# EFFECT OF SOAKING, PARBOILING AND TEMPERATURE ON THE PROPERTY OF BEAN POWDER FOR FAST FOOD PRODUCTION

**BY**

**AUDU, ANTHONY ENECHE**

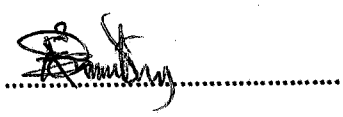
**2003/14784EA**

**BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.**

**NOVEMBER, 2008.**

# DECLARATION

I hereby declare that this Project is a record of a work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of other were duly referenced in the text.



Audu Anthony Eneche

24/11/2008

Date

# CERTIFICATION

This is to certify that this project was carried by Audu, Anthony Eneche in the Department of Agricultural and Bioresources Engineering, Federal University of Technology, Minna.

Engr. Prof. E. S. A. Ajisegiri

SUPERVISOR

Date

Engr. Dr. (Mrs.) Z. D. Osunde

HEAD OF DEPARTMENT

25/11/2008

Date

External Examiner

15/11

Date

# DEDICATION

This work is dedicated to God Almighty for the grace and strength He grant onto me in accomplishing my studies successfully.

I also wish to dedicate this write-up in memory of my late father Mr. Audu D. Eneche who was the best friend I had while growing up and he made me to understand that there is time for everything in life.

# ACKNOWLEDGMENTS

My sincere gratitude goes to God Almighty for making it possible for me to start my education and for the opportunity, wisdom, strength and blessing throughout my studies.

My heartfelt thanks to my supervisor Engr. Prof. E. S. A. Ajisegiri for the knowledge he impacted in me and the courage to always face challenges.

I will like to acknowledge the effort of Engr. Dr. Mrs. Z. D. Osunde, Head of Department Agricultural and Bioresources Engineering for always giving attention and advice when need be and the pride she instill in us in the department.

I would like to express my deep gratitude to the entire lecturers in Agricultural and Bioresources Engineering Department especially the following lecturers; Engr. Peter Adeoye, my level adviser, Engr. Dr. (Deacon) O. Chukwu,. Engr. Mrs. Mustapha, Engr. Solomon, Engr. Peter Idah, Engr. Prof. Yisa, Engr. Sadiq Mallam Suleiman, Mallam A. M. Ishiaku, Dr. Fabunmi and others.

To members of my family, my mother Mrs. Rebecca A. Eneche, Mr. Eneche Audu Danlami and his family, Issa Audu and his family, Debora, Eleojo and Jummai who assisted me in one way or the other I wish to thank them for their love and encouragement.

I will like to recognize my friends particular Isah I. Abah, Ismaila Mohammed and also my course mates in Agricultural and Bioresources Engineering Department like Jude Omodibo, Oyilola Ronke Mulicat, Henry Asuquo, Chinedu Ogwuego, Adetoro, Ameh J. Ojomah, Rhoda Akawo, and other, I say thanks for your various assistance and may God bless all of you.

# ABSTRACT

This project Effect of Soaking, Parboiling and Temperature on the Property of Bean for fast food Production, provide information cowpea as a type bean and on the chemical composition of bean which is done at different temperature both for soaking and parboiling. The soaking was done at 30, 40, 50, and 60°C and the time are 30, 60, 90 and 120 minutes respectively. Furthermore, parboiling was done at 70, 80, 90 and 100°C and the time used are20, 40, 60 and 80 minutes respectively. The value obtained is then compared with the value of raw bean and a decorticated sample used for preparing bean cake (akara, moi-moi) and other fast food. Significantly is the value of protein and carbohydrate obtained for all the samples. The highest among the soaked and parboiled sample for carbohydrate is sample C (57.54). This value is higher than the value obtained for Raw sample (50.92), thus treatment of the sample before processing is justified. On the other hand, the value of protein obtained for all the samples is higher than the decorticated sample (28.00), indicating that the (hull) shaft of bean should not be necessarily removed.

# TABLE OF CONTENTS

## LIST OF TABLES

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1.0 Definition of Bean

Bean is a common name for large plant seeds of several genera of the family Fabaceae (formerly Leguminosae) used for human food or animal feed.

Although "beans" usually means the seeds of bean plants, it can also mean (especially in the US) the whole young pods of bean plants, which if picked before the pods ripen and dry, can be tender enough to eat whole, whether cooked or raw. Thus the word "green beans" means "green" in the sense of unripe (many are in fact, not green in color), as the beans inside the pods of green beans are too small to comprise a significant part of the cooked fruit (http://www.enwikipedia.org).

### 1.1.1 Bean History

Beans are one of the oldest foods known to man; they have been an important part of the human diet for thousands of years. They were one of the earliest food crops cultivated. Common beans were domesticated about 7,000 years ago in both Peru (the Andean center of domestication) and southern Mexico (the Meso American center of domestication). Both centers of domestication have a wide array of colors. In fact, in Mexico, the Indians developed white beans, black beans and all other colors and color patterns. In the Andes, the same is true, but very lively and bright colors were developed. The tribes in Mexico started cultivating small-seeded varieties, while at the same time; the natives in Peru were developing large-seeded types. Since Indian tribes

crisscrossed the American continent, these beans and native farming practices spread gradually all over North and South America, as Indian groups explored, migrated and traded with other tribes. By the time Portuguese and Spanish explorers discovered the New World; several varieties of beans were already flourishing. The early explorers and traders subsequently shared American bean varieties around the world, and by the early 17th century, beans also were popular crops in Europe, Africa and Asia (www.northarvest bean.org).

### 1.1.2 Types of beans

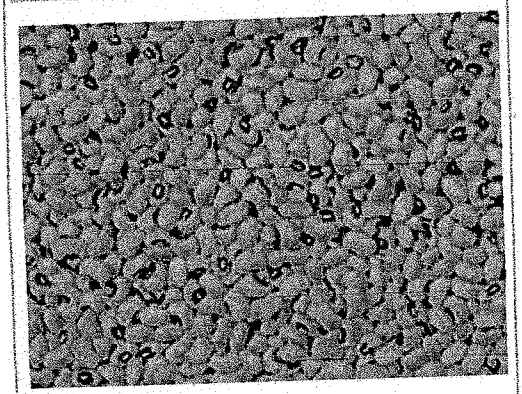
As illustrated by 15 bean soup, there is a great variety of beans types, including:

- *Vicia*
  - *Faba* or broad bean
  - *Vica faba* or broad beans, known in the US as fava beans
- *Vigna*
  - *Aconitifolia* or Moth bean
  - *Angularis* or azuki bean
  - *mungo* or urad bean
  - *radiata* or mung bean
  - *umbellatta* or rice bean
  - *unguiculata* or cowpea (includes the black-eyed pea, yardlong bean and others)
- *Cicer*
  - *arietinum* or chickpea (also known as the garbanzo bean)
- *Pisum*
  - *sativum* or pea
- *Lathyrus*

- *Lathyrus sativus* (Indian pea)
- *Lathyrus tuberosus* (Tuberous pea)
- *Lens*
    - *culinaris* or lentil (http://en.wikipedia.org).

### 1.1.3 Cowpea as a type of Bean

Table 1.1.3; Cowpea

| Cowpea |
| --- |
|  |
| Black-eyed peas |
| **Scientific classification** |
| Kingdom: Plantae<br>Division: Magnoliophyta<br>Class: Magnoliopsida<br>Order: Fabales<br>Family: Fabaceae<br>Subfamily: Faboideae<br>Genus: *Vigna*<br>Species: *V. unguiculata* |
| **Binomial name** |
| *Vigna unguiculata*<br>(L.) Walp. |

(http:// www.en.wikipedia.org).

Cowpea, common name for any of a genus of leguminous herbs. Cowpeas are sprawling or twining herbs with triple leaves and with pods 20 to 30 cm (8 to 12 in) long, enclosing several kidney-shaped seeds. Cowpeas were originally native to Asia and are now an important forage and cover crop in the southern United States. The seeds, usually called black-eyed peas or black-eyed beans, are cooked and eaten. A South American variety is the asparagus bean, which has a long, shriveled pod. (Microsoft ® Encarta ® 2007. © 1993-2006 Microsoft Corporation. All rights reserved).

### 1.1.4 History of Cowpea

Cowpea (*Vigna unguiculata* L. Walp.), an annual legume, is also commonly referred to as southern pea, blackeye pea, crowder pea, lubia, niebe, coupe or frijoles. Cowpea originated in Africa and is widely grown in Africa, Latin America, Southeast Asia and in the southern United States. It is chiefly used as a grain crop, for animal fodder, or as a vegetable. The history of cowpea dates to ancient West African cereal farming, 5 to 6 thousand years ago, where it was closely associated with the cultivation of sorghum and pearl millet. Worldwide cowpea production has increased dramatically in the last 25 years.

### 1.1.5 Uses of Cowpea

Cowpea seed is a nutritious component in the human diet, as well as a nutritious livestock feed. Nutrient content of cowpea seed is summarized in Table 1.1.5.

Table 1.1.5. Nutrient content of mature cowpea seed (average of eight varieties).

| | |
|---|---|
| Protein | 24.8% |
| Fat | 1.9% |
| Fiber | 6.3% |
| Carbohydrate | 63.6% |
| Thiamine | 0.00074% |
| Riboflavin | 0.00042% |
| Niacin | 0.00281% |

(From Bressani R. Chap. 28 in Cowpea Research, Production and Utilization, Wiley and Sons).

The protein in cowpea seed is rich in the amino acids, lysine and tryptophan, compared to cereal grains; however, it is deficient in methionine and cystine when compared to animal proteins. Therefore, cowpea seed is valued as a nutritional supplement to cereals and an extender of animal proteins.

Cowpea can be used at all stages of growth as a vegetable crop. The tender green leaves are an important food source in Africa and are prepared as a pot herb, like spinach. Immature snapped pods are used in the same way as snapbeans, often being mixed with other foods. Green cowpea seeds are boiled as a fresh vegetable, or may be canned or frozen. Dry mature seeds are also suitable for boiling and canning.

In many areas of the world, cowpea is the only available high quality legume hay for livestock feed. Digestibility and yield of certain cultivars have been shown to be comparable to alfalfa. Cowpea may be used green or as dry fodder. It also is used as a green manure crop, a nitrogen fixing crop, or for erosion control. Similar to other grain legumes, cowpea contains trypsin inhibitors which limit protein utilization (http:/www.hort purdue.edu).

### 1.1.6 Soaking Bean

Soaking before cooking helps to soften and return moisture to dry-packaged beans, and reduces cooking time; it also makes beans easier to digest. Since beans will rehydrate to at least 2-3 times their dry size, it is good to start with a large enough pot. Add 10 cups of cold water for each pound of dry beans. Bring the water to boiling and simmer beans for 2-3 minutes. Remove from heat and cover the pot. Let stand; a 4-hour soak is ideal, but beans may be soaked for 1-24 hours. A longer soaking time (up to 4 hours) allows greater amount of gas-causing properties to dissolve in water and be more easily digested. Drain and rinse. Do not cook beans in soaking water.

### 1.1.7 Cooking Bean

After soaking, simmer beans in fresh water for about two hours, or until tender, adding additional water if needed. Add seasonings during this cooking time.

- A tablespoon of oil or butter added during cooking reduces foaming and boil-over.
- To prevent split skins, simmer and stir beans gently. Avoid over-cooking.
- Increase soaking and cooking times in hard-water or high-altitude areas.

- Because acidic ingredients can prevent beans from becoming tender, be sure to add these after beans have been soaking and fully cooked: lemon juice, vinegar, tomatoes, chili sauce, ketchup, molasses or wine (http://www.northarvestbean.org).

### 1.1.8 Powder

A powder is a dry, bulk solid composed of a large number of very fine particles that may flow freely when shaken or tilted. Powders are a special sub-class of granular materials, although the terms *powder* and *granular* are sometimes used to distinguish separate classes of material. In particular, *powders* refer to those granular materials that have the finer grain sizes, and that therefore have a greater tendency to form clumps when flowing. *Granulars* refers to the coarser granular materials that do not tend to form clumps except when wet (http://www.en.wikipedia.org).

### 1.1.9 Fast Food

Fast food is any food that is quick, convenient, and usually inexpensive. You can buy fast food just about anywhere that sells food and snacks. Vending machines and drive-thru restaurants are probably the most common places to find fast food.

There is nothing bad inn fast food. All foods can fit into a healthy meal plan! It's true that fast food is usually high in fat, calories, cholesterol, and sodium, but eating fast food every once in a while is not going to cause you problems. If you eat too much fast food over a long period of time, though, it can lead to health problems like high blood pressure, heart disease, and obesity (http://www.youngwomenshealth.org).

## 1.2 Objective of the Study

1. To determine the effect of soaking parboiling and temperature on beans flour.
2. To determine the moisture content of the flour.
3. To ensure that the flour to be obtained can be use to prepare different type of meals using bean.

## 1.3 Justification of the Study

1. This project aim to reduce the time taken in preparing meal using beans.
2. It reduces the attack on beans during storage.
3. It provides many ways of making beans edible besides cooking the seed.

## 1.4 Statement of Problem

1. The attack on beans by pest and insect is reduced when stored in powdery form at home.
2. Provide household a faster way of preparing various meal using beans flour.

## 1.5 Scope of the Study

This project is limited to the preparation of the bean seed by firstly cleaning, then soaking, parboiling, drying and the milling it into flour.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Physiology of Cowpea

Physiology is the study of the physical and chemical processes that take place in living organisms during the performance of life functions. It is concerned with such basic activities as reproduction, growth, metabolism, excitation, and contraction as they are carried out within the fine structure, the cells, tissues, organs, and organ systems of the body (Microsoft ® Encarta ® 2007. © 1993-2006 Microsoft Corporation. All rights reserved).

#### 2.1.1 Seeds, Seed Germination and Seed Emergence

Selection during and after domestication of cowpea has led to considerable change in reproductive strategy and structure. Some changes are pertinent to current efforts to increase not only the magnitude of the economic yield but also the rate and synchrony of seed production.

- The life forms of cowpea cultivar have tended to greatocater 'annualness', i.e., in physiologic terms, after flowering, plants are programmed to allocate carbon and nitrogen in larger proportions to fruits than to vegetative component;
- Individual fruit and seed sizes have increased;
- Fruits are less prone to dehisce;
- Seed dormancy has been reduced or even lost.

Seed dormancy, conditioned by impermeable testae, is common in wild and weedy subspecies but is confined to a few smooth-seeded cultivated lines (Lush and Wien, 1980). When seeds are

sown at conventional depths (2-3 cm) at 28°C, germination is epigeal, and seedlings emerge within 2-3 days (Lush and Wien, 1980). The base temperature for germination of the improved line TVx 3236 (one of IITA's most productive, thrips resistant releases, which has become popular among African farmers) is 8.5°C (Covell, 1984). Temperatures of about 40°C are detrimental for hypocotyls elongation (Ndunguru and Summerfield, 1975).

Although the size of the seedlings at emergence is directly and positively related to the weight of the size of cotyledons of the seed sown subsequent seedlings growth is affected little since cotyledonary dry matter is mobilize rapidly during hypocotyls elongation and the cotyledons abscise within about 5 days of emergence (Ndunguru and Summerfield, 1975).

### 2.1.2 Accumulation and Partitioning of Dry Matter

The rate at which a crop increase in dry weight depends on leaf area index (LAI) and net assimilation rate (NAR). Changes in LAI depend on the growth in leaf and senescence, whereas NAR reflects the balance between photosynthetic gain and respiratory loss in carbon. Knowledge of these four processes and how they are affected by environment is incomplete and they are all under genetic control (Wallace *et al.*, 1972) but unlikely to be equally amendable to exploitation by breeding (Evans, 1974).

Leaves are initiated about twice as rapidly at 30°C then at 20°C. Minimal temperature at night limit expansion, with the base temperature of leaf appearance and expansion being at 16°C and 21°C , respectively (Littleton *et al.*, 1979).

In general, LAI of both determinate and indeterminate cultivars is larger at close (e.g. 25cm × 25 cm) than at wider (e.g. 25 cm × 125 cm) spacings. Maxima light interception with at LAI of 3

under humid tropical conditions but larger values of LAI may be required in regions of greater in isolation (Wien, 1982).

### 2.1.3 Carbon Exchange Rate

Cowpea leaves have maximal rates of photosynthesis at full expansion and for about 20 days thereafter. Green fruits have a net loss of $CO_2$ even in full sunlight; they respire much more rapidly than do leaves. These high rates of fruit respiration mean that temperature is particularly important at irradiance values less than full sunlight (Wien and Littleton, 1975). Littleton *et al* (1981) reported that respiration rates of fruit in the dark increase by 62 per cent as temperature increased from 28° to 40° but in full light were reduced by 81 per cent. Thus, fruits above the cowpea canopy may represent a smaller respiratory burden than those under it, although the peduncles elevating them have gas-exchange rates similar to those of fruits (Littleton *et al.*, 1981). Still, the peduncles serve along with the stems, a source of carbohydrate and nitrogen for the seeds in the large reproductive phase (Atkins *et al.*, 1982) and may be far more detrimental to large seed yield than suggested in the past. No positive relation has been demonstrated between maximum carbon fixation per hectare and economic yield in grains legumes; the rates of leaves initiation and expansion during vegetative growth and the rate of leave area decline during the reproductive period are probably more important.

### 2.1.4 Dry-matter Production and Partitioning

Cowpea crops in the vegetative and early reproductive stags of development produce dry matter at rates comparable with those recorded for soybean (Summerfield *et al.*, 1983) but smaller than the largest values recorded for other broadleaf crops with metabolism ( a daily rate of 34-39 $g/m^2$).

The limit data available (Littleton *et al.*, 1979) indicates that vegetative cover crops intercept about 50 per cent of total incoming solar radiation linear period of vegetative growth and assimilate dry matter with a conversion efficiency of 1.7 -1.9 per cent. Large amounts of dry matter are produced when crops of more or less determinate cultivars maintain relatively large and healthy leaf areas for prolonged periods: in the crops that produce the most dry matter in the trials of Littleton et al (1979), an early cool period delayed the onset of leaf death, and warm conditions after 20 days produce a large leaf area at flowering so that relatively young leaves were present where plants became reproductive. For large economic yields, leaf indices between 1 and 2 are required for as long as possible after flowering but need to be couples with efficient partitioning of dry matter into fruits.

### 2.1.5 Flowering and Fruiting

Cowpea show extreme variation in the start and end of the reproductive period. Some cultivar flower within 30 days from sowing and are ready for dry-seed harvest 25 days later; other take more than 100 days to flower and take between 210 and 240 days to mature.

In general, genotypes that early flower has shorter blooming periods. Flower are produced in inflorescences that are compound racemes of several modified simple racemes borne on peduncles arises from auxiliary nodes in which only one of the three buds present normally develops. Thus, individual nodes generally just have a single peduncle.

Reproductive development, yield potential and seed yield in cowpeas are notoriously sensitive to the vagaries of weather. Numerous studies have shown that most cowpea genotype respond to photoperiod in a manner typical of quantitative short-day plant; that some genotype are

insensitive to a wide range of photoperiods; and that warmer temperature can hasten the appearance of flower in both photoperiod- sensitive and insensitive genotypes.

### 2.1.6 Plant Size and Flowering

Plant size and flowing (and so the number of nodes produced) has important consequences for subsequent economic yield in determining genotype, which have only a limited capacity for continued growth and leaf production once the first flush of fruit has been set. Adverse plant conditions during the vegetative period (Summerfield *et al.*, 1983) may stunts sufficiently to prevent recovery during the reproductive period and so yield are small. However, the large majority of cowpeas are indeterminate botanically and plant size at flowering in these types has relatively little effect on economic yield.

### 2.1.7 Duration of Reproductive Period

The reproductive period of cowpea is composed of overlapping periods of development of individual fruits, each lasting about 19 days (Wien Ackah, 1978). The longer the reproductive period, the greater the number of fruits that mature and the larger the yield. (Wien and Summerfield, 1983).

Cultivars that have a small percentage of buds set under field conditions are not restricted vegetative by the demands of frit growth (Wien and Tayo, 1978). Consequently, the morphology of such plant consists of numerous branches with many nodes compared with the more confined growth periods of a cultivar with good fruit set characteristics.

Genetic differences in the duration of the reproductive period are related to growth habit, with determinate cultivars of limited leaf areas senescing as early as 20 days after the onset of

flowering and indeterminate cultivars requiring 45 days after flowering to senesce and die during the same growing season.

### 2.1.8 Seed Yields

When grown by subsistence famers in the lowland tropic of West Africa, cowpeas yield about 88 kg/ha (Slade, 1997). They are usually intercropped with cereals and are grown at populations of 1000 plants/ha, or less, without fertilizer or protection from insects or diseases. When grown as monocrop with good management, cowpea crops can produce yields ranging from 1000 to 4000 kg/ha. Largest yields have been achieved by crops relatively slow to flower and mature (grown at relatively low temperatures), confirming result from controlled environment ( Huxley and Summerfield, 1996). Unfortunately, the climatic conditions under which larger yields were obtained have not been documented in most cases, so the main factors conducive to large yield can not be quantified.

## 2.2.0 CHEMICAL COMPOSITION AND NUTRITIVE VALUE OF COWPEA

### 2.2.1 Chemical Composition

The chemical composition of cowpea (Table1.1.5) is similar to that of most edible legumes. It contains about 24 per cent protein, 62 per cent soluble carbohydrates and small amount of other nutrients (Elias, 1984). Thus, most of its nutritional value is provided by proteins and carbohydrates.

### 2.2.2 Protein

Variability in protein content has been reported to be from 23 to 30 per cent and is influenced by genotype as well as the as environmental factor (Bliss, 1995).

Because of the differences between cultivars, selection for higher amounts may be possible. Lysine content is relatively high, making cowpea an excellent improver of the protein quality in cereal grains. However cowpea protein, as in the case of other food legumes, is deficient in sulphur-containing amino acids. The deficiency is definitely important when the diet is based on root crops or starchy foods, and, even in diets based on cereal grains, increases in sulphur-containing amino acid in cowpea protein would be nutritionally beneficial.

Addition of methionine to cowpea protein increases the protein quality significantly, demonstrating the nutritional value of sulphur amino acid content in cowpea protein (Boulter *et al.*, 1995). Similar result has been shown by others and represents a common finding for all food legumes.

### 2.2.3 Carbohydrate

Because the protein content in legumes is higher than in other vegetables, the other major component, carbohydrate, has been somewhat neglected. Total carbohydrate varies from 56 to 68 per cent, with starch contributing from 32 to 48 per cent. Data from other food legumes suggest that more than 50 per cent of the starch is in the form of amylase. The carbohydrate fraction is relatively rich in total sugars, and cowpea has their share (about 6 per cent of total chemical composition) of these oligosaccharides, well known for their flatulence effect.

The amount of amylase in starch influences starch solubility, lipid binding and many fictional properties, such as swelling solubility, water absorption, gelatinization and pasting that affect cooking practices and acceptability.

Because cowpea and other legumes are not considered carbohydrate source or energy foods, studies on the nutritional value of starch they contain are not readily available.

## 2.3 ANTINUTRITION IN COWPEA

### 2.3.1 Toxins and detoxification of Cowpea

Some kinds of raw beans and especially red kidney beans and cowpea contain a harmful toxin (the lectin Phytohaemagglutinin) that must be destroyed by cooking. A recommended method is to boil the beans for at least ten minutes; undercooked beans may be more toxic than raw beans. Cooking beans in a slow cooker, because of the lower temperatures often used, may not destroy toxins even though the beans do not smell or taste 'bad' (though this should not be a problem if the food reaches boiling and stays there for some time).

Fermentation is used in some parts of Africa to improve the nutritional value of beans by removing toxins. Inexpensive fermentation improves the nutritional impact of flour from dry beans and improves digestibility, according to research co-authored by Emire Shimelis, from the Food Engineering Program at Addis Ababa University. The study is published in the International Journal of Food Science & Technology. Beans are a major source of dietary protein in Kenya, Malawi, Tanzania, Uganda and Zambia. (Sub Saharan Africa page, Science and Development Network website), (http://www.en.wikipedia.org).

## 2.4 Bean Flour

Bean flour is made from natural, Ontario-grown, whole dried Romano (cranberry) beans and also from cowpea. First, they are precooked (micronized) in their dry state and then. They are stone ground to uniform fine flour in the milling process. Nothing is wasted.

Nutritionally, whole bean flour is impressive. It provides more calcium, iron, potassium, thiamin, riboflavin, folate, and fat more dietary fiber than all-purpose flour and other gluten-free flours except for soybean flour.

Bean flour is one great way to put your beans or other legumes to use. Bean flour can be added to any recipe calling for wheat flour. Replace up to 1/4 of the total amount of wheat flour with bean flour. Super nutrition can be added to any commercial dry mix (cakes, cookies, muffins, breads) by adding a few tablespoons of bean flour to the dry ingredients, then adding extra liquid as necessary. Combining bean and wheat flours also helps form a complete protein for those cutting out or down on meat. The best part is that no one will ever know they're eating beans. (http://www.beprepared.com).

### 2.4.1 Utilization of Bean flour

Cowpeas are frequently consumed in West Africa as fried "Akara balls and steamed moin-moin", both of which are prepared from ground beans.

When added to boiling water, bean flours thicken in only 1 minute, and in 3 minutes are ready to eat. Bean flours added to baked goods increase vitamins and minerals and provide a source of complete protein. (http://www.waltonfeed.com).

# CHAPTER THREE

## 3.0 Materials and Methods

### 3.1 Materials

The materials for cowpea processing include the following.

1. Bowl
2. Water
3. Electric cooker
4. Cooking pot
5. Thermometer
6. Oven
7. Dish
8. Blender
9. Weigh balance
10. Desiccator
11. Thimble
12. Buncher funnel
13. Filter paper

### 3.1.1 Raw Materials Preparation

#### 3.1.1.1 Raw Materials Collection

The sample used for the project was collected from Bosso, Minna Niger State. The specie of cowpea used is *Vigna Unguiculata L Walp.*

#### 3.1.1.2 Cleaning of Materials

Contamination may be inevitable in certain situations to find dust on the sample for analysis. Other contamination like fertilizer or lime blown into the seeds during harvest or the contamination during storage of the seeds.

## 3.2 METHODS

### 3.2.1 Soaking of Sample

The sample to be soaked was weighed using a weighing balance; 500g of cowpea was soaked in 1500ml of water at 30°C and for 30 minutes. The same amount of water was used to soak the same quantity of cowpea at 40°C and for 60 minutes. Using the same amount of water and the same quantity of cowpea soaking was done at 50°C for 90 minutes and at 60°C for 120 minutes.

### 3.2.2 Parboiling of Sample

After the soaking, the cowpea was drained of water. Fresh water heated to 70°C was use to simmer for 20 minutes the cowpea that have earlier been soaked for 30 minutes at 30°C. Using water heated to 80°C, the sample that was soaked for 60 minutes was simmered. Also using a temperature of 90°C of water, the sample soaked for 90 minutes was further simmered for 60

minutes and lastly, using water at 100°C, the sample soaked for 120 minutes was simmered for 80 minutes.

### 3.2.3 Grinding of Samples

Grinding was done to reduce seed materials to small uniform particles that aid analysis. Grinding allow sample to be manipulated with greater care, ensuring greater uniformity in terms of its composition.

## 3.3.0 CHEMICAL ANALYSIS

### 3.3.1 Moisture Content

The determination of moisture content is one of the most important and widely used measurements in samples that absorb and retain water. Chemical analysis was made on dry matter basis. Moisture content determination look very simple in concept, but in practice the accurate determination is complicated by number of factors which vary considerably from one sample to another.

Among the factors are the relative amounts of water available and the ease with which the moisture can be removed. Methods that are based upon the removal of water from the same and its measurement by loss of weight or the amount of water separated (Ibitoye, 2005).

PROCEDURE

- A clean and labeled dish that has been oven dried was weighed ($w_1$).
- Sample was added into the dish and weighed ($w_2$).

- The dish and content were transferred to the thermo setting oven at 105°C for about 24 hours.
- The dish was tranfered from the oven to desiccator, cool for about an hour and weighed ($w_3$).
- Then the moisture content was determined.

**Calculation**

$$\% \ moisture = \frac{Loss\ in\ weight}{weight\ of\ sample\ before\ drying} \times 100$$

$$= \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad (1)$$

### 3.3.2 Total Ash

The ash of biological materials is analytical term for the inorganic residue that remains after the organic matter has burnt off. The ash is not usually the same as the inorganic matter present in the original material since there may be losses due to the volatilization or chemical interaction between the constituents. The important of the ash content is that it gives an idea of the amount of mineral element present and the content of organic matter in the same sample. The organic matter account for the quantitative constituents of protein, lipid or fat and carbohydrate (Ibitoye, 2005).

PROCEDURE

1. A dish was placed in muffle furnace for about 15 minutes at 350°C

2. The dish was removed, cool in a desiccator for about an hour at room temperature ($w_1$).

3. Sample was added into the dish ($w_2$).

4. The dish was placed inside the muffle furnace and the temperature was slowly increased from 200- 450°C this is to avoid incomplete ashing.

5. The dish was then removed, allow to cooling at room temperature and the ash content was determined.

6. The crucible and the content were reweighed ($w_3$).

**Calculation**

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times 100 \qquad (2)$$

### 3.3.3 Lipid (Fat) Extraction

By definition, fats are mixture of various glycericide of fatty acids, which are soluble in certain organic solvent. Extraction is carried out with Soxhlet apparatus with petroleum ether. The usual procedure is to continuously extract the fat content with 40/60°C petroleum ether in a convenient extractor. The ether extract method is based on the principle that non-polar components of the sample are easily extracted into organic solvents. Direct extract gives the proportion of free fat but gives no clue to the particular fatty acids. (Ibitoye, 2005).

PROCEDURE

- Weighed the thimble previously dried ($w_1$).
- Sample was added into the thimble and weighed again ($w_2$).

- A 500ml round bottom flask was weighed ($w_3$).
- The flask was filled with petroleum ether up to ⅔ of the 500ml flask.
- The flask was fitted in such a way that the solvent was made to boil gently using heat.
- The petroleum ether siphoned over the barrel, the condenser was detached and the thimble removed.
- The flask containing the fat residue was dried in an oven at 100°C for 5 minutes and weighed.
- The thimble was placed in the beaker in an oven at 50°C and dried to constant weight with sample and cooled in desiccators.

**Calculation**

$$\% \text{ Fat} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \qquad (3)$$

### 3.3.4 Crude Fiber

Crude fiber is that portion of the plant material which is not ash or dissolves in boiling solution of 1.25% $H_2SO_4$ or 1.25% NaOH. Crude fiber was originally thought to be indigestible portion of any main food. It is known however that fiber consists of cellulose which can be digested to a considerable extent by both ruminants and non ruminants. The interest in fibre in food and feed has increased, base on the noticed number of serious illnesses associate with diet low in fibre. Fibre swells and form gelatinous mass with high water retention capacity with the digestive

system. Findings show that fibre product can absorb cholesterol, toxic agents and raise the excretion of bile acids and sterols (Ibitoye, 2005).

PROCEDURE

- 3.5-5g of the sample was placed into 500ml conical flask ($W_1$).
- 200ml of boiling 1.25% $H_2SO_4$ was added and brought to boiling within one minute and allowed to boil gently for 30 minutes.
- Using buncher funnel it was rinsed with hot water and separate material back into the flask with spatula.
- 200ml of boiling 1.25% NaOH was added and a few drops of antifoaming agent, bring to boiling within one minute and boil gently for 30 minutes using cooling finger (KOH can be used in the place of NaOH) and vegetable oil as antifoaming agent.
- It was filtered through filter paper and washed with hot water.
- The residue was salvaged into the crucible after drain, dry in the oven at 105°C, cool in the desiccators and weighed ($W_2$).
- It was then placed in muffle furnace at about 300°C for about 30 minutes.
- It was removed into dessicator and allowed to cool at room temperature and weighed ($W_3$).

**Calculation**

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{W_1} \times 100 \qquad (4)$$

### 3.3.5 Nitrogen Determination

The acceptable standard methods for the determination of nitrogen in any sample involve complete digestion of the sample in hot concentrated acid, and in the presence of an appropriate catalyst. The catalyst is to convert all nitrogen in the nitrogenous materials in the sample into ammonium ion.

Upon the addition of alkali to the digest, ammonia is released which may then either be distilled out of the sample and determined by simple acid- base titration, or the ammonia can react with an appropriate reagent such as phenol and sodium hypochlorite, to give a coloured derivative which can be measured with colourimeter or spectrophotometer.

The Kjeldahl digestion is usually performed by heating the sample with $H_2SO_4$ - containing substances which promote oxidation of organic matter by increasing the boiling point of the acid ($K_2SO_4$ or $NaSO_4$) and Se or Cu which increases the state of oxidation of the organic matter. This reagent here is referred to as a digestion catalyst.

It is necessary to digest the sample for certain period until you obtain a clear solution to ensure accurate results.

PROCEDURE

**Digestion (Stage I)**

1a. 2g of wet sample was weighed into 50 ml Kjeldahl flask, add 20ml conc. $H_2SO_4$ with one Kjeldahl catalyst tablet.

1b 0.5g of dry sample was weighed into 50 ml micro Kjeldahl flask, and 5 ml concentrated $H_2SO_4$ with half Kjeldahl catalyst tablet. Let the weight be ($W_1$).

2 The sample was heated on a heater stating with a low heat for 15 minutes, increase to 30 minutes again and finally at high heating until digested.

3 The sample was allowed to cool, wash and made up the digest up to 50, 100 ml or as appropriate.

**Distillation (Stage II)**

1. 5ml of 2% of boric acid ($H_3BO_3$) was placed into 100 ml conical flask (as receiving flask). $H_3BO_3$ as an acid will trap down the ammonial vapour from the digest.

2. 3 drops of mix indicator was added ($H_3BO_3$) and the indicator can be prepared together. Mix indicator – 0.198g bromocresol green plus 0.132g Methyl red in 200 ml alcohol.

3. The receiving flask was placed so that the tip of the condenser tube is below the surface of the boric acid.

4. 5 ml of samples rich in nitrogen and 10 ml of sample low in nitrogen were pipette into the Markham distiller or any available that has similar operation.

5. 10ml of NaOH was added; the joint was tight and distil for 50 ml into the receiving flask.

**Titration and Calculation (Stage III)**

Titrating the distilled with standard mineral acid (0.01 m HCL or 0.025m $H_2SO_4$). Titrating a blank with the acid as well.

Sample titre $T_1$

Blank titre $T_2$

Control titre = $T_1 - T_2 = T$

And Molarity or Acid = M

Reactions:

Digestion

$$H_2SO_4 + 2NH_3 = (NH_4)_2SO_4$$

Nitrogen converted to ammonia and reacted with $H_2SO_4$ to form $(NH)_4SO_4$.

Distillation

$$(NH_4)_2SO_4 + 2NaOH = 2Na_2SO_4 + NH_3 + 2H_2O$$

$$NH_3 + H_3BO_3 = NH_4^+ + H_2BO_3$$

Titration

$$NH_4^+ + H_2BO_3 + HCl = NH_4Cl + H_3BO_3$$

1 Mole of HCl = 1 Mole of NH

Molarity of HCl = $\frac{M \times T}{1000}$ = Molarity of NH

Mass of NH = $\frac{M \times T}{1000} \times 17 \ \frac{14g}{17}$

$= M \times T \times 0.014g$

$$\%\,N = \frac{M \times T \times 0.014}{W} \times \frac{V_1}{V_2} \times 100$$

### 3.3.6 Crude Protein

The amount of crude protein contained in the roots seed, roots, tubers and other stuff can be obtained by multiplying the nitrogen content of the food by 6.25. The factor 6.25 owes its origin to the assumption that all food protein contains 16%nitrogen, and that all nitrogen in a feed is present as protein. Although this assumptions are not entirely valid. The protein contained in plant tissue or feed may vary in terms of nitrogen content from 13 - % in many cases, a factor other then 6.25 would be more valid.

# CHAPTER FOUR

# RESULT AND DISCUSSION

4.0

## 4.1 Result

TABLE 4.1; THE VALUE OBTAIN FOR ALL THE SAMPLES

(All values are in percentages – wt/wt).

| S/N | PARAMETERS | RAW | DECORTICATED | A | B | C | D |
|---|---|---|---|---|---|---|---|
| 1 | MOISTURE CONTENT | 34.42 | 50.29 | 6.20 | 5.80 | 5.20 | 7.80 |
| 2 | ASH CONTENT | 3.00 | 1.5 | 1.5 | 3.00 | 2.50 | 4.50 |
| 3 | ETHER EXTRACT | 6.00 | 7.0 | 6.50 | 7.50 | 5.50 | 6.00 |
| 4 | CRUDE PROTEIN | 36.75 | 28.00 | 34.65 | 34.65 | 32.55 | 32.73 |
| 5 | CRUDE FIBER | 3.33 | 4.00 | 4.67 | 2.00 | 5.33 | 4.67 |
| 6 | CARBOHYDRATE | 50.92 | 59.50 | 52.68 | 50.15 | 57.45 | 52.83 |

## 4.2 DISCUSSION

### 4.2.1 Moisture Content

Moisture content is the amount of water that is removed by drying. Water as body moisture content plays some important roles on the human body, in that, its adhesive property binds body equilibrium and helps the liver breakdown and release more fat. Also it carries every nutrient, mineral, vitamin, protein, hormone and chemical messenger in the body to its destination. The proteins and enzymes which are the bases for the body healing capacity function efficiently with

enough water. It also supplies energy because the chemical reactions are water- dependent. In addition, water carries message from the brain to the other parts of the body. In fact, it has been reported that water constitute 85% of the brain tissues

The moisture content obtained for Raw sample (34.42%) is higher than A (6.20%), B (5.80), C (5.20) and D (7.80), but the moisture content for the decorticated sample (50.29) is the highest. This is due to the fact that the method used in the decortication, here the cowpea was soaked for 60 minutes in water at room temperature. There is comparison between the raw sample cowpea and the samples that has been soaked parboiled and dried, the higher value of the raw beans is due to the fact that it has not passed through any treatment yet, while the difference in moisture content seen in the rest of the sample is because of the different soaking and parboiling time.

TABLE 4.2.1; THE MOISTURE CONTENT OF THE SAMPLES

| SAMPLES | $W_1$ | $W_2$ | $W_3$ | Result |
|---|---|---|---|---|
| Raw | 46.38 | 52.31 | 50.60 | 28.79 |
| DECOTICATED | 44.06 | 95.20 | 69.48 | 50.29 |
| A | 41.98 | 46.98 | 46.67 | 6.20 |
| B | 41.20 | 46.02 | 45.73 | 5.80 |
| C | 43.49 | 48.49 | 48.18 | 5.20 |
| D | 43.31 | 48.31 | 48.05 | 7.80 |

### 4.2.2 Ash Content

The ash content is the organic residue that remains after all the organic matters and water has been burnt off in furnace. It indicates the presence of mineral elements as well as the organic matter in the sample.

The ash content for sample D (4.50) seems to be the highest. The reason for this can be understood in that fact that, the soaking and parboiling which is for 120 minutes at 60°C and 80 minutes at 100°C.

TABLE 4.2.2; ASH CONTENT FOR THE SAMPLES.

| SAMPLES | $W_1$ | $W_2$ | $W_3$ | RESULT |
|---|---|---|---|---|
| RAW | 13.87 | 15.87 | 13.93 | 3.00 |
| DECORTICATED | 42.79 | 44.79 | 42.82 | 1.50 |
| A | 13.17 | 15.17 | 13.20 | 1.50 |
| B | 22.59 | 24.59 | 22.65 | 3.00 |
| C | 15.39 | 17.39 | 15.44 | 2.50 |
| D | 12.06 | 14.04 | 12.15 | 4.50 |

### 4.2.3 Crude Protein

Crude protein is the amount of all the substance that contains Nitrogen in food samples. Protein pays some roles in the body. It is essential for growth and maintenance of tissues. It is good for the formation of essential body compounds. It also regulates water balance, maintain body neutrality, and stimulate antibody formation and transportation of nutrient.

The crude protein of the Raw sample (36.75) can be seen to be slightly higher then those that has soaked and parboil. This reason is because of the protein was loss due to continuous heating. The result shows that the protein content reduces with continuous parboiling. The value obtained from the crude protein of the decorticated sample (28.00) is small when compared with other samples; this is because the coat of beans contains some amount of protein.

TABLE 4.2.3; THE CRUDE PROTEIN FOR THE SAMPLES

| CRUDE PROTEIN | TITRE VALUE | RESULT |
|---|---|---|
| RAW | 2.10 | 36.75 |
| DECORTICATED | 1.6 | 28.00 |
| A | 1.98 | 34.65 |
| B | 1.98 | 34.65 |
| C | 1.86 | 32.55 |
| D | 1.87 | 32.73 |

### 4.2.4 Ether Extract

Ether extract is the measure of the components that are soluble in organic solvents, but insoluble in water. These are fats. Fats (lipid) play more roles in the body like the regulation and protection of vital body organs and it is also used for energy reserve.

The lipid extract sample B (7.50) is seen to be the highest. This is due to the soaking and parboiling treatment it passes through.

TABLE 4.2.4; EHTER EXTRACT FOR THE SAMPLES

| SAMPLE | $W_1$ | $W_2$ | $W_3$ | RESULT |
|---|---|---|---|---|
| RAW | 0.72 | 2.72 | 2.60 | 6.00 |
| DECORTICATED | 0.84 | 2.84 | 2.70 | 7.00 |
| A | 0.71 | 2.71 | 2.58 | 6.50 |
| B | 0.71 | 2.71 | 2.56 | 7.50 |
| C | 0.70 | 2.70 | 2.59 | 5.50 |
| D | 0.72 | 2.72 | 2.59 | 6.50 |

### 4.2.5 Crude Fiber

This is the plant polysaccharide that is indigestible by humans together with the lignin. Crude fiber is important to man in that it absorbs a lot of water and binds other food residues to itself, thus ensuring that faeces are soft, bulky and pass easily out of the body in the minimum time. It also helps against cancer, heart disease and diabetes.

The crude fiber of the raw sample (3.33%) is lower than the samples A (4.67) and D (4.67). The crude fiber is seen to increase when a sample of beans is subjected to soaking and parboiling time.

TABLE 4.2.5; CRUDE FIBER FOR THE SAMPLES

| SAMPLE | $W_1$ | $W_2$ | $W_3$ | RESULT |
|---|---|---|---|---|
| Raw | 1.5 | 14.26 | 14.21 | 3.33 |
| DECORTICATED | 1.5 | 12.11 | 12.05 | 4.00 |
| A | 1.5 | 16.12 | 16.05 | 4.67 |
| B | 1.5 | 14.44 | 14.41 | 2.00 |
| C | 1.5 | 15.82 | 15.74 | 5.33 |
| D | 1.5 | 16.11 | 16.04 | 4.67 |

### 4.2.6 Carbohydrate Content

The carbohydrate content does not constitute a particular substance or group of substance but instead consist of all the starches and sugar, some semi cellulose and varying proportion of lignin. Carbohydrate is used in the body as a source of energy and it also acts as a protein sparer so that protein can be used for its primary function.

The carbohydrate content obtained for the raw sample (50.92) is lower compared to the result obtained in the other samples except sample B. This is due to temperature increases that is parboiling the samples at different temperature increases the carbohydrate content of beans. The value obtained for the decorticated sample (59.50) is the highest and this value can be understood in relation to the crude protein. The result for carbohydrate content is available in table 4.1

# CHAPTER FIVE

# 5.0 CONCLUTION, RECOMMENDATIONS AND SUGGESTIONS

## 5.1 CONCLUSION

Food legumes are always processed in one way or the other before consumption. The most common method is some form of cooking which if not carried out under controlled conditions, may decrease their nutritional value and therefore, their supplementary effect to cereal grains and other food (Zamora *et al.*, 1997).

Protein digestibility in all the soaked and the parboiled samples could be similar but the weight gain and protein quality decrease with increased cooking time. Form the value obtained in Table 3; that the protein quality decrease as the cooking time increased.

Noticeable is the value obtained for the decorticated sample, though is neither soaked nor parboiled, the protein content is low compared with the value of other samples. This implies that the coat (hull) of cowpea contain nutrient because of the difference in value the raw and the samples that have been soaked and parboiled.

Removal of the carbohydrate fraction from cowpea produces a protein isolate that can be compared with cowpea meal. This can be seen in Table 3; an increase in the protein content implies decrease in the carbohydrate content and vice versa.

## 5.2 RECOMMENDATIONS

The hulls of cowpea is a sources of food as it contain nutrient particularly protein and so, it should no longer be discarded when cowpea is to be processed into meal other then cooking. If

possible it can be incorporated into animal's feeds which would later be consumed by human instead of being wasted.

In processing cowpea, parboiling should be done but the time for parboiling can very depending on the conclusion reach and the time that will be considered suitable. Also other minerals considered necessary to be determined along with chemical composition can be done to determine the suitability of the processing methods to be used.

# REFERENCES


Attins, A D., Way, M. J. and W. J. Sando (1979). Root nodule anatomy, type of export product and evolutionary origin in some leguminosae. *Plant, Cell and Environment* **3**: 35 – 43.

Bliss, J. T. (1995). *Water deficit and nitrogen – fixing nodules.* In Kozlowski, water Deficits and plant Growth, Academic press New York, United State of America Pp 145 – 240.

Boulter, J. U., Luse, R. A. and K. U. Leusliner (1995). Groundnut oil for the control of cowpea weevil. *Journal of Stored Products Research* **14**:77 – 80.

Cowell, B. J. (1984). Evolution and Evolutionary Problems in food legumes. *Economic Botany* **34** (3): 219 – 235.

Elias, T. J. (1984) Evolution of Pulse Crops. *Economic Botany* **32:** 185 – 198.

Evans, A. D. (1974). Nature of Carbohydrate inn Pulse. *Journal of Agriculture and Food Chemistry* **24**: 958 – 961.

Ibitoye, A. A. (2005). *Laboratory Manual on Basic Quantitative Chemistry Methods and calculations* Foladare Publishing company, Akure, Nigeria **5**: 1 – 18.

Ibitoye, A. A. **(2005).** Laboratory Method on Basic Plant Analysis. Published by Concept and Educationan Consults Akure, Nigeria.

Littleton, O. T., Smithson, J. B., and R. Redden **(1999).** Recent progress in cowpea breeding at IITA. *Tropical Grain Legume Bulleting* **8**: 5 – 6.

Microsoft ® Encarta ® 2007. © 1993-2006 Microsoft Corporation. All rights reserved.

Singh S. R. and K.O. Rachie (1985). Cowpea Research, production and Utilization. John Wiley and Sons limited, New York, United State of America. Pp 65- 86, and 355-366.

Slade, R. H. (1977). Crop areas and yields for 1976/77 in the Funtua, Gombe and Gusau Agricultural development projects. Kaduna, Agricultural Projects Monitoring, Evaluation and Planing Unit, Evaluation Technical note 3.

Summerfield, R. J. and P.O. Ndunguru (1975). Vigna Unguiculata. In Halevy, A Handbook of Flowering Boca Raton. FL CRC Press.

Summerfield, R. J. and P. A. Huxley (1996). *Cowpea Field Crop Abstracts* 27 (7): 301 – 312.

Summerfield, R. J. Robents, E. H. and F. R. Minchin (1983). Realization of Yield Potential in Soybeans and Cowpea. In British Crop Protection Council, opportunities for Chemical Plant Growth Regulation, London, United Kingdom, Monograph **21**:125 – 134.

Wallace, D. H., Ozbun, J. L. and H. M. Munger (1975). Physiological genetics of cowpea yield. *Advances in Agronomy* 24: 97 – 146.

Wien, H. C. (1982). Dry matter production, leaf area development and light interception of the cowpea lines with broad and narrow leaflet shapes. *Crop Science* **22**: 733 – 737.

Wein, H. C. and E. E. Ackah (1978). Pod development period in cowpeas; varietal differences as related to seed characters and environmental effects. *Crop Science* **18**: 791 – 794.

Wein H. C. and E. J. Littleton (1975). Glip physiology subprogram. Meeting on Grain Legume Improvement, Ibadan, Nigeria, IITA, 127 – 129.

Wein, H. C. and T. O. Tayo (1978). The effect of detoliation and removal of reproductive structures on growth and yield of tropical grain pests of Grain legumes. Ecology and control, Academic press London, United Kingdom, Pp. 241 – 251.

Zamora, A. F., and Fields, M. L. (1997). Nutritive quality of fermented cowpeas (Vigna sinesis) and chick-peas (Cicer arietinum). *Journal of food Science* **44**: 234 – 236.

http:// www.ag.ndsu.edu/pubs/plantsci/rowcrop

http://www.beprepared.com/article

http://www.en.wikipedia.org/wiki/Biological_classification

http://www.en.wikipedia.org/wiki/Powder_ (substance)#column - one#

http://www.en.wikipedia.org/w/index.php

http://www.food processing.com/resource_center/new_food_product/index.html

http:/www.hort.purdue.edu/newcrop/afcm/index.html

http://www.northarvest bean.org/html/grower.cfm

http://www.waltonfeed.com/grain/passport/beans.html

http://www.youngwomenshealth.org/cholesterol

# APPENDICES

**Moisture Content**

$$\% \text{ Moisture} = \frac{\textit{Loss in weight}}{\textit{weight of sample before drying}} \times 100$$

$$= \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

where

$w_1$ = weight of empty dish

$w_2$ = weight of dish plus sample

$w_3$ = weight of dish plus dried sample

**Calculating the moisture content for the Samples**

Using eqn (1)

$$\% \text{ Moisture for Raw sample} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$= \frac{52.31 - 50.60}{52.31 - 46.37} \times 100$$

$$= \frac{1.71}{5.94} \times 100$$

$$= 28.79$$

$$\% \text{ Moisture for Decorticated sample} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$= \frac{95.20 - 69.48}{95.20 - 44.06} \times 100$$

$$= \frac{25.71}{51.15} \times 100$$

$$= 0.5029 \times 100$$

$$= 50.29$$

% Moisture for sample A = $\frac{W_2 - W_3}{W_2 - W_1} \times 100$

$= \frac{46.98 - 46.67}{46.98 - 41.98} \times 100$

$= \frac{0.31}{5} \times 100$

$= 6.20$

% moisture for sample B = $\frac{W_2 - W_3}{W_2 - W_1} \times 10$

$= \frac{46.02 - 45.73}{46.02 - 41.02} \times 100$

$= \frac{0.29}{5} \times 100$

$= 5.80$

% moisture for sample C = $\frac{W_2 - W_3}{W_2 - W_1} \times 100$

$= \frac{48.31 - 48.05}{48.31 - 43.31} \times 100$

$= \frac{0.39}{5} \times 100$

$= 5.20$

% moisture for sample D = $\frac{W_2 - W_3}{W_2 - W_1} \times 100$

$= \frac{48.49 - 48.10}{48.43 - 43.49} \times 100$

$= \frac{0.39}{5} \times 100$

$= 7.80$

**Ash Content**

Using eqn. (2)

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

where

$w_1$ = weight of empty crucible

$w_2$ = weight of crucible plus sample

$w_3$ = weight of crucible plus ash

**Calculating the ash content for each of the sample**

$$\% \text{ Ash for Raw sample} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{13.93 - 13.87}{15.87 - 13.87} \times 100$$

$$= \frac{0.06}{5} \times 100$$

$$= 3.00$$

$$\% \text{ Ash for Decorticated sample} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{42.82 - 42.79}{44.79 - 42.79} 100$$

$$= \frac{0.03}{2} \times 100$$

$$= 0.015 \times 100$$

$$= 1.50$$

$$\% \text{ Ash for sample A} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{13.20 - 13.87}{15.87 - 13.89} \times 100$$

$$= \frac{0.03}{2} \times 100$$

$$= 0.015 \times 100$$

$$= 1.50$$

$$\% \text{ Ash for sample B} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{22.65 - 22.59}{24.59 - 22.59} \times 100$$

$$= \frac{0.06}{2} \times 100$$

$$= 0.03 \times 100$$

$$= 3.00$$

$$\% \text{ Ash for sample C} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{15.44 - 15.39}{17.39 - 15.39} \times 100$$

$$= \frac{0.05}{2} \times 100$$

$$= 2.50$$

$$\% \text{ Ash for sample D} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$= \frac{12.15 - 12.06}{14.06 - 12.06} \times 100$$

$$= \frac{0.09}{2} \times 100$$

$$= 4.5$$

**Ether Extract**

Using eqn. (3)

$$\% \text{ Fat} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

where

$W_1$ = weight of empty crucible

$W_2$ = weight of crucible plus

$W_3$ = weight of crucible plus

**Calculating the fat content for all samples**

$$\% \text{ Fat for Raw sample} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.72 - 2.60}{2.72 - 0.72} \times \frac{100}{1}$$

$$= \frac{0.12}{2} \times \frac{100}{1}$$

$$= 0.06 \times 100$$

$$= 6.00$$

$$\% \text{ Fat for Decorticated sample} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.84 - 2.70}{2.84 - 0.84} \times \frac{100}{1}$$

$$= \frac{0.14}{2} \times \frac{100}{1}$$

$$= 0.07 \times 100$$

$$= 7.00$$

$$\% \text{ Fat for sample A} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.71 - 2.58}{2.71 - 0.71} \times \frac{100}{1}$$

$$= \frac{0.13}{2} \times \frac{100}{1}$$

$$= 0.065 \times 100$$

$$= 6.50$$

$$\% \text{ Fat for sample B} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.71 - 2.56}{2.71 - 0.71} \times \frac{100}{1}$$

$$= \frac{0.15}{2} \times \frac{100}{1}$$

$$= 0.075 \times 100$$

$$= 7.5$$

$$\% \text{ Fat for sample C} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.70 - 2.59}{2.70 - 0.70} \times \frac{100}{1}$$

$$= \frac{0.11}{2} \times \frac{100}{1}$$

$$= 0.055 \times 100$$

$$= 5.50$$

$$\% \text{ Fat for sample D} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

$$= \frac{2.72 - 2.59}{2.72 - 0.72} \times \frac{100}{1}$$

$$= \frac{0.13}{2} \times \frac{100}{1}$$

$$= 0.065 \times 10$$

$$= 6.5$$

**Crude Fibre**

Using eqn. (4)

$$\% \text{ Fibre} = \frac{W_2 - W_3}{W_1} \times 100$$

where

$w_1$ = weight of sample used

$w_2$ = weight of crucible plus sample

$w_3$ = weight of crucible plus ash

**Calculating the crude fibre for the samples**

$$\% \text{ Fibre for Raw} = \frac{W_2 - W_3}{W_1} \times 100$$

$$= \frac{14.26 - 14.21}{1.5} \times 100$$

$$= \frac{0.05}{1.5} \times 10$$

$$= 0.0333$$

$$= 3.33$$

$$\% \text{ Fibre for Decorticated sample} = \frac{W_2 - W_3}{W_1} \times 100$$

$$= \frac{12.11 - 12.05}{1.5} \times 100$$

$$= \frac{0.06 \times 100}{1.5}$$

$$= 0.04 \times 100$$

$$= 4.00$$

$$\% \text{ Fiber for sample A} = \frac{W_2 - W_3}{W_1} \times 10$$

$$= \frac{16.12 - 16.05}{1.5} \times 100$$

$$= \frac{0.07}{1.5} \times 100$$

$$= 0.0467 \times 100$$

$= 4.67$

% Fiber for sample B $= \frac{W_2 - W_3}{W_1} \times 100$

$= \frac{14.44 - 14.41}{1.5} \times 100$

$= \frac{0.03}{1.5} \times 100$

$= 0.02 \times 100$

$= 2.00$

% Fiber for sample C $= \frac{W_2 - W_3}{W_1} \times 100$

$= \frac{15.82 - 15.74}{1.5} \times 100$

$= \frac{0.08}{1.5} \times 100$

$= 0.053 \times 100$

$= 5.33$

% Fiber for sample D $= \frac{W_2 - W_3}{W_1} \times 100$

$= \frac{16.11 - 16.04}{1.5} \times 100$

$= \frac{0.07}{1.5} \times 100$

$= 0.0467 \times 100$

$= 4.67$

**Crude Protein**

Using the equation

Crude protein is giving as $Cp = N \times 6.25$

But $N = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$

where

Cp = Crude protein

N = Nitrogen

Tv = Titre value

Ma = Molarity of the acid = 0.1

Weight of the sample = 0.5

**Calculating the Crude Protein for each of the samples**

Cp for Raw

$$N = \frac{Tv \times Ma \times 0.014 \times 10 \times}{weight\ of\ the\ sample} \times 100$$

$Tv = 2.10$

$$N = \frac{2.10 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0294}{0.5} \times 100$$

$$= 0.0588 \times 100$$

$$= 5.88$$

$Cp = N \times 6.25$

$$= 5.88 \times 6.25$$

$$= 36.75$$

Cp for Decorticated sample

$$N = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$$

Tv= 1.6

$$N = \frac{1.6 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0224}{0.5} \times 100$$

$$= 0.045 \times 100$$

$$= 4.5$$

$$Cp = N \times 6.25$$

$$= 4.5 \times 6.25$$

$$= 28.00$$

Crude Protein for sample A

$$N = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$$

$$Tv = 1.98$$

$$N = \frac{1.98 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0277}{0.5} \times 100$$

$$= 0.0554 \times 100$$

$$= 5.54$$

$$Cp = N \times 6.25$$

$$= 5.54 \times 6.25$$

$$= 34.65$$

Crude Protein for sample B

$$N = = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$$

Tv = 1.98

$$N = \frac{1.98 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0277}{0.5} \times 100$$

$$= 0.0554 \times 100$$

$$= 5.54$$

$$Cp = N \times 100$$

$$= 5.54 \times 100$$

$$= 34.65$$

Crude Protein for sample C

$$N = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$$

Tv = 1.86

$$N = \frac{1.86 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0260}{0.5} \times 100$$

$$= 0.0521$$

$$= 5.2$$

$$Cp = 5.21 \times 6.25$$

$$= 32.55$$

Crude Protein for sample D

$$N = \frac{Tv \times Ma \times 0.014 \times 10}{weight\ of\ the\ sample} \times 100$$

$$Tv = 1.87$$

$$N = \frac{1.87 \times 0.1 \times 0.014 \times 10}{0.5} \times 100$$

$$= \frac{0.0262}{5} \times 100$$

$$= 0.0524 \times 100$$

$$= 5.24$$

$$Cp = 5.24 \times 6.25$$

$$= 32.73$$

**Carbohydrate**

Using the equation

Carbohydrate (CHO) = 100 - (% ash + % fiber + % protein + % fat)

**Calculating the Carbohydrate for the samples**

Carbohydrate for Raw sample

CHO = 100 - (% ash + % fiber + % protein + % fat)

= 100 – (3 + 6 + 3.33 +36.75

= 100 – 49.08

= 50.92

Carbohydrate for Decorticated sample

CHO = 100 – (% Ash + % fiber + % protein + % fat)

= 100 – (1.50 + 7.00 + 4.00 + 28.00)

= 100 – 40.5

= 59.50

Carbohydrate for sample A

$$CHO = 100 - (\%\ ash + \%\ fiber + \%\ protein + \%\ fat)$$

$$= 100 - (1.5 + 4.67 + 34.65 + 6.5)$$

$$= 100 - 47.32$$

$$= 52.\ 68$$

Carbohydrate for sample B

$$CHO = 100 - (\%\ ash + \%\ fiber + \%\ protein + \%\ fat)$$

$$= 100 - (3.00 + 2.00 + 34.65 + 7.5)$$

$$= 100 - 47.15$$

$$= 52.85$$

Carbohydrate for sample C

$$CHO = 100 - (\%\ ash + \%\ fiber + \%\ protein + \%\ fat)$$

$$= 100 - (2.5 + 5.33 + 32.55 + 5.50)$$

$$= 100 - 45.88$$

$$= 54.12$$

Carbohydrate for sample D

$$CHO = 100 - (\%\ ash + \%\ fiber + \%\ protein + \%\ fat)$$

$$= 100 - (4.5 + 4.67 + 32.73 + 6.00)$$

$$= 100 - 47.90$$

$$= 52.10$$

Sample A is bean soaked for 30 minutes at 30°C and parboiled for 20 minutes at 70°C.

Sample B is bean soaked for 60 minutes at 40°C and parboiled for 40 minutes at 80°C.

Sample C is bean soaked for 90 minutes at 50°C and parboiled for 60 minutes at 90°C.

Sample D is bean soaked for 120 minutes at 60°C and parboiled for 80 minutes at 100°C.