animals without being optimal. If this is the case, this treatment should be abandoned for the detriment of another which appears optimal compared to the others. To do our analysis better we took the turnover (monetary value of meat on the market decrease by all production costs over the entire processing period). The following table has given us a summary:

Table 23: Analysis of project profitability with Mucuna purchased

	The charges			
	T1	**T2**	**T3**	**T4**
Feed cost	282,653	458,232	558,552.46	687,469.36
Other charges	150,500	150,500	150,500	150,500
Total charges	**433,153**	**608,732**	**709,052.46**	**837,969.36**
Gross profits				
Monetary value of meat (3900F / kg)	390,000	409,500	522,600	487,500
Monetary value of manure (100F / kg)	22,323	22,581	22352	22,709
Total Gross Benefits	**412,323**	**432,081**	**544,952**	**510,209**
Profitability	**-20,830**	**-176,651**	**-164,100.46**	**-327,760.36**
Return on the monetary unit invested	**-0.05**	**-0.41**	**-0.30**	**-0.64**

For a period of 3 weeks of experimentation that each treatment had taken, none of the 4 treatments was optimal. T3 and T4 treatments were respectively the first to improve pig performance (daily weight gain of 0.798 and 0.744 kg / day respectively), but in contrast, it was these same treatments that could lead to huge losses of 164,100.46 and 327,760.36 Burundian francs respectively compared to the T1 treatment (control group) which does not contain any proportion of Mucuna which could generate at least a slight loss of 20,830 Burundian francs.

The return of 1F invested for all 4 treatments would be negative. 1F invested in pig feed with T1 would result in a loss of .05052 F and 0.40884 F, 0.30113 F, and 0.6424 F respectively for T2, T3 and T4 treatment diets.

4.12. Evaluation of the profitability of pigs fed with cultivated Mucuna

The procedure remains that used previously for Mucuna purchased at the market to assess the profitability of pigs with the *Mucuna pruriens* cultivated by the members of the TERIMBERE association in order to highlight the treatment capable of ensuring the good growth of pigs while also generating a better profit on the feed cost for the breeders of this association. The following table summarizes the results:

Table 24: Analysis of project profitability with Mucuna cultivated

	The charges			
	T1	**T2**	**T3**	**T4**
Feed cost	282,653	259,404.24	263,334.456	287,403.36
Other charges	150,500	150,500	150,500	150,500
Total charges	**433,153**	**409,904.24**	**413,834.56**	**437,903.36**
Gross profits				
Monetary value of meat (3900F / kg)	390,000	409,500	522,600	487,500
Monetary value of manure (100F / kg)	22,323	22,581	22,352	22,709
Total Gross Benefit	**412,323**	**432081**	**544952**	**510209**
Profitability	**-20,830**	**22,176.76**	**131,117.44**	**72,305.64**
Return on the monetary unit invested	**-0.05**	**0.05**	**0.24**	**0.14**

During the 3 weeks that the experimental period lasted for each treatment, the T3 treatment is the best indicated to ensure the good performance of the pigs and to generate a profit (131,117.44 BIF in 3 weeks) clearly higher than that which can be generated by the other treatments.

Compared to the T1 treatment (control group), which was a reference treatment, all the treatments which contain *Mucuna pruriens* flour would have a positive effect on the performance of the pigs and on the economic profitability of the pigs, but at very different levels. 1F invested in the T1 treatment to feed the pigs without Mucuna cultivated by the association members, would have a negative return of .05052F in a period of 3 weeks when the T2, T3 and T4 treatments would give a positive return on the monetary unit invested respectively of 0.05 F, 0.24 F and 0.14 F.

Compared to other treatments, T3 gives pigs daily body weight gain of .796kg / day with a return on investment of 0.24F in 3 weeks for 1f invested.

4.13. Discussions on the use of *Mucuna pruriens* flour in pig feed

Animals' needs are summed up in energy, protein, minerals, vitamins and water, and they can vary depending on the type and physiological condition of the animal. Newly weaned piglets need a diet rich in protein to start well and grow normally, which is not the case with older pigs. The amount of *Mucuna pruriens* flour that pigs need should match their needs to avoid wastage and diseases associated with improper use. But this quantity must also be optimal to ensure the profit margin of breeders.

Here the results of the ANOVA and the post-hoc Tukey test revealed that with the Mucuna produced by the pig breeders themselves at a lower cost than that found at the market, the third treatment which contains 30% of the Mucuna flour is the treatment which provides the average daily body weight gain of pigs and a profit margin which is higher than that of other treatments. The ingredients constituting the T1 treatment are very expensive to such an extent that it leads the breeder to realize losses. The fourth treatment is taken as a waste, the average daily body weight gain of pig is low with a lower profit margin than that of the T3 treatment and so is the second T2 treatment.

CHAPTER 5: CONCLUSION AND SUGGESTIONS

5.1. Conclusion

This present study which has as subject: **"Analysis of the effect of incorporating processed *Mucuna pruriens* as a source of protein and energy in home-mixed rations on the performance of growing pigs and determination of the optimal quantity"** as research of the second university cycle was carried out under the direction of the International Institute for Tropical Agriculture (IITA) in collaboration with the thesis director of the University of Burundi in rural economy and management of agribusiness companies. The study was carried out on the Crop Livestock project implemented by the International Institute for Tropical Agriculture with main objective "determine a practical way to reduce the anti-nutritional factors in Mucuna grains in order to transform it into a protein and energy-generating feed that must be economically incorporated into home-mixed rations of growing pig capable of ensuring its good performances and so that become competitive at the market".

In order to achieve this overall objective, 4 specific objectives to be tested one by one were set up, namely:

1. The first which was "Determine an effective, economic and practicable way to reduce concentration of L-dopa and other anti-nutritional factors in Mucuna grain through soaking and boiling procedures"

To meet this objective, the Mucuna grains were washed with fresh water before being soaked in water for 48 hours and then the remaining water from imbibition was discarded with single flush of fresh water to remove anti-nutritional factors that still existed on the grains before being cooked for a period of 3 hours. The beans cooked were rinsed again in a single flush before being dried. When the grains of *Mucuna pruriens* were thoroughly dried, they were milled through a 5.0 mm screen to them made into flour which we incorporated into the house-mixed rations of the growing crossbred Large white male growers' pigs.

2. The second objective was: "Evaluate the feeding value of different pig rations constituted with processed Mucuna grain as protein and energy source".

To meet this objective, the 4 treatments used in our research were analyzed in ISABU laboratories to find out their chemical compositions. For treatment T1 containing 33.7% rice bran, 30% corn, 20% palm meal, 10% cotton, 5% molasses, 1% bone meal and 0.3% salt , we found its chemical composition to be 88.97% of dry matter, 12.7% of ash, 19.7%

of crude protein, 9.11% of crude fat, 9.07% of crude fiber, 4.47% of total sugar, 9891 mg / kg of phosphorus, 32327 mg / kg of calcium, 4481 mg / kg of magnesium, 1308 mg / kg of sodium and 5697 mg / kg of potassium. The treatment T2 which containing 33.7% rice bran, 30% maize, 10% palm cake, 5% molasses, 1% bone meal, 0, 3% salt and 20% of flour *Mucuna pruriens* flour without cotton cake, we found its chemical composition to be 87.73% of dry matter, 10.4% of ash, 10.6% of crude protein, 8.45% of crude fat, 5.13% of crude fiber, 5.60% of total sugar,8191 mg / kg of phosphorus, 13778 mg / kg of calcium, 2818 mg / kg of magnesium, 2796 mg / kg of sodium and 5001 mg / kg of potassium.

The T3 treatment which was composed of 33.7% rice bran, 30% maize, 5% molasses, 1% bone meal, 0.3% salt and 30% *Mucuna pruriens* flour, we found its chemical composition to be 87.87% of dry matter, 10.9% of ash, 22.6 % of crude protein, 8.32% of crude fat, 4.57% of crude fiber, 5.55% of total sugar,9308 mg / kg of phosphorus, 39913 mg / kg of calcium, 2026 mg / kg of magnesium, 1900 mg / kg of sodium and 6862 mg / kg of potassium.

And finally, the T3 treatment which was composed of 23.7% rice bran, 30% maize, 5% molasses, 1% bone meal, 0.3% salt and 40% *Mucuna pruriens* flour, we found its chemical composition to be 87.79% of dry matter, 9.04% of ash, 20.5 % of crude protein, 6.24% of crude fat, 4.27% of crude fiber, 5.61% of total sugar, 7550 mg / kg of phosphorus, 42507 mg / kg of calcium, 4784 mg / kg of magnesium, 4207 mg / kg of sodium and 8174 mg / kg of potassium.

3. The third objective was: “determine the optimal treatment that can give pig farmers of Carire a better profit margin on the feed cost”

The three different treatments T2, T3 and T4 containing 20%, 30% and 40% respectively of the Mucuna flour incorporated into this treatment diets to replace cotton cake, palm cake and rice bran depending on the bromatological value of the raw material to be replaced which were almost the same and the other reference not containing Mucuna T1 were administered to the pigs for analysis which of these treatments would be able to ensure the good performance of the pigs. Pig body weights were recorded weekly and for each treatment. From the weight of the onset and the end of the experimental period we were able to calculate the body weight gain of the pigs. These data were processed in stata13 to test whether the difference between the means of these 4 treatments was statistically significant at the 5% level. The results showed that the T3 treatment containing 30% of the Mucuna flour is best indicated to ensure the good performance of pigs with gives an average daily body weight gain of .798kg, after which comes the T4 treatment containing 40% of the Mucuna flour with a body weight gain of .744kg and at the follow is T2 containing 20% of the Mucuna flour which gives them a body weight gain of .625kg and lastly T1 does not contain flour of Mucuna which causes a daily increase in pig body weight of .595kg.

To find out which treatment offers a better profit margin on the cost of feed, we calculated the costs that we had invested in feeding the pigs treatment by treatment, in the purchase of antibiotics, the costs of transforming the Mucuna into feed producing energy and proteins, the guarding costs, pig rationing costs and pigsty cleanliness. These costs invested in this project were compared to the estimated value of the products of pigs (meats and organic manures) The results showed that:

- **When Mucuna seeds are bought at the market**: Treatments containing Mucuna flour bought in the market are not all cost effective including the treatment that does not contain Mucuna. 1F invested in pig feed with a treatment containing 20% Mucuna caused a loss of 0.40884 F and respectively a loss 0.30 F of and 0.64 F for the treatments containing 30% and 40% of the Mucuna flour. It was the same for the T1 treatment which did not contain Mucuna. its use would result in a loss of 0.05F
- **When the Mucuna is cultivated by the members of the association:** 1F invested in the T1 treatment (control group) to feed the pigs which does not contain Mucuna cultivated by the association members, would have a negative return of 0.05 F in a period of 3 weeks when the T2, T3 and T4 treatments would give a positive return on the monetary unit invested respectively of 0.05 F, 0.24 F and 0.14 F

Compared to other treatments, T3 gives pigs daily body weight gain of .796kg with a return on investment of .27F in 3 weeks for 1f invested.

The incorporation of the flour from the grains of *Mucuna pruriens* cultivated by the breeders themselves in the home-mixed rations of growing pigs as substitutes for cotton cake and palm cake after having been transformed into feed generating energy and proteins, has a potential to improve the performance and economic profitability of pigs. Concentrates are more expensive, once they are replaced with Mucuna flour produced by the breeders themselves at a production cost lower than the purchase price on the market, it reduces feed costs and increases the average daily weight gain of pig which, therefore, provides farmers with a satisfactory profit margin capable of increasing household income.

5.2. Suggestions

The animal feed industry manufactures a wide range of micro-ingredients (concentrates and premixes) adapted to the physiological needs of animals which are likely to optimize the growth, zootechnical performance and reproduction of these animals wanting to improve to the maximum the economic return of the farms.

Indeed, the national references on production costs confirm that these industrial feeds (concentrates and premixes) are very expensive for breeders compared to the selling price of animals. Thus, breeders no longer have to measure properly determining the quantity to be given to an animal and at what physiological stage the animal needs such or such other food, while poorly valued concentrates can lead to health problems. in animals and / or be a source of waste, causing enormous losses for the breeder. The objective of this study is therefore to improve the food autonomy of farms and to adjust to evaluate the growth of large crossed white pigs fed with rations containing different levels of flour from the grains of *Mucuna pruriens* cultivated by the breeders themselves to improve their profit margin on the cost of feed.

This study focused almost on one factor which is feed while there are just as many other factors that can ensure good performance in pigs, so we suggest:

To researchers

- To extend the study to other factors likely to ensure the growth of pigs and especially the period factor to know when to administer a particular treatment to the pig;
- To work in frank collaboration with the breeders to know the problems that the breeders have.

To breeders

- Incorporate *Mucuna pruriens* into their crops, which will serve them, not only to feed their animals by replacing expensive ingredients but also to regenerate their land in order to increase the production of other crops;
- Apply CBA to assess whether the choices they make more explicit the costs and benefits of their breeding;
- To scrupulously respect the instructions given by the researchers by applying them properly for good technical and economic performance.

To administrative authorities

- Fund research activities, train animal nutrition specialists and promote inter-professional structuring intended to link production and demand by prohibiting clandestine slaughtering by taking very stringent measures for those who practice it.
- Ensure good technical and economic supervision of farms, if possible, organize training sessions for farmers to provide them with knowledge on technical management of livestock; on zootechnical and health parameters to improve the profitability of breeding
- To encourage and financially support associations of pig breeders by granting them credit,

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APPENDIX

Appendix: Critical Values of F-Distribution (at 5 per cent)

V1 / V2	1	2	3	4	5	6	8	12	24	∞
1	161,4	199,5	215,7	224,6	230,2	234,0	238,9	243,9	249,0	254,3
2	18,51	19,00	19,16	19,25	19,30	19,33	19,37	19,41	19,45	19,50
3	10,13	9,55	9,28	9,12	9,01	8,94	8,84	8,74	8,64	8,53
4	7,71	6,94	6,59	6,39	6,26	6,16	6,04	5,91	5,77	5,63
5	6,61	5,79	5,41	5,19	5,05	4,95	4,82	4,68	4,53	4,36
6	5,99	5,14	4,76	4,53	4,39	4,28	4,15	4,00	3,84	3,67
7	5,59	4,74	4,35	4,12	3,97	3,87	3,73	3,57	3,41	3,23
8	5,32	4,46	4,07	3,84	3,69	3,58	3,44	3,28	3,12	2,93
9	5,12	4,26	3,86	3,63	3,48	3,37	3,23	3,07	2,90	2,71
10	4,96	4,10	3,71	3,48	3,33	3,22	3,07	2,91	2,74	2,54
11	4,84	3,98	3,59	3,36	3,20	3,09	2,95	2,79	2,61	2,40
12	4,75	3,88	3,49	3,26	3,11	3,00	2,85	2,69	2,50	2,30
13	4,67	3,80	3,41	3,18	3,02	2,92	2,77	2,60	2,42	2,21
14	4,60	3,74	3,34	3,11	2,96	2,85	2,70	2,53	2,35	2,13
15	4,54	3,68	3,29	3,06	2,90	2,79	2,64	2,48	2,29	2,07
16	4,49	3,63	3,24	3,01	2,85	2,74	2,59	2,42	2,24	2,01
17	4,45	3,59	3,20	2,96	2,81	2,70	2,55	2,38	2,19	1,96
18	4,41	3,55	3,16	2,93	2,77	2,66	2,51	2,34	2,15	1,92
19	4,38	3,52	3,13	2,90	2,74	2,63	2,48	2,31	2,11	1,88
20	4,35	3,79	3,10	2,87	2,71	2,60	2,45	2,28	2,08	1,84
21	4,32	3,47	3,07	2,84	2,68	2,57	2,42	2,25	2,05	1,81
22	4,30	3,44	3,05	2,82	2,66	2,55	2,40	2,23	2,03	1,78
23	4,28	3,42	3,03	2,80	2,64	2,53	2,38	2,20	2,00	1,76
24	4,26	3,40	3,01	2,78	2,62	2,51	2,36	2,18	1,98	1,73
25	4,24	3,38	2,99	2,76	2,60	2,49	2,34	2,16	1,96	1,71
26	4,22	3,37	2,98	2,74	2,59	2,47	2,32	2,15	1,95	1,69
27	4,21	3,35	2,96	2,73	2,57	2,46	2,30	2,13	1,93	1,67
28	4,20	3,34	2,95	2,71	2,56	2,44	2,29	2,12	1,91	1,65
29	4,18	3,33	2,93	2,70	2,54	2,43	2,28	2,10	1,90	1,64
30	4,17	3,32	2,92	2,69	2,53	2,42	2,27	2,09	1,89	1,62
40	4,08	3,23	2,84	2,61	2,45	2,34	2,18	2,00	1,79	1,51
60	4,00	3,15	2,76	2,52	2,37	2,25	2,10	1,92	1,70	1,39
120	3,92	3,07	2,68	2,45	2,29	2,17	2,01	1,83	1,61	1,25
∞	3,84	2,99	2,60	2,37	2,21	2,09	1,94	1,75	1,52	1,00

V1: Degrees of freedom for greater variance.

V2: Degrees of freedom for smaller variance.