ECONOMIC ANALYSIS OF COWPEA PRESERVATION TECHNOLOGIES WITH SPECIAL FOCUS ON THE HYDROTHERMAL TREATMENT TECHNOLOGY

BY

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THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY IN AGRICULTURAL ADMINISTRATION

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DECLARATION

I, Emmanuel Delali Kwamla Ofori, the author of this thesis titled "**Economic Analysis of Cowpea Preservation Technologies with Special Focus on the Hydrothermal Treatment Technology**" hereby declare that, this work was done entirely by me in the Department of Agricultural Economics and Agribusiness, University of Ghana, Legon.

The work has never been presented either in whole or in part for any other degree of this University or elsewhere except for other people's work, which have been duly cited.

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This thesis has been presented for examination with our approval as supervisors.

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DEDICATION

This work is wholeheartedly dedicated to my parents Mr. G. G. K. Ofori and Mrs. Edith B. Ofori for their immense contribution to my education most especially at the postgraduate level. I pray that you live long to fully enjoy the fruit of your toil.

It is also dedicated to the memory of my late cousin Mr. Ammishadai Kwasi Agbenosi Ofori who died mysteriously on July 1, 1985 at the University of Cape Coast. Brother, rest in peace.

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ABSTRACT

The need to increase and sustain the production of cowpea in Ghana has been recognised. It is a cheaper source of protein and thus has the potential to alleviate protein malnutrition. Specifically, the study determines the various storage and preservation technologies that are known and/or used by cowpea farmers, the profitability of cowpea preservation by means of the newly introduced technology called the hydrothermal treatment technology and also identifies the characteristics that determine the purchase decision of cowpea consumers. The socio-economic factors that influence the adoption of preservation and storage technologies of cowpea grain by farmers was also determined.

The results show that the four storage and preservation technologies most widely practised by cowpea farmers are: preservation with ash, chemical preservation, sealed bag storage and pod storage. The hydrothermal treatment technology simply involves steaming of dry cowpea grains for about 10 minutes after which the grain is properly dried and stored. The profitability of cowpea preservation using the hydrothermal treatment technology was determined by the use of Net Present Value and Internal Rate of Return criteria. The estimates of the profitability indicators at the 38% discount rate suggest that the hydrothermal treatment technology is profitable. The estimated values of NPV and IRR were ¢345,262.42 and 90% respectively. Benefits envisaged with the adoption of this technology include the reduction of cowpea storage losses induced by insect pests thereby leading to an increase in productivity and subsequent increase in the income earning capacities of the farmers.

The three most important characteristics of cowpea grains that are considered by consumers in making their purchase decisions are: absence of impurities, lack of insect emergence holes in the grain, and cooking time in that order.

It is recommended that similar profitability studies should be carried out on other technologies used in the preservation and storage of cowpea grain. The results of such studies will form the basis for farmers to compare and make informed choices.

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ABBREVIATIONS/ ACRONYMS

CRSP	-	Collaborative Research Support Program
CSIR	-	Council for Scientific and Industrial Research
FAO	-	Food and Agriculture Organisation
GDP	-	Gross Domestic Product
GGDP	-	Ghana Grain Development Project
Ha	-	Hectare
IFPRI	-	International Food Policy Research Institute
IITA	-	International Institute of Tropical Agriculture
IRR	-	Internal Rate of Return
JIRCAS	-	Japan International Research Centre for Agricultural Sciences
Kg	-	Kilogramme
MOFA	-	Ministry of Food and Agriculture
NPV	-	Net Present Value
PPMED	-	Policy Planning Monitoring and Evaluation Directorate
WHO	-	World Health Organisation

CHAPTER ONE

INTRODUCTION

1.1 Background and Problem Statement

Food items such as cereals, root and tubers, meat, milk, fish, edible oils and fats are nutritionally more rewarding. However, their domestic production in certain countries have not yet caught up with the demands of the rapidly expanding and urbanising population. Local food supplies from the farms are essentially seasonal; availability is highest soon after harvest and lowest in the interval between planting and harvesting of the next main food crops. This seasonal food shortage or the "hungry" season is a well-known phenomenon in African peasant agriculture.

The paramount role of improved methods of food production, preparation, processing, preservation, storage, distribution and marketing for the improvement of food consumption patterns to achieve a high level of nutrition and improved quality of life of the African people cannot be over-emphasised. According to Yudelman (1998), the supply of food – especially grains in developing countries will have to rise by around 70 percent by the year 2020 if the 6.5 billion people who are expected to be living in Africa, Asia and Latin America by then are to be food secure.

Cowpea [*Vigna unguiculata* (L.) Walp] belongs to a group of crops called grain legumes or pulses, which are generally noted for their high protein content, and has the potential of alleviating protein malnutrition most especially in developing countries.

Cowpea is an important legume of the tropics, with various uses, including grains in processed foods, a vegetable (fresh leaves, peas, and pods), and as fodder. Cowpea pulse processed into products such as flour or meal could be used to make sweets, cakes and porridge for human consumption. Ground cowpea grain is considered a valuable feedstuff for poultry and ruminant diets. Dovlo et al. (1976) reported that cowpea is chosen in an extrusion cooking as a source of nutrient because of its relatively high protein content and its amino acid profile which are both superior to and complementary to that of cereal grains. According to Barrett (1990), cowpea is among the top three or four leafy vegetables used in many parts of Africa.

Cowpea in combination or association with cereals and other grain legumes contributes to the sustainability of cropping systems in marginal lands of the semiarid areas, with its fixation of nitrogen, ground cover, and the soil improvement it provides from plant residues. These features of cowpea make it a particularly attractive crop for the subsistence farmers of Sub-Saharan Africa, where about 70% of the world's cowpea are grown (Singh et al. 1990; Singh et al. 1997).

Ghana has a favourable climatic condition for cowpea cultivation. The crop grows well in hot tropical climates; it requires a temperature range of 20 and 30 degrees Celsius, and rainfall range of between 400 and 800 millimetres per annum (Muleba and Ezumah, 1985; Singh, 1985). Despite the prevailing favourable climatic conditions and the high nutritional value of the crop, production figures continue to fluctuate in Ghana. An indication of the performance of cowpea production in Ghana between 1980 and 1996 is given in Table 1.1, which contains data on the quantity produced and annual growth in output. The quantity of cowpea produced declined from 17,000 tonnes in 1981 to the lowest value of 11,000 tonnes in 1985 although a break in the downward trend was recorded in 1984 when the quantity was 14,000 tonnes. Between 1986 and 1996, there was a steady increase in the quantity produced with 85,244 tonnes at the end of the period. The average production estimates over the period under consideration (1980–1996) is 38,909 tonnes per annum.

Table 1.1 Annual Quantities of Cowpea Produced in Ghana (1980-1996).

Year	Quantity of Cowpea Produced ('000 kg).	Annual Growth in Output (%).
1980	16,100	-
1981	17,000	5.6
1982	14,100	-17.1
1983	11,700	-17.0
1984	14,000	19.7
1985	11,000	-21.4
1986	19,500	77.3
1987	23,500	20.5
1988	35,000	48.9
1989	51,000	45.7
1990	48,000	-5.9
1991	52,000	8.3
1992	56,316	8.3
1993	60,990	8.3
1994	71,535	17.3
1995	74,472	4.1
1996	85,244	14.5

Source: PPMED, MOFA, Accra.

Cowpea production in Ghana therefore presents a picture of a fluctuating but basically upward trend. The fluctuating output in Ghana despite the useful features of cowpea could be due to low investment in cowpea industry, which is considered risky because of the numerous problems in growing, harvesting and storing the crop (Jackai and Adalla 1997).

Severe yield losses of cowpea are caused in tropical Africa by the interplay of abiotic (for example, drought) and biotic (for example, arthropod pests, diseases, birds, and rodents) constraints. Ranked first among the latter group, a wide array of insect pests can cause total yield failure in cases of severe attack (Jackai and Daoust, 1986). Insect pests damage cowpea from seedling emergence to storage. It has been shown that field pest problems during the crop's vegetative cycle are substantial, and insects such as *Maruca* spp and *Apion* are highly implicated in production losses. Insect infestation both in the field and during storage reduces markedly both yield and quality of the grain.

The principal storage pest of cowpea grain is the cowpea bruchid, *Callosobruchus maculatus*, also known erroneously as the "cowpea weevil" (Taylor, 1981). *Callosobruchus maculatus* infestations start in the field and continue in storage. Cowpea on sale in markets often has bruchid emergence holes. Other important insect pests of cowpea in storage include *Bruchidius atrolineatus* and *Callosobruchus chinensis*.

The financial and nutritional losses in cowpea due to storage pests in Sub-Saharan Africa are not well documented, but are clearly high. Low-resource farmers often sell their cowpea at harvest, when prices are lowest in the year, partly because they anticipate storage losses. Being aware of the storage problem, they are interested in better techniques for preserving their grain after harvest (Murdock et al. 1997). Caswell (1984) has documented the loss of cowpea grain during traditional post harvest storage in Nigeria. He found out that pods stored for 8 months had 50% of the grain damaged by bruchids, but when stored as grain, 82% of the grain had one or more holes. Since emergence holes represent insects that have developed and left the seed, mated, and laid additional eggs, counting emergence holes to assess damage undoubtedly represents only a part of the problem. The next generation of larvae, more numerous will generally still be developing within the grain.

Technologies are now available to limit post harvest losses due to insect pests infestation of cowpea grain. Solar disinfestation, combined with subsequent storage under conditions that prevent reinfestation, enables long-term preservation of threshed grain from insect attack (Murdock et al., 1997). Cowpea varieties with seed resistance, pod-wall resistance, and combined seed and pod-wall resistance have been bred through the joint efforts of breeders and entomologists (Kitch, 1992).

Cowpea grain storage in airtight containers, such as metal drums or triple plastic bags, arrests the development of storage insect populations (Kitch and Ntoukam, 1991a). Mixing the grain with wood ash also stops damage to grain by storage insect pests (Wolfson et al., 1991; Kitch and Ntoukam, 1991b). Cowpea grain treatments with numerous plant-derived oils, such as that from groundnut, are also effective

(Schoonhoven, 1978; Singh et al., 1979). In addition, insecticides are the fire-fighting analogue in cowpea pest control, a function for which they remain unrivalled (National Academy of Sciences, 1969). Currently, economic necessity, sensitivity to environmental destruction and health considerations (chemical residues) has rendered insecticide use socially unacceptable. The use of insecticides to protect cowpea grain in storage is probably more commonplace and controversial than their use on the field crop, because chemical residues are feared to persist in the bean after cooking.

The Department of Nutrition and Food Science of the University of Ghana has developed a new method of cowpea preservation called **hydrothermal treatment technology**. This method is applicable to cowpea both on the farmer's field and at the market place in response to the need to address the high level of post harvest losses in cowpea. The hydrothermal treatment technology, which is a simple, inexpensive and safe physical modification process, is chemical free, and does not require the use of sophisticated equipment or trained personnel. As a result it could alleviate the fear associated with insecticide use. It involves the exposure of whole cowpea seeds to steam followed by drying to acceptable storage moisture content. Preliminary work by Sefa-Dedeh et al. (1994) showed that 5 to 10 minutes steamed cowpeas were resistant to the weevil. Subsequent studies were conducted to determine the effect of the steaming process on the seeds, and some of the results have been presented in the chapter on literature review of this study.

Despite these developments in technologies, the problems of post harvest losses in cowpea are still evident in Ghana. It is therefore necessary to identify the constraints limiting the cowpea industry in the country. Such studies on cowpea development must lay emphasis on analysis of constraints in the entire production chain, that is, from field production to consumption and utilization, including what happens to the produce during storage and processing. This study basically attempts to investigate the financial viability of the hydrothermal treatment technology for cowpea preservation. The study therefore proposes to address the following questions: What preservation technologies do cowpea farmers know and /or use? Of those farmers who know of these technologies but do not use them, what are the factors that prevent their use? Is the hydrothermal treatment technology profitable? What are the characteristics of cowpea grains that influence the purchase decisions of consumers? What are the factors that determine the adoption of pest control technologies by cowpea farmers? These are some of the issues this study has tried to address.

1.2 Objectives of the Study

The primary objective of the study is to determine the viability of the hydrothermal treatment technology of cowpea preservation.

The specific objectives are:

1. To identify the various technologies used by farmers in the preservation and storage of cowpea.
2. To determine the profitability of the hydrothermal treatment technology in preserving cowpea.
3. To determine the characteristics of cowpea that influence purchase decisions of consumers.
4. To determine the factors that affects the adoption of pest control technologies by cowpea farmers.

1.3 Relevance of the Study

Protein deficiency disorders, such as kwashiorkor and marasmus are major nutritional problems in most developing countries including Ghana. The total daily protein intake of an adult human being recommended by FAO is 55.0 grammes for normal growth and healthy mental development (Bender, 1992). Ghana's per capita protein intake according to FAO (1994) report was 46.9 grammes falling short of the recommended intake value. Cowpea, which can easily be integrated into the farming system, is high in protein and can serve as a relatively cheap source of vegetable protein. On average, cowpea grain contains 23-25% protein and 50-67% starch (Silano et al. 1981). Cowpea is also of importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics. From the production of this crop, rural families variously derive food, animal feed and cash, together with spill over benefits to their farmlands through, for example, in situ decay of root residues, use as animal feed, and ground cover from cowpea's spreading and low growth habit. In addition, because the grain is widely traded in production areas, it provides a cheap and nutritious food for relatively poor urban communities. In fresh form, the young leaves, immature pods, and peas are used as vegetables, while several snacks and main meal dishes are prepared from the matured dry grain. All the plant parts that are used as food are nutritious, providing protein, vitamins, and minerals.

Beyond its importance for food and feed, cowpea can equally serve as the fulcrum of sustainable farming in semiarid lands. It provides ground cover thus providing some protection against soil erosion. Another important feature of cowpea as a food legume in the cropping system is its ability to produce nitrogen and so increase the overall fertility of the soil, thus partially replacing the use of expensive nitrogenous fertilizers.

According to Kay (1979) a vigorous growing food legume such as the cowpea can add as much as 45 kg/ha of nitrogen to the soil, which is equivalent to 112 kg/ha of urea, or 225 kg/ha of ammonium sulphate.

In addition, cowpea is drought hardy, and it is able to maintain some growth or at least survive under dry soil conditions. This trait is in part explained by the deep rooting habit of some varieties, and it accounts for the crop's ability to grow and yield under the semi desert conditions of the African Sahel.

The off-take of cowpea fodder makes an important contribution to feed supplies for large and small ruminants. The spill over benefits are that traction animals maintain reasonable health status during the dry season, enabling timely land preparation when the wet season begins. Also, return of animal manure to the land by cartage from kraals or in situ grazing contributes to soil fertility.

With the development of irrigation schemes in some areas of West and Central Africa, and the general increased use of wetlands, cowpea has found a niche in dry-season cropping. This is based mainly on the use of residual soil moisture, and it is somewhat similar to the production of cowpea in rice-based cropping systems. This relatively new production system is popular and expanding. As with rain fed production, both grain and fodder are produced (Quin, 1997).

Considering the above uses and potential advantages of cowpea, there is the need to undertake this study to establish the profitability of the hydrothermal treatment technique. Recommendations based on the findings would be useful in sustaining the cowpea industry through reduction of post harvest losses and enhancing the quality of available grain for consumption.

1.4 Organisation of the Study

The study is organised into five chapters. The background and problem statement, objectives of the study, the relevance of the study and the organisation of the study, which constitutes the introduction, are presented in chapter 1. The literature review is presented in chapter 2. The methodology employed to achieve the objectives of the study are outlined in chapter 3. The results of the study and discussion are presented in chapter 4. The final chapter presents the conclusion and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents a review of the relevant literature on cowpea preservation methods. The review entails general as well as literature specific to the Ghanaian situation.

2.1 Pest Management Philosophy

Insects are considered pests because of the socio-economic and medical threat they pose to man and his property. Biologically, an insect is a pest when its population density and/or damage level exceeds a pre-established or conceptualised threshold (the economic injury level) below which the insect does not constitute an economic threat (Horn, 1986). This is defined as the lowest population or damage level capable of causing economic impact (Poston, et al 1983). If the population of an organism exceeds the economic injury level, the organism becomes a pest. When an insect is introduced into a favourable environment, its population density tends to increase to the carrying capacity of the resource. This is not usually exceeded because of the balance in environmental stress factors such as predation, competition, and other natural mortality factors, constituting the environmental resistance.

The economic injury level is usually below the carrying capacity of the resource. Maintaining a pest population below this level may require some manipulation using one or more of the interventions such as resistant cultivars, beneficial organisms and insecticides at the disposal of growers. Usually, the damage or population density of the pest is not allowed to reach levels that would result in economic loss before action is taken. The resource damage level, or pest population density prior to the economic injury level is the economic or action threshold (Stern et al, 1959), or damage boundary (Pedigo et al., 1986). Control measures must therefore be introduced, augmented, or applied to the system (Horn, 1986; Metcalf and Luckmann, 1994). Alterations in crop-pest dynamics, for instance by many of man's agricultural activities, dictate how pest management proceeds and the tools that can be used.

2.2 Insect Infestation

Storage is one of the very important operations in cowpea production. Essentially, it prolongs the shelf life of the harvest, making it available on the market for a much longer period of time. Farmers are well aware of the losses they suffer in storage and in many cases estimate that everything will be eventually lost if no control measures are taken (Wolfson et al. 1990; Goldman 1991).

Cowpeas are seasonal and there is therefore the need to store the surplus for use during the lean season. During storage, various pests including rodents, moulds and insects attack cowpeas. Amegatse (1995) reports that 66.7% of respondents in a survey in Ghana indicated that insect (weevil) infestation was the major problem associated with cowpea storage. About 80 insect species have been identified as pests of stored cowpeas in Ghana including *Callosobruchus maculatus*, which is one of the nine major pests, identified (Agen-Sampong, 1977). The infestation usually occurs on the field and sometimes during storage by cross contamination. The females reproduce rapidly and therefore the population can grow exponentially within a few months.

The FAO (1989) estimates that post-harvest food losses of grains in developing countries through mishandling, spoilage and pest infestation average 25% of the total food grain production. Various estimates of the magnitude of the post harvest losses (due to insect attack) have been made. The values are generally very high, an estimated 30% of stored rice is lost to insects in Sierra Leone whilst, 25-45% of stored maize is lost to insect pests in Ghana (Hill and Waller, 1988). Comparable levels of losses have been reported in East and Southern Africa and other parts of the tropical world (Boxall, 1989). In the Sahelian areas of Nigeria, weevil infestation of cowpea grain may reach 40% in markets by the early wet season, which is June/July (Caswell, 1981).

The loss of food material as a direct result of insect attack occurs through two main means. Insect activity either through boring into the seeds and/or surface feeding results in the removal of food material, usually from the portions of highest nutritional value. There is also the respiring activity of the insects, which results in high moisture development in the stored grain encouraging the growth of micro organisms with their own associated problems.

A relatively insignificant weight loss in a grain sample may have far reaching effects. This is especially important if it leads to either a total rejection of the whole batch by the consumer or to a drastic price reduction. According to Singh and Jackai (1985), up to 30% loss in weight may occur after six (6) months with 70% of seeds being infested and grain being almost unfit for consumption. Insect infestation leads not only to economic losses but also results in nutritional losses in cases where the attack is substantial. The nutritional losses occur from decrease in essential amino acids and vitamins, and also from contamination with uric acid, a metabolite of insects (Bressani, 1985; Uzogara and Ofunya, 1992). Seed viability can also be affected (Wolfson, 1989; Lowenberg-deBoer, 1995).

2.3 Control of Storage Pests

Pest management techniques are varied and involve methods that integrate either cultural practice, biological, chemical or physical factors. The choice of the method is affected by many considerations including the availability and costs of inputs, labour requirement, time frame for application of the technique, the level of know how for using the technology, the economic status of the person, cultural considerations and amount of grain to be stored (Murdock, et al., 1997). Amegatse (1995) found that majority (56.2%) of cowpea farmers interviewed in the Ga District of the Greater Accra Region, Ghana, employed intermittent drying of bagged cowpeas whilst 27% used chemical pesticides or airtight containers. Preservation with palm kernel oil, smoke, wood ash and kerosene were other traditional or indigenous methods used.

2.3.1 Chemical Preservation of Cowpea

Synthetic chemicals continue to be important agents in the control of insect pests of stored grains, especially in developing countries, in spite of the continuing controversy surrounding their harmful side effects (Yudelman et al., 1998). Even though these chemicals are generally targeted at insect pests, some of them are broad-spectrum biocides that have profound effects on non-target species in the agricultural ecosystem. There is also a problem of chemical residues after application, which could exceed the recommended safety levels. For instance, applying 100 grammes of actellic super dust per 90-100 kilogramme bag of grain produces residues of 3.3 milligrammes permethrin and 17.7 milligrammes pirimiphos methyl per kilogramme grain. This is more than the

FAO/WHO recommended residual levels of 2 milligrammes and 10 milligrammes per kilogramme, respectively (Golob, 1988; Uronu, 1988).

In Africa, most subsistence farmers do not keep their produce in storage for long periods. Thus there is the danger of consuming or selling grains with high chemical residues. In Tanzania, it has been reported that 1000 deaths per year could be attributed to various pesticide poisoning (Ak'habuhaya and Lodenius, 1988). Although cowpea farmers have long recognised the usefulness of insecticides, factors such as availability, information and cost have kept the technology beyond their reach (Jackai et al., 1985).

2.3.2 Edible oils and Biologic Materials

Mixing dry cowpea seeds thoroughly with small amounts of vegetable oils has proved to be an effective protection against insect pests (Schoonhoven, 1978; Singh et al., 1979). The oil covers the testa and plugs the egg micropyle (acting as an ovicide) and therefore prevents oxygen supply to the embryo. It also deters oviposition and causes death of adult insect pests. Varieties of oils are suitable, for example palm kernel oil, cotton seed oil and groundnut oil. According to studies undertaken by Singh et al., (1979) and Pereira (1983), groundnut oil was found to be the most effective of the edible oils, providing complete protection for up to 25 weeks after treatment. Cockfield (1992), studying the effectiveness of groundnut oil as a control measure, found that using the oil afforded a protection similar to that of pirimiphos methyl.

The amount of oil needed for an effective preservation is usually very small, 5 millilitres per kilogramme of grain (Singh et al., 1979). There are, however, some difficulties associated with this treatment. Thorough mixing of oil and grain becomes tedious when the quantity of grain is large. There is also the problem of rancidity or other inherent negative properties, for example neem oil stains the hands and has an unpleasant 'garlic' odour (Murdock et al., 1997). It is also easy to pick up dust and debris.

Another method involves the use of plant parts such as leaves of various mints or pungent smelling plant materials. Ofunya (1986) noted that onion scales and dried chilli pepper conferred some degree of protection against *Callosobruchus maculatus*.

2.3.3 Sealed Container Storage

In this method, the moisture present results in germination of some grains. The resulting respiration eliminates oxygen in the enclosure thus suppressing insect infestation. Sealed containers may be large, underground silos or simple metal drums (Murdock et al., 1997).

A practical drum storage technique has been developed in Senegal under the Bean/Cowpea Collaborative Research Support Program (CRSP). The beans are first sun dried and then the drum is filled with the dry beans. It has been recommended that the drum be sealed for a minimum period of 2 months before opening. It is also important that the drum be airtight. Its advantages include the relatively low initial cost and repeated use of the drums. However, the period within which the drum must remain sealed for the treatment to be effective is quite long. There is also the problem of weight of large drums but this is usually overcome by using racks.

Storage using triple plastic bagging is another simple and inexpensive method also developed by the CRSP in Cameroon. The technique makes use of clear plastic bags, which are widely available. The grains are put in a bag (40-50 kilogrammes) and tightly sealed with twine. This is then placed completely into a second and then a third bag and sealed similarly. Tests in various Cameroonian villages have shown that the method is effective and readily accepted by small-scale farmers. Due to the transparent nature, the farmer can observe the grains periodically. However, the bags can be easily destroyed through improper handling and they are also vulnerable to rodent attack (Murdock et al., 1997).

The Grains Development Project in Ghana has investigated the potential of storing cowpeas in Sealed Kilner jars and found the method to be effective but did not look at the acceptability of the method to farmers in storing their output (Osei, 1993).

2.3.4 Co-storage with Ash and other Abiotic Materials

Wolfson et al., (1989) found that the most common traditional post harvest storage method in Northern Cameroon was the use of ash. This has also been noted in other Sub-Saharan African countries including Ghana (Murdock et al., 1997). The ash used comes from the cooking fire and results vary with differences in mode of application as well as the ash to grain ratio used. The latter factor is usually more effective if the ratio is three or more parts ash to four parts grain. Although the ash stops the development of the bruchid population in the grain stored, it does not kill them. It is therefore important to mix the ash immediately after threshing.

2.3.5 Biological Control

Huffer and Smith (1980) defined biological control as both the undisturbed activity of antagonists naturally present in a given ecosystem (naturally occurring biological control), and the manipulation of natural enemies in order to achieve better control levels (applied biological control). Generally, biological control as an intervention tactic refers to the latter form and, more specifically, to "classical biological control" as the introduction of exotic antagonists against exotic pests. One of the best-documented examples of classical biological control is the successful introduction of the solitary endoparasitoid *Epidinocasis lopezi* (De Santis) (Hymenoptera Encyrtidae) to control the cassava mealy bug *Phenacoccus manihoti* Mat. -Ferr. (Heminoptera, Pseudococcidae) in Africa (Herren and Neuenschwander, 1991).

The term "biological control" concerning pest control in cowpea has usually been used to indicate the naturally occurring interactions between pests and their antagonists (Singh et al., 1990; Ezueh, 1991). Recommendations for biological control were therefore merely aimed at preserving the available natural enemies (Ezueh, 1991). Murdock et al., (1997) gave an example of biological control method involving the use of resistant seeds or pods or a combination of resistant seeds and pods. They observed that seed resistance is a valuable tool but it must be carefully controlled to avoid the rapid development of a virulent bruchid biotype. Some observations in Cameroon have suggested that the development of varieties with combined resistance to bruchid both in pods and seeds could result in an effective approach to achieving a durable and high level of bruchid resistance.

2.3.6 Solar and other Heat Disinfestation Techniques

(a) Susceptibility of Insects to Thermal Destruction: High temperatures can be used to kill insects due to their limited physiological capability of thermoregulation. As a result, bruchid eggs, larvae and pupae that are immobile cannot escape from a hot environment and therefore are excellent targets for post harvest management using elevated temperatures. Sub-Saharan African farmers who disinfest cowpea have used this for a long time by heating on iron plates over fire. Though this technique works, it is difficult to control the cowpea from overheating and burning (Murdock et al., 1997).

(b) CRSP Plastic Solar Heater: This also exploits the thermal susceptibility of the storage pest. A simple solar heater was developed from a sheet of black polythene placed on the ground. The grains are spread out on the sheet and the two edges folded and secured with objects like stones thus enveloping the grains. When exposed to the sunrays for 2 hours, all stages of the insects were killed. The method did not change the cooking time, rate of germination or the vigour of the seedlings. The solar heater has been field tested and introduced in North Cameroon (Murdock et al., 1997).

2.3.7 Irradiation

Radiation sterilisation using gamma rays helps to reduce the fertility of the female *Callosobruchus maculatus* (Ahmed et al., 1979). A combination of irradiation with other measures such as temperature has been suggested as a viable means of controlling insect infestation of stored food. However, irradiation has not been fully accepted by most consumers on food safety basis (Wolf, 1992). There is also the problem of the high initial capital requirement, especially for African processors who are mostly small-scale industrialists.

2.3.8 Storage in Pods

Cowpeas are sometimes stored in the pods by farmers. Kitch et al., (1991) conducted studies to determine whether storage in pod form were effective in limiting *Callosobruchus maculatus* damage. Their findings indicated that pods, which resist breakage and are non-dehiscent, form a physical barrier to the developing larvae, and can reduce *Callosobruchus maculatus* emergence by as much as fifty percent. In addition, some varieties also possess pod-wall resistance factors that are believed to account for an additional 20-30% mortality above that due to the physical barrier effect alone. Since bruchid larvae have to penetrate both the pod wall as well as the testa of the underlying seed, pod-seed interactions which involve specific seed characteristics such as seed coat texture and pod characteristics such as pod strength or thickness also play an important role in resistance.

2.4 Review of Some Effects of the Hydrothermal Treatment of Cowpea Seeds

The hydrothermal treatment is a simple, inexpensive and safe physical modification process, which does not require the use of sophisticated equipment or trained personnel. It involves the exposure of the whole cowpea seeds to acceptable storage moisture content. Sefa-Dedeh et al., (1994) reported that 5 to10 minutes steamed cowpeas were resistant to the weevil. A detailed study was subsequently undertaken to compare the effect of steam and solar heat on some aspects of the developmental biology (oviposition, developmental period, sex ratio, and food preference) and control of *Callosobruchus maculatus* under ambient laboratory conditions (Sefa-Dedeh et al., 1998). It was concluded that even though the number of eggs laid was not affected by the treatment, there was no emergence of adult insects in the steamed cowpeas. This was the same even after 6 months storage whilst the seeds of the untreated and solar dried samples were completely destroyed within the period.

Egyir-Yawson (1999) obtained similar results. According to his report, microscopic examination showed that all hatched eggs had initiated feeding but somehow were unable to complete development in the steamed seeds and had died at an early instar. It is suggested that death could have resulted from an inability to utilise the nutrients possibly, due to structural changes in the protein and starch molecules after steaming. The study also revealed significant differences in the resistance shown in steamed samples dried either in the solar dryer as compared to those dried in an air oven. The latter samples were not resistant to the attack, that is, there was emergence of adult insects.

Preliminary field studies have been conducted both at the farm and market levels (Sefa-Dedeh and Saalia, 1997). Results have shown that up to 10 weeks of storage, steamed seeds were still clean with no signs of insect infestation. After this period, the 5 minutes steamed seeds showed some signs of infestation, however, the rate of damage was much lower compared with the control. The 10 minutes steamed seeds remained uninfected for the entire experimental period of 24 weeks. Another observation made was that infestation was stopped when infested samples were steamed and then stored. Seed viability was, however, completely lost following steaming and seeds could thus not be used for cropping.

Sefa-Dedeh and Demuyakor (1994) investigated the effects of steaming and storage on some physicochemical properties of cowpea seeds and flour. They reported that whilst the steaming resulted in an increase in water absorption of the flour samples, the steamed seeds showed reduced water absorption capacities. Storage further reduced the water absorption capacity for both seeds and flour. Steaming also increased the fat absorption capacity of the flour whilst the foaming property decreased with steaming and storage for the seeds and also the flour.

Obeng (1996) investigating the effect of steam treatment on processing and chemical characteristics of cowpea seeds and flour recorded reduced seed viability with steaming. The effect of the steam treatment was more pronounced in the "Amantin" variety compared to "Asontem". A general reduction in both tannic and phytic acid concentration with increasing steaming time was also recorded. It was also found out that cooked seed hardness was affected significantly by cowpea variety, cooking time and steaming time. Both variety and cooking time but not steaming time also significantly affected acceptability of the cooked bean.

Sefa-Dedeh and Saalia (1996) have also conducted consumer evaluation studies on the steamed seeds. Two procedures were used- administering questionnaires and focus group discussion. Steaming reduced the acceptability of the cowpea based on the appearance, an attribute deemed important in consumer selection of product. A majority of the respondents (84%) reported that unsteamed seeds had higher swelling capacity than the steamed seeds. However, the steamed seeds soaked were relatively softer to touch as compared to the unsteamed. No conclusive information was obtained on the time required to cook the beans to the desired softness. The reported 'normal' cooking time ranged between 45 to 120 minutes possibly due to differences in heating systems. Steaming affected neither the flavour nor the taste of the cowpea meals prepared using the samples.

CHAPTER THREE

METHODOLOGY

3.1 The Study Area

The study was carried out in the Greater Accra Region. The region has been producing some amount of cowpea and is a major cowpea-consuming centre with a high marketing potential.

"Mallata" market in Accra was selected for the study; cowpea consumers were interviewed with the assistance of cowpea traders. A village called Maanpehyia in the Ga District of the Greater Accra Region was also selected where cowpea producers were interviewed. The choice of these locations is based primarily on the fact that Bean/Cowpea CRSP of which this study is a part undertook some preliminary studies at these locations. Some of these farmers and traders have been introduced to the hydrothermal treatment method of preserving cowpea. Also, a farmers group exists in Maanpehyia and an Agricultural Extension Officer is currently working with. This was very useful in identifying the respondents.

3.2 Analytical Framework

Information gathered from both primary and secondary sources were analysed to achieve the objectives of the study.

3.2.1 Identification of Preservation and Storage Technologies

The first objective of this study is to identify the various cowpea preservation technologies used by farmers in the study area in preserving cowpea grain. This objective was achieved by asking the respondents to indicate the technologies that they know of and use in preserving cowpea through the use of questionnaire. The information was analysed using graphs and descriptive statistics, mainly frequencies and percentages. In addition, other documented technologies including traditional ones were reviewed through literature search.

3.2.2 Determination of the Profitability of the Hydrothermal Treatment Technology

The second objective of this study is to determine the profitability of the hydrothermal treatment technology in preserving cowpea. The method of analysis used to achieve this objective was to compute the Net Present Value (NPV) and the Internal Rate of Return (IRR) of investing in the technology to determine its financial viability.

3.2.2.1 Net Present Value (NPV)

The Net Present Value is the most straightforward discounted cash flow measure of project worth. It is simply the present worth of the incremental net benefits or incremental cash flow stream and may be interpreted as the present value of the income stream generated by an investment (Gittinger, 1982).

The method consists of discounting all future cash flows to the present value by means of an appropriate rate of interest. NPV works on a simple but fundamental principle that, an investment is worth pursuing if, and only if, the present value of the cash inflows is at least equal to, or greater than, the present value of the cash outflows arising from an investment (Selvavinayagam, 1991).

Dyson (1994) asserts that NPV is considered a highly acceptable method of investment appraisal because it takes into account the timing of the net cash flows, project profitability and the return of the original investment.

The NPV will be computed for investing in the steamer used in the hydrothermal treatment technology of preserving cowpea grain.

The quantitative data required to calculate NPV are:

- the initial investment cost
- the value of future cash flow (inflow and outflow) in each period
- the economic life of investment inputs
- the discount rate representing cost of capital (Selvavinayagam, 1991).

Mathematically, NPV is computed as follows:

$$NPV = \sum_{t=0}^{t=n} [(B_t - C_t)/(1+i)^t] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: B_t is the benefit in year 0,1,2,...n

C_t is the cost in year 0,1,2,...n

'n' is the expected economic life span of the investment

't' takes values of 0,1,2,....n

'i' is the discount rate.

The decision criterion is to accept all independent investments/projects with NPV of zero or greater when discounted at the appropriate cost of capital.

3.2.2.2 Internal Rate of Return (IRR)

Another way of using incremental net benefit stream or cash flow for measuring the worth of an investment is to find the discount rate that makes NPV of the incremental net benefit stream equal to zero. This discount rate is called the internal rate of return. It measures the average earning capacity of an investment year after year throughout its useful life. In other words, IRR is the maximum interest that a project could pay on average for the resources used if the project is to just recover its investment and operating costs (Gittinger, 1982).

Merrett and Sykes (1973) assert that IRR is the rate of return on capital outstanding per period while it is invested in a project.

Mathematically, IRR is expressed as the discount rate, R such that:

$$\sum_{t=0}^{t=n}\left[(B_t - C_t) \Big/ (1+R)^t\right] = 0 \quad \text{..........(2)}$$

Where:

B_t, C_t, n and t are as earlier defined

'R' is the IRR in equation 2.

The IRR was computed by iteration, which means using trial and error method. The computation involves choosing an arbitrary discount rate to compute the NPV. If the NPV is found to be greater than zero, a higher discount rate is used; and a lower discount rate used if computed NPV is found to be less than zero. The process is repeated until a discount rate that equates NPV to zero is discovered. This discount rate is the IRR.

To determine where the real IRR lies between the lower discount rate that gives a negative NPV and the higher interest rate of return that gives a positive NPV, linear interpolation technique was employed as shown in equation 3.

$$IRR = L_D + (U_D - L_D)\frac{NPV_L}{|NPV_U| + |NPV_L|} \quad \text{.......................................(3)}$$

Where,

L_D = Lower discount rate;

U_D = Higher discount rate;

NPV_L = Net present value at the lower discount;

NPV_U = Net present value at the higher discount.

$/NPV_U/+ /NPV_H/$ = Sum of the absolute net present values at the two discount rates (signs ignored).

The decision criterion for IRR as a measure for financial analysis is to accept all independent projects or investments having an IRR equal to or greater than the cost of capital or cost of loan.

3.2.2.3 Choosing the Discount Rate

To be able to use the discounted measures of project worth, there was the need to make a decision on the discount rate to use to calculate NPV or the rate below which it will be unacceptable for the IRR to fall (the cut-off rate). According to Gittinger (1982), the discount rate for financial analysis is the marginal cost of money to the firm for which the analysis is being done. This is often the lending rate or the rate at which the enterprise is able to borrow money. The lending rate quoted by the Bank of Ghana during the period of the study (January to June, 2001) was used.

3.2.2.4 Sensitivity Analysis (Treatment of Uncertainty)

One of the real advantages of a careful investment analysis is that, it may be used to test what happens to the earning capacity of the project if events differ from guesses made about them during planning. For example, how sensitive is a project's NPV at financial prices or its financial rate of return? Reworking to see what happens under these changed circumstances is called sensitivity analysis (Gittinger, 1982).

A variation of sensitivity analysis is the switching value. Calculating switching value involves determining how much an element would have to change in unfavourable direction before the project would no longer meet the minimum level of acceptability as indicated by one of the measures of project worth. One switching value test is to determine the maximum benefit delay before the NPV of an investment will fall below zero for the investment to be rejected.

3.2.3 Determination of Cowpea Characteristics that Influence Consumers Purchase Decisions

The third objective of the study is to determine the characteristics of treated and untreated cowpea that influence consumers purchase decisions. This objective was achieved through the use of structured questionnaire and/or personal interviews to collect data on the factors and/or characteristics of cowpea that influence purchase decisions of consumers. The information collected was analysed using descriptive statistics, mainly frequencies, percentages and ranking.

3.2.4 Identification of Socio-economic Factors that Affect Farmers' Choice of Preservation Methods

The fourth objective of the study is to determine the socio-economic factors that affect the adoption of pest control technologies by cowpea farmers. The chemical pest control method as a technology was used for the analysis. This was determined using the Probit regression model.

3.2.4.1 The Probit Model

The Probit regression model was used to determine objective four. Farmers face outcomes from the adoption of storage technologies that are uncertain. In this model, cowpea farmers are assumed to make adoption decisions based upon an objective of utility maximisation.

The Probit model is given as:

$$\phi(\beta\chi_i) = \int_{-\infty}^{\beta\chi_i} \frac{1}{\sqrt{2\pi}} \exp\left(\frac{-t^2}{2}\right) dt \qquad \text{.............................(4)}$$

Where:

t is a random variable distributed as a standard normal deviate

β is a vector of unknown coefficients

X_i is a vector of characteristics of the individual

$\phi(\beta X_i)$ is the probability that the i^{th} individual will adopt the technology.

Thus the probability of adoption is the area under the standard normal curve between the - ∞ and βX_i. The larger the value of βX_i, the more likely adoption is to take place (Madalla, 1983).

An iterative maximum likelihood algorithm was used to estimate the empirical model in order to obtain asymptotically efficient parameter estimates (Rahm and Huffman, 1984). The statistical power of the estimated model was evaluated using the likelihood ratio test.

3.2.4.2 Specification of the Model

The empirical specification of the adoption model was employed to investigate post harvest chemical pest control decision of cowpea farmers. A Probit model was estimated on chemical pest control technology. The model was fitted to a sample of cowpea farmers in the study area.

The probability of adoption of pest control technology was specified as a function of farmers' specific socio-economic characteristics. The dependent variable is given by chemical pest control (CPC), which takes on the value 1 if the farmer uses chemical to control storage pests of cowpea and zero otherwise. The explanatory variables used in the model were sex, age, educational level, household size, number of years of experience in cowpea farming, infrastructure, origin of the respondent and the proportion of cowpea output in trade. The descriptions of the variables in the empirical model are given in Table 3.1.

Table 3.1 Description of the Variables used in the Empirical Model

Variable	Description
AGE	Age of the Farmer (years).
SEX	Gender of respondents. 1=Male; 0=Female.
EDU_0	Farmers' level of Education. 1= No formal education 0=otherwise.
EDU_1	Farmers' level of Education. 1= Basic level; 0= otherwise.
EDU_2	Farmers' level of Education. 1=Secondary and above; 0=otherwise.
FSIZE	Family Size (number).
EXP	Farmers' number of years of experience in cowpea farming.
ORI	Is farmer a native of the Village? 1=Yes; 0= No.
INF	Whether the Farmer has storage Infrastructure. 1=Yes; 0=No.
PCT	Proportion of cowpea in trade activity.

The Regression Model is specified as follows:

$$CPC = \alpha + \gamma_1 AGE + \gamma_2 EDU_0 + \gamma_3 EDU_1 + \gamma_4 EDU_2 + \gamma_5 SEX + \gamma_6 EXP + \gamma_7 FSIZE + \gamma_8 INF + \gamma_9 ORI + \gamma_{10} PCT + \varepsilon$$

Where:

α and γ are coefficients to be estimated

CPC = represents chemical pest control

AGE = age of farmer

EDU_0 = educational level of the farmer: 1=no formal education; 0=otherwise

EDU_1 = educational level of the farmer: 1=basic level; 0= otherwise

EDU_2 = educational level of the farmer: 1=Secondary and above; 0=otherwise

SEX = gender of the farmer

EXP = farmer's number of years of experience in cowpea farming

FSIZE = household size of the farmer

INF = storage infrastructure

PCT = percent proportion of cowpea output sold

ORI = origin of farmer

ε. = Stochastic error term which represents all variables which were not explicitly included in the model.

AGE is a variable that measures the age of the farmer. With age, farmers are more likely to accumulate more personal capital in addition to personal experience and, thus show a greater likelihood of investing in innovations. Also, older farmers may be elders in the zone and have preferential access to new information or technologies through extension services. It is hypothesised that age is positively related to adoption.

Education enhances the ability of people to take advantage of improved technologies. Educated individuals are therefore more likely to adopt new technologies and/or are more likely to be early adopters (Kedebe et al, 1989; Norris and Batie, 1987). It is therefore hypothesised that education is positively related to the use of pest control technologies.

SEX is a variable that indexes the gender of the respondent, taking on the value of 1 if farmer is male and zero if female. Some authors argued that female farmers are generally discriminated against in terms of access to external inputs such as credit (Donkor, 1989, cited in Obeng, 1994). It is hypothesised that sex is negatively related to the dependent variable.

EXP reflects farmer's year of experience with cowpea. With increasing experience, farmers may be able to better assess pest problems. Number of years of experience may be positively related to adoption.

FSIZE measures farmer's household size. A large family often has a large number of working members. Due to the high labour demands for applying chemical pesticide, the larger the family, holding other things constant, the higher will be the probability of adoption (Kedebe et al, 1989).

INF is a dummy variable that indexes whether a farmer has storage infrastructure or not. Farmers that have storage infrastructure would be expected to have higher likelihood of adopting technologies. It is hypothesised that infrastructure is positively related to adoption of pest control technologies.

ORI is a binary variable, which indexes whether the farmer is a native of the village or a migrant, and take on the value of 1 if a native and zero otherwise. It is hypothesised that origin is positively related to the use of pest control technologies.

PCT is the percentage of cowpea output going into trade. A large percentage of cowpea may indicate commercial orientation of farmer in growing cowpea. Thus the probability of adopting pest control technologies.

3.3 Data Sources

Both primary and secondary data were used for this study. The primary data were collected from 48 producers of cowpea at Maanpehyia. The cowpea producers were identified with the assistance of the Agricultural Extension Officer in the area. Sixty-four (64) consumers of cowpea were also interviewed. Cowpea traders were not interviewed because during the pre-testing of the questionnaires, it was found out that the farmers mostly carry out the preservation.

Secondary data were obtained from the personnel and reports of Bean/Cowpea CRSP Project of the Department of Nutrition and Food Science of the University of Ghana. Other relevant institutions such as the PPMED of the Ministry of Food and Agriculture (MOFA), and the Crop Research Institute of the Council for Scientific and Industrial

Research (CSIR) were also sources of data. Published information and reports such as Ghana Grain Development Project (GGDP) Annual Reports and discussions with other relevant institutions involved in the grain and legume production and handling were other sources.

3.4 Method of Data Collection

Three types of questionnaires were used in the survey; one set for cowpea farmers, another set for consumers and the last one for the researchers working on the hydrothermal treatment technology. The questionnaires were designed to gather relevant qualitative and quantitative information for analysis and drawing of conclusions on the study's objectives. The questions were mainly open-ended covering storage practices, socio-economic characteristics of the respondents, prices and consumer perception on how the level of damage to cowpea by pests affects their purchase decisions. Copies of the questionnaires are in Appendices I, II and III.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of the study as well as the discussion of the results. This includes the identification of technologies used by cowpea producers in controlling storage pests and the factors that affect the adoption of these technologies. Also presented in this chapter are the results on the profitability of the hydrothermal treatment technology as well as the cowpea quality characteristics that influence the purchase decision of consumers.

4.2 Socio Economic Characteristics of the Respondents

The socio economic characteristics of the two categories of respondents interviewed are presented in this section. The two categories are cowpea farmers in and around Maanpehyia in the Ga District and cowpea consumers who buy from the "Mallata" market in Accra.

4.2.1 Cowpea Farmers

The managerial ability of a farmer is largely influenced by his/her socio-economic status. It is therefore prudent to give a brief socio-economic background of the respondents.

A total of 48 cowpea farmers were interviewed out of which 38 (79%) were males with the remaining being females. This could be attributed to the fact that married women support their husbands as household heads most especially in subsistence farming.

The age distribution of the respondents is presented in Table 4.1.

Table 4.1 Age Distribution of the Farmers

Age Range (years)	Frequency	Percentage
Below 21	3	6
21- 30	9	20
31- 40	11	24
41- 50	16	35
51- 60	4	9
Above 60	3	6
Total	**46**	**100**

Source: Survey Data.

The mean age of the respondents was 40 years with the minimum and the maximum ages at 15 and 71 years respectively. Seventy nine percent (79%) are between the ages of 21 and 50 years.

Education greatly enhances the introduction and acceptance of a new technology by any group of people. According to Donkor (1989), (cited in Obeng 1994), illiteracy poses problems for development as there is a great correlation between education and receptivity of new innovations. This is because education gives people the ability to access information, process or analyse and use that information. The illiterate therefore tend to be more cautious and more resistant to change while the literate tend to be more risk taking and innovative. The educational status of the farmers as presented in Table 4.2, shows that 21 (44%) are illiterates with 26 (54%) having up to basic level education. Only one respondent (2%) had up to second cycle level of education. None of the respondents had tertiary education.

Table 4.2 Educational Levels of the Farmers

Educational Level	Frequency	Percentage
None	21	44
Basic	26	54
Secondary	1	2
Total	**48**	**100**

Source: Survey Data.

Eighty one percent of the farmers are married with the remaining 13% and 6% being single and widowed, respectively. Trading in agricultural and non-agricultural commodities and food processing were some of the income generating activities being undertaken by the respondents as a means to supplement their incomes from farming.

4.2.2 Cowpea Consumers

Some consumers of cowpea were also interviewed to have their opinion on what they look out for in buying cowpea. This is very important, as it will guide farmers, researchers and all other people involved in the handling of the product before it gets to the final consumers. The concerns of the consumers can then be known and taken care of.

There were two groups of cowpea consumers that the study identified. Those that buy the grain and process into food for sale to the general public, which can be, regarded as cooked food sellers (bulk purchasing) constitute only 6% of the respondents. The other group is the final household consumers, which constitutes 94% of the respondents. They buy the grain in smaller quantities on a much frequent basis than the first group (retail purchased).

The study also tried to find out the opinion of consumers about whether they cared to find out if the cowpea grain they purchased is treated with chemicals against losses to storage pests and its effect their purchase decision. From Table 4.3, it can be inferred that majority (81%) of the consumers sampled were indifferent as to whether the grain they are buying has been treated chemically or not. All respondents classified as cooked food sellers are in this category together with some final household consumers.

Table 4.3 Consumers Response on whether they cared to find out if the Cowpea grain they purchased has been Treated Chemically

Response	Frequency	Percent
Yes	12	19
No	52	81
Total	**64**	**100**

Source: Survey Data.

The rest of the respondents whose decisions were affected by the use of chemicals indicated that they get over this by only ensuring that the grain is properly washed before cooking and this group of consumers constitute only 8% of the total respondents.

It is worth noting that those consumers whose decisions on the purchase of chemically treated cowpea hold this opinion simply because it is very difficult to identify grains on display that are treated chemically. This leaves the consumers with the only option of either to buy with its attendant risk or desist. It has been documented that despite the protection of grains afforded during storage with chemicals, the repercussions from their use on the health of man and the environment are considerable and they must therefore be used with extreme caution (Pretty, 1995).

Out of the 64 respondents interviewed, 95% were females with males constituting the rest. The age distribution of the consumers interviewed is presented in Table 4.4.

Table 4.4 Age Distribution of the Consumers Interviewed

Age Range (years)	Frequency	Percentage
Below 21	2	3.0
21- 30	24	37.5
31- 40	24	37.5
41- 50	11	17.0
51- 60	3	5.0
Above 60	-	-
Total	**64**	**100.0**

Source: Survey Data.

It can be observed that majority of the sampled cowpea consumers were aged between 21-30 years and 31-40 years with each class consisting of 37.5% of the total respondents. Seventeen percent of the consumers were between the ages of 41-50 years whilst 5% and 3% were respectively aged between 51- 60 years and aged below 21 years. None of the respondents was above 60 years. The mean age was 35 years with the minimum and the maximum ages at 19 and 58 years, respectively.

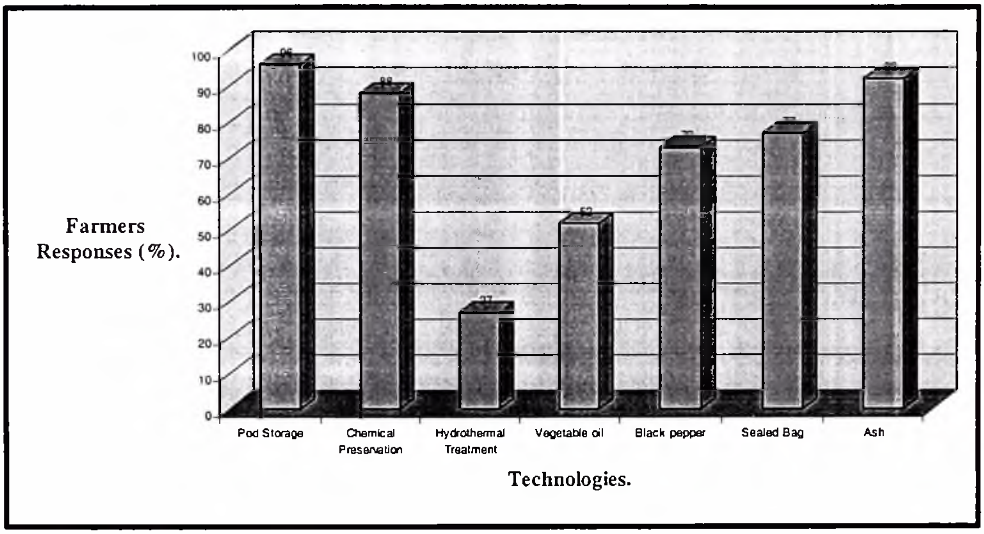
Cowpea consumers interviewed have various levels of education with 19% having no formal education. Forty seven percent (47%) had up to basic level education, whereas 23% indicated that they had education up to second cycle level. Those respondents having education up to the tertiary level constituted only 11%. Sixty four percent (64%) of the respondents were married with 28%, 6% and 2%, respectively, constituting those that were single, separated and widowed.

4.3 Storage Pest Control Technologies Used by Cowpea Farmers

Different types of technologies are known and /or are being used by cowpea farmers in controlling storage pests. On the basis of this, information was collected from the cowpea farmers on the storage technologies known to them as well as those they are currently practising.

The survey data revealed that the technologies well known to cowpea farmers were preservation with ash (92%), preservation with inorganic chemicals (88%) and storage in pod (96%). Newly introduced hydrothermal treatment technology was also known to another 27% of the respondents whilst 77% had knowledge of storing cowpea in sealed bags. Another 73% and 52% of the farmers indicated that they were aware of the use of black pepper and groundnut oil, respectively, in controlling cowpea storage pest. This trend is indicated in Figure 4.1.

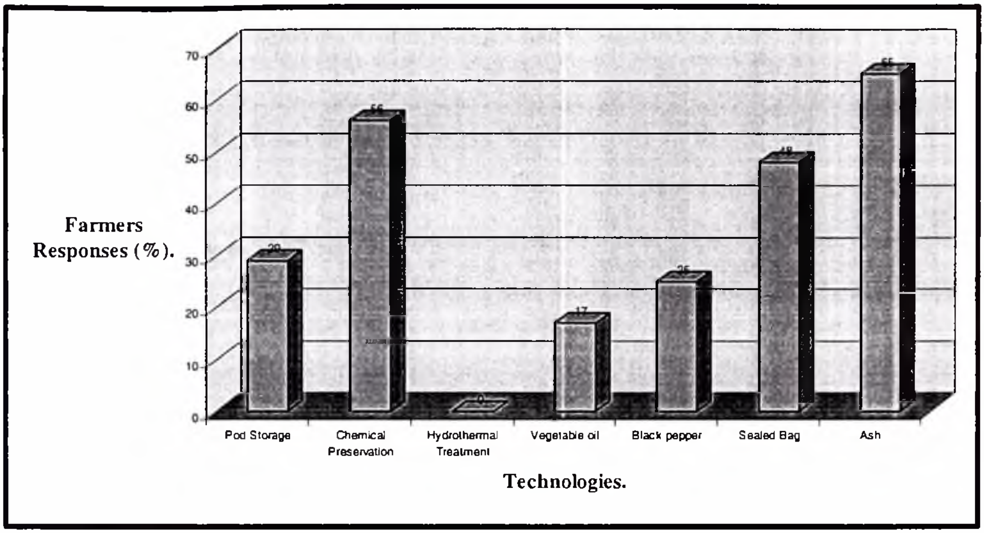
Figure 4.1 Technologies known to Farmers in Controlling Storage Pests of Cowpea



Source: Survey Results.

Apart from the determination of the storage technologies known to the farmers in controlling pests, the study also tried to find out those technologies that the farmers actually adopt. Figure 4.2 is a graphical presentation of those technologies in use by the respondents.

Figure 4.2 Technologies in Use by Farmers in Controlling Storage Pests of Cowpea



Source: Survey Results.

The predominant technology being practised by the respondents in the control of storage pests is the use of ash as indicated by 65% of the farmers interviewed. This could be due to the fact that the ash is a household waste product, which is readily available and is free. This was followed closely by another 56% of the respondents who indicated that they use inorganic chemicals to preserve the cowpea in storage against insect pests. Actellic 25 is the chemical most widely used in protecting cowpea against insect infestation during storage and 95% of the farmers who uses storage chemicals indicated its usage. This was followed by Super Actellic, which was indicated by 35% of the respondents who uses storage chemicals for cowpea grain treatment. The use of storage chemicals despite the fact that they are expensive and sometimes dangerous to use may be due to its effectiveness against storage pests.

Another 48% of the respondents indicated that they use sealed bag method in preserving their grains whereas 29% of them keep their grains in the pods as a means of preserving grains against storage pests. Reasons given by the respondents for above trend were that, the inputs required for making the storage infrastructure such as baskets and barns for the storage were readily available locally at relatively cheaper prices. For effective pod storage, the pod must first be resistant to breakage during and after harvest. In general, local landrace cultivars are very resistant to breakage whereas most improved, exotic varieties have lost this trait, presumably after being bred for easier threshing.

Twenty five percent (25%) and 17% of the respondents (farmers) respectively uses black pepper and vegetable oil such as groundnut oil in the control of storage pests. Hydrothermal treatment technology, which was introduced to some of the respondents, recently was only mentioned as known (as indicated in Figure 4.1), but none has adopted this technology in preserving their produce. This may be due to the fact that they are not very familiar with the technology and might be going through the usual adoption process and are only at the awareness stage.

Apart from chemical preservation and hydrothermal treatment technology, the rest of the methods being practised by the farmers as presented in Figure 4.2 can be referred to as indigenous methods such as pod storage which are either complementary to chemical treatments or substitute for storage chemicals completely in some cases. Comparing the indigenous methods with the use of chemicals, it was found that, indigenous control methods were not as widely used despite the fact that chemicals are expensive and sometimes not readily available and dangerous when not used properly.

Farmers indicated the following two major reasons for storing their cowpea. Firstly, they store to await better market price because at harvest time, the prices are low most especially during bumper seasons. It therefore makes economic sense to store some to be sold in the future at the time prices are higher. Secondly, farmers also store their grain for family consumption.

In general, it is seen that storage losses exist for cowpea and are a major constraint in the development of the cowpea sub-sector in the country. The farmers are all aware of the problem. About a third of them reported that they do not treat their cowpea during storage, and the main reason given by 56% of this group was that, the period from the harvest of the pods and when it is sold is too short to warrant any grain treatment. Some of the respondents who do not treat their stored produce indicated that they cultivate only pest resistant varieties. Some other reasons that compel farmers to sell their produce during or just after harvest was to avoid storage for the fear of damage of the produce by insect pests during storage. It is far better to sell at harvest and get some money than to store only to have the grain destroyed by storage pests. Some farmers also indicated that they sometimes needed money for emergency situations and are thus compelled to sell their produce at harvest when prices are at the lowest.

4.4 Investment Analysis

In the profitability analysis, the net present value at 38% discount rate and the internal rate of return on capital and operating expenditure for acquiring a steamer and its accessories for preserving cowpea using the hydrothermal treatment technology were determined, respectively, as ¢345,262.42 and 90% (Refer to Appendix IV for reference notes and assumptions). The result is summarised in Table 4.5.

Table 4.5 Determination of Profitability Indicators (NPV and IRR)

	YEAR 0 (¢)	YEAR 1 (¢)	YEAR 2 (¢)	YEAR 3 (¢)	YEAR 4 (¢)	YEAR 5 (¢)	YEAR 6 (¢)
Investment Cost							
Steamer	240,000.00						
Buckets	77,000.00						
Bowls	25,000.00						
Sub-Total	**342,000.00**						
Annual Operating Cost							
Water		78,000.00	80,180.00	84,300.00	84,000.00	84,000.00	84,000.00
Labour Cost		133,000.00	154,500.00	154,500.00	154,500.00	154,500.00	154,500.00
Energy		83,000.00	84,000.00	103,000.00	103,000.00	103,000.00	103,000.00
Packaging Expenses		42,780.00	51,940.00	57,100.00	57,100.00	57,100.00	57,100.00
Value of untreated Cowpea		1,100,000.00	1,100,000.00	1,100,000.00	1,100,000.00	1,100,000.00	1,100,000.00
Sub-Total	-	**1,436,780.00**	**1,470,620.00**	**1,498,900.00**	**1,498,600.00**	**1,498,600.00**	**1,498,600.00**
TOTAL COST	**342,000.00**	**1,436,780.00**	**1,470,620.00**	**1,498,900.00**	**1,498,600.00**	**1,498,600.00**	**1,498,600.00**
TOTAL REVENUE	-	**1,777,600.00**	**1, 777,600.00**	**1,777,600.00**	**1,777,600.00**	**1,777,600.00**	**1,777,600.00**

YEAR	TR (¢)	TC (¢)	CF (¢)	DF @ 38%	PV_{TR} (¢)	PV_{TC} (¢)
0	-	342,000.00	-342,000.00	1.0000	0	342,000.00
1	1,777,600.00	1,436,780.00	340,820.00	0.7246	1,288,048.96	1,041,090.79
2	1,777,600.00	1,470,620.00	306,980.00	0.5251	933,417.76	772,222.56
3	1,777,600.00	1,498,900.00	278,700.00	0.3805	676,376.80	570,331.45
4	1,777,600.00	1,498,600.00	279,000.00	0.2757	490,084.32	413,164.02
5	1,777,600.00	1,498,600.00	279,000.00	0.1998	355,164.48	299,420.28
6	1,777,600.00	1,498,600.00	297,000.00	0.1448	257,396.48	216,997.28
TOTAL					**4,000,488.80**	**3,655,226.38**

Source: Survey Data.

Note:

TC	-	Total Cost
TR	-	Total Revenue
CF	-	Cash Flow
DF	-	Discount Factor
PV_{TC}	-	Present Value of Total Cost
PV_{TR}	-	Present Value of Total Revenue
CF	=	TR - TC

(i) Determination of NPV (at 38% discount rate):

$$\begin{aligned} NPV &= PV_{TR} - PV_{TC} \\ &= 4{,}000{,}488.80 - 3{,}655{,}226.38 \\ &= \underline{¢345{,}262.42} \end{aligned}$$

(ii) Determination of IRR:

NPV at 88% discount rate = ¢8,609.85
NPV at 92% discount rate = -¢5,036.86

$$\begin{aligned} IRR &= 88 + (92 - 88)\,[\,8{,}609.85 \div (8{,}609.85 + 5{,}036.86)] \\ &= 88 + 4\,(0.6309) \\ &= \underline{90\%} \end{aligned}$$

The NPV value represents the total of each year's net returns over the economic life of the investment. The positive value of the NPV at the discount rate or cost of capital of 38% is an indication that the venture is profitable. On the basis of this, investing in a steamer to preserve cowpea grains using the hydrothermal treatment technology for storage is profitable.

The computed IRR for investing in a steamer for preserving cowpea using hydrothermal treatment technology denotes the maximum interest that the project can pay annually for the resources used in order to recover its investment and operating expenses and just break-even (Gittinger, 1982). This IRR value of 90% is higher than the prevailing borrowing rate of 38% and hence should pass for a profitable business.

Sensitivity Analysis is an analytical technique to test systematically what happens to the earning capacity of a project if events differ from the estimates made about them during planning. An adverse situation could render once profitable investment unprofitable.

Sensitivity analysis was conducted by calculating NPV and IRR for the investment over the economic life on the following assumptions:

1. It was assumed that the selling price per 90 kg bag of the preserved cowpea grain falls by 10 percent. (That is, from ¢160,000.00 to ¢144,000.00). Since the selling price of the output determine the revenue from the investment, it is important to find out the impact of a decline in the selling price of the preserved output on the profitability of the investment. The choice of 10% level of decline in selling price has no scientific basis.

2. In the second case, it was assumed that the cost of untreated cowpea increased by 10%. The value of untreated cowpea constitutes more than 70% of the annual total operating cost. This component being a major cost element has a great impact on the profitability of the investment.

The computed values of the sensitivity analysis are presented in Appendix V and summarised in Tables 4.6 and 4.7.

Table 4.6 Computed NPV and IRR values assuming 10% fall in the Price of Treated Cowpea

Profitability Indicator	Initial Favourable Values	Values after 10% reduction in the Price of treated cowpea
NPV at 38% (¢)	345,262.42	- 54,786.46
IRR (%)	90	-

Source: Computed from Survey Data, 2001.

Table 4.7 Computed NPV and IRR values assuming 10% increase in the Cost of Untreated Cowpea

Profitability Indicator	Initial Favourable Values	Values after 10% increase in the Cost of untreated cowpea
NPV at 38% (¢)	345,262.42	97,707.42
IRR (%)	90	54

Source: Computed from Survey Data, 2001.

When a 10% reduction in the price of treated cowpea was assumed (Table 4.6), the NPV declined from ¢345,262.42 to -54,786.46 Cedis. The IRR was not determined since the NPV value was less than zero. These results of the sensitivity analysis indicated that the investment is sensitive to a decline in the selling price of treated cowpea as shown by a negative NPV value, which renders the investment unprofitable.

It can be seen from Table 4.7, that when a 10% increase in the price of untreated cowpea was assumed, the NPV at 38% opportunity cost of capital, fell from ¢345,262.42 to ¢97,707.42 and the IRR also declined from 90% to 54%. The two measures of project worth (NPV and IRR) still meet the decision criteria for the project to be profitable.

Sensitivity analysis not only has important implications for investment decisions, but also has very important implications for project management. With these possible outcomes known from the sensitivity analysis, whoever must make decisions will be informed about the risk of the investment if these variables are not monitored. Since these conditions could render the investment unprofitable, it is important to take control measures such as judicious use of resources to minimise operating cost. Good market prices for stored grains will definitely improve this situation.

4.5 Characteristics of Cowpea Grain that Influence the Purchase Decision of Consumers

The final consumer is very important in any production process. From this premise, it is thus important to determine the quality characteristics that are acceptable to the final consumer. The study tried to find out from consumers these qualities, which were ranked to know those that are very important and least important. It is worth noting that the value of grain depends not only on the market situation, that is, on the conditions of supply and demand, but also, and especially on its quality. Quality is judged according to many characteristics, which can be divided into two groups. The first group is appraisal on sight of the external characteristics, which includes whether the grains are well filled, homogenous, and do not contain impurities or broken grains; colour and odour are also important. The second group is appraisal by analysis in order to determine the internal characteristics including protein and flour contents. This study basically considered the appraisal based on sight and taste, which consumers look out for in the grain.

The quality characteristics of the cowpea grain that were considered includes; taste, cooking time, grain colour, absence of impurities, absence of insect emergence holes in the grain, smoothed seeds and level of swelling when cooked. The result is summarised in Table 4.8.

Table 4.8 Consumer Ranking of Quality Characteristics of Cowpea Grain

Quality Characteristics	Number of Respondents	Percent	Rank
Absence of Impurities	61	95	1
Absence of Holes	58	91	2
Cooking Time	52	81	3
Taste	22	35	4
Grain Colour	18	29	5
Level of Swelling	8	13	6
Smoothed Seeds	5	8	7

Source: Survey Data.

The ranking was based on the proportion of the respondents who placed the quality characteristic as ranked. For instance, a rank of 2 for absence of holes in the grain means 91% of the respondents placed that quality characteristic second. Brief comments on the characteristics from the point of view of the consumer are presented below.

(i) Absence of Impurities: This is ranked first as the most important quality considered by consumers with 95% of the respondents alluding to this. Foreign matter, other grains, small stones, sand, bits of string, straw blades, for example, cause difficulties during later cleaning process and thus lower the quality of the produce.

(ii) Absence of holes in the Grain: The presence of insect pests causes nutritional loss to the grain thereby reducing its quality as well as value. It is therefore very important for cowpea farmers to use appropriate measures at their disposal to ensure that insect pests do not infect their stored grains by feeding on the grain and creating holes in them, which eventually reduces its quality. This quality characteristic is ranked second by 91% of the respondents making it very important.

(iii) Cooking Time: Cooking time is important in consumer preference for cowpea because of high energy (fuel) and time required for the culinary preparation of cowpea based foods. This may be a constraint for increased consumption of cowpea. This particularly applied to the cooking of dry seeds, which is consumed in combination with the primary staples in the diet, which include cassava (gari), yam, rice, plantain, cocoyam and sweet potatoes. Legumes generally take considerably longer time for cooking than any other vegetable product. This is especially true with whole grains. Cooking time depends to some extent upon the thickness of the seed coat and its composition. In addition to seed coat, the composition of the seed itself has some influence on cooking time. The cowpea consumers sampled thus rank cooking time as the third most important quality that determines consumer preference.

(iv) Taste: Taste as a quality characteristic of cowpea depends on the variety and the processing method to which the grain is subjected. Cowpeas generally have natural flavours, which can be influenced with the addition of some additives during processing or cooking. The consumer prefers grains, which gives good flavour after it is cooked.

(v) Grain Colour: A uniform colour conforming to that expected of the variety is required. The taste of the consumer together with the use to which the grain is put determined the choice of grain colour by consumers. This characteristic was ranked fifth by the respondents in terms of importance in the making of purchase decision.

(vii) Level of Swelling: This characteristic is very much relevant to commercial cooked food sellers who are much more concerned with the quantity of the food.

(vii) Smoothed Seeds: Smoothed seeds as a characteristic only appeals to the eye. No wonder some consumers classify it as not being important at all in affecting their purchase decisions.

It is worthwhile to note that whereas the above characteristics play important roles in consumer preference when the consumer is in a position to spend a little more, cost plays a very important role in the case of the consumer who can barely afford that commodity. When the consumers are not in position to buy pulses, the question of preference does not arise. If they buy at all, they buy the grain, which costs the least.

4.6 Regression Results

The Probit model was estimated to determine the probabilities associated with the adoption of pest control methods in cowpea storage. The results from the model are presented in Table 4.9.

Table 4.9 Probit Model Results for Chemical Pest Control by Cowpea Farmers

Dependent Variable : Chemical Pest Control (CPC)

Method : Binary Probit

Sample : 1 48

Included Observations : 48

Convergence achieved after 4 iterations.

Variable	Coefficient	Standard Error	t-statistic	Probability
EDU_1	-1.5886	0.9508	-1.6708	0.0948 *
SEX	1.0759	0.5935	1.8127	0.0699*
FSIZE	0.0134	0.1047	0.1282	0.8980
INF	0.4337	0.4183	1.0367	0.2999
EDU_0*EXP	-0.0214	0.0314	-0.6824	0.4950
EDU_1*EXP	0.0006	0.0364	0.0169	0.9865
CONSTANT	0.1681	0.7961	0.2112	0.8327

* Significant at 10% level

Loglikelihood = -29.03212

Obs with Dep = 0 21

Obs with Dep = 1 27

EDU_0 -No formal education; EDU_1- Basic level education; EXP- experience in cowpea farming; SEX - gender of the respondent; FSIZE- household size; INF- infrastructure.

Source: Model Results.

The results for the adoption of chemical pesticide model as given in Table 4.9 indicate that sex (SEX) and basic level education (EDU_1) were the only variables that are significant in explaining the probability of adoption of chemical pesticides at the 10 percent level. While sex had the expected sign, basic level education did not. However, household size (FSIZE), infrastructure, experience in cowpea farming (EXP) and no formal education (EDU_0) were not significant. The following variables, age (AGE), origin (ORI) and proportion of cowpea in trade activity (PCT) did not enter the model due to the problem of singularity in the data. Although infrastructure (INF) and household size (FSIZE) were both insignificant, they had the expected signs.

The negative coefficient of the variable depicting basic level education (EDU_1) could be attributed to the fact that educated farmers tend to have access to more information, and as a result are able to use preservation methods other than chemical usage. Again, their knowledge about the effects of the improper usage of these chemicals on the consumer's health as a result of chemical residues could make them to shift to the use of other modern methods of preserving their grains without the use of chemicals.

The positive coefficient of the sex of the respondents indicates that males tend to adopt the use of chemicals more than their female counterparts. This could be explained as the males having more access to credit than the females. This enables them to afford the purchase of these chemicals, which are expensive.

Whether basic or no formal education and experience had an effect on the use of chemical pesticide in storage of cowpea was tested with the interactive terms (EDU0*EXP and EDU1*EXP). None were significant.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study has identified the different means of preservation and storage of cowpea against insect pests. It has also determined the characteristics of cowpea grains that influence the purchase decisions of consumers as well as the profitability of the hydrothermal treatment technology as a means of preserving cowpea grains.

It was found that cowpea farmers are aware of the following storage pest control technologies of cowpea: pod storage, sealed bag storage, hydrothermal treatment technology, chemical preservation, and preservation with ash, black pepper and groundnut oil. Although the farmers know these technologies, they cited the fear of damage of the produce by insect pests during storage and sometimes need for money for emergency situations as reasons for not storing their produce. It is interesting to note that none of the farmers practises hydrothermal treatment technology although some of them know of it.

Empirical evidence from the probit model on the adoption of technologies indicated that, chemical preservation as a technology was significantly affected by farmer's sex (gender) and the farmer having some basic level of education.

The study also identified the following as some of the external characteristics of cowpea grain that affect the purchase decisions of the consumer, ranked in order of importance and beginning with the most important: absence of impurities, lack of holes in the grain, taste, grain colour, cooking time, level of swelling and smoothed seeds.

Estimates of net present value of ¢345,262.42 and an internal rate of return of 90% suggest that cowpea preservation by way of hydrothermal treatment technology is generally profitable. However, when a sensitivity analysis was carried out assuming a drop in the selling price of treated cowpea by 10%, the investment turned out to be unprofitable. Handsome financial returns may be realised from cowpea preservation through the hydrothermal treatment technology by adopting the technology in areas such as the Northern Region of Ghana where cowpea prices are relatively low most especially at harvest periods.

5.2 Recommendations

Based on the results of the study, the following are recommended for consideration by policy makers and other interest groups.

1. Agricultural Extension Services Department should educate or introduce more farmers to the new technology of preserving their cowpea grains using the hydrothermal treatment technology, which was found to be profitable. This will allow for the farmers to test it along side their current methods.

2. Farmers must be encouraged to form cooperatives to handle their input purchases and output sales on behalf of members. This will enable the farmers to enjoy discounts for buying inputs in bulk from wholesalers or manufacturers and also protect them from middlemen and women who sometimes cheat them by buying their produce at ridiculously low prices. Protection of farmers from middlemen is important as the study indicated that the profitability of the hydrothermal treatment technology is sensitive to decline in the selling price of cowpea.

3. Similar profitability studies should be carried out on other cowpea grain preservation and storage technologies. The results of such studies will form the basis for comparism and making of informed choices by farmers.

4. The characteristics of cowpea such as taste and cooking time as identified by this study as determining the choice and purchase decisions of consumers should be considered in breeding programmes of cowpea varieties.

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11. Give an estimated proportion of your cowpea output that was sold for last season in percentage terms..

12. What variety(ies) of cowpea do you cultivate?

1 [ ] Asontem	4 [ ] Local variety
2 [ ] Amantin	5 [ ] No idea
3 [ ] bengkpla	6 [ ] Other (specify)............................

13. What is (are) the reason(s) for the choice of a particular variety (ies)?
    1 [ ] Early maturing
    2 [ ] Resistant to insect pests
    3 [ ] High yielding
    4 [ ] That is what is available
    5 [ ] Others (specify)...

14. (a) Do you store the cowpea you produce? 1 [ ] Yes 2 [ ] No.

15. If Yes to question 14, what is the purpose of storage?
    1 [ ] Await better market price
    2 [ ] For family consumption
    3 [ ] Maintain quality
    4 [ ] Assemble larger volume
    5 [ ] Other (specify)...

16. If No to question 14, provide reasons.

    1 [ ] Fear of damage by insect pests
    2 [ ] Needed money for an emergency
    3 [ ] Other (specify) ....

17. Do you preserve cowpea before storage? 1 [ ] Yes 2 [ ] No.

18. Do you own or have access to a storage infrastructure such as silo etc?

    1 [ ] Yes 2 [ ] No.

19. Which of the following cowpea preservation methods or technologies is/are known to you and which ones do you use? (Tick as many as appropriate).

Preservation Method	**Known to me (Please tick)**	**Using it (Please tick)**	**Estimated effective protection time (months)**
Chemical preservation (treat with chemical before storage).			
Pod storage (keep in pod)			
Sealed bag storage			
Preservation with ash			
Hydrothermal treatment			
Others (Specify).			

20. Provide the following information by stating the inputs associated with the various storage technologies with their input costs for year 2001. **NB: Excluding chemical preservation.**

Technology	**Inputs**	**Cost per unit**
1	....	....
2	....	....
3	....	....

21. List the chemicals that you normally use in chemical preservation of cowpea.

(i)...

(ii)...

(iii)...

22. For each chemical used kindly answer the following questions.

(a) (i) Name of chemical...

(ii) Why is the chemical used?...

(iii) Who applies the chemical?..

(iv) When is the chemical applied?...

(v) How often is the chemical applied?......................................

(vi) How is the chemical applied? 1. [ ] Spray 2.[ ] Dust 3.[ ] Other......

(vii) In what concentration is the chemical applied?...............................

(viii) Does the use of the chemical represent a health hazard to consumers?

1. [ ] Yes 2. [ ] No

If yes, explain...

(ix) Give the cost of the chemical per unit treatment...............................

(b) List other chemicals and provide information (i)- (ix) as listed under 22 (a) above.

23. To whom do you sell cowpea?

1 [ ] Wholesalers
2 [ ] Retailers
3 [ ] Final consumers
4 [ ] Other (specify)...

24. Provide the highest and the lowest price per unit of cowpea for last year (2001).

Highest price ¢...

Lowest price ¢..

25. How many ''olonka'' of cowpea make up one maxi bag in your area?...............

26. What problems do you face relating to cowpea preservation and storage?

1 [ ] High cost of chemicals for preservation
2 [ ] Difficulty of getting access to the chemicals for preservation.
3 [ ] Others (specify)..

....

....

....

27. What problems do you face relating to cowpea marketing?

....

....

....

APPENDIX II

QUESTIONNAIRE FOR COWPEA CONSUMERS

Code Number...
Date..
Location...
Interviewer..

1. To what use do you put the cowpea purchased?
   1. [ ] Final household consumption
   2. [ ] Commercial cooked food
   3. [ ]Others (specify)...

2. Prices in the market you buy your grains are largely determined by:
   1. [ ] Individual traders
   2. [ ] Traders association
   3. [ ] Co-operatives
   4. [ ] Government
   5. [ ] The market
   6. [ ] Others (specify)...

3. How often do you buy cowpea? ....times per ....1. week 2.month

4. How much quantity of cowpea on the average do you buy per trip?...........

5. Do you care to know whether the grain has been treated with chemical?
   1 [ ] Yes. 2 [ ] No.

6. If Yes to question 5 above, how does it affect your purchase decision? (explain)

....
....
....
....

7. Consider each of the following quality characteristics of the cowpea grain. From your experience, how do these qualities of cowpea grain determine your purchase decision? Indicate your answer by rank ordering each of the qualities from the most to the least important. **(Please Tick).**

Quality Characteristics	**Order of importance**								**Not important**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Taste									
Cooking time									
Grain colour									
Lack of holes/ Absence of insects									
Absence of impurities such as stones.									
Smoothed seeds									
Level of swelling									

8. Please provide any comment you have on the cowpea you buy.

<u>Cowpea Variety</u> <u>Comment</u>

(a)

....

....

(b)

....

....

(c)

....

....

9. Gender of Respondent 1 [ ] Male 2 [ ] Female

10. Age (years)..

11. Marital status

1 [ ] Married 3 [ ] Widowed 5 [ ] Separated.
2 [ ] Single 4 [ ] Divorced

12. Level of education
1 [ ] None
2 [ ] Primary/ JSS/ Middle
3 [ ] Secondary / Training College/ Technical
4 [ ] Tertiary
5 [ ] Non-Formal education

13. Which of these economic activities are you engaged in?
1 [ ] Artisan/ skilled craft person
2 [ ] Public servant
3 [ ] Trader
4 [ ] Farmer
5 [ ] Cooked food seller
6 [ ] Student
7 [ ] Unemployed
8 [ ] Others (specify) ....

APPENDIX III

QUESTIONNAIRE FOR RESEARCHERS WORKING ON THE HYDROTHERMAL TREATMENT TECHNOLOGY

1. Name of respondent..

2. Name the equipment used in the hydrothermal treatment of cowpea together with the subsequent questions.

Equipment	No. of Equipment	Cost Per Unit	Total Cost

3. Complete the Table below.

Item	Quantity used per Batch	Price per unit of Item	Annual Cost
(i) Water			
(ii) Casual labour			
(iii) Polythene Sacks			
(iv) Energy			
(v) Value of cowpea to be treated			
(vi) Transport cost			
(vii) List other items			

4. How much does a 90 kg (maxi) bag of untreated cowpea cost?..........................

5. At full capacity, how much quantity of cowpea can be processed in a month?..........

APPENDIX IV

REFERENCE NOTES AND ASSUMPTIONS MADE CONCERNING THE DETERMINATION OF PROFITABILITY INDICATORS (NPV and IRR).

(i). The year 2001 was the base year. Therefore, 2001 market prices for each commodity or service was used and subsequently forecasted.

(ii). It was assumed that the steamer has the capacity to treat one tonne of cowpea per annum.

(iii). The steamer was assumed to have a useful life of 6 years and a zero salvage value.

(iv). Depreciation and interest payments were not included in the determination of annual operating cost due to the fact that, the major characteristic of the incremental net benefit stream or Incremental cash flow is that it includes, without differentiating, both the return of capital (that is, depreciation) and return on capital (that is, interest payments) (Gittinger, 1982, page 316).

(v). One (1) maxi bag of cowpea grain is weighed 90 kilogramme (kg).

(vi). The value of cowpea to be treated was determined with harvest time selling price of ¢100,000.00 per 90 kg bag of the grain.

(vii). Total Revenue was computed with year 2001 lean season price of ¢160,000.00 per 90 kg bag of cowpea.

(viii). A zero percent loss of cowpea was assumed during storage.

APPENDIX IV

REFERENCE NOTES AND ASSUMPTIONS MADE CONCERNING THE DETERMINATION OF PROFITABILITY INDICATORS (NPV and IRR).

(i). The year 2001 was the base year. Therefore, 2001 market prices for each commodity or service was used and subsequently forecasted.

(ii). It was assumed that the steamer has the capacity to treat one tonne of cowpea per annum.

(iii). The steamer costs ¢240,000.00 and was estimated to have a useful life of 6 years and a zero salvage value.

(iv). The initial unit prices of the other cost items were as follows: Bowl - ¢2,500.00 each; Bucket - ¢7,000.00 each; Water - ¢2,000.00 per 155 litre container; Labour cost - ¢2,000.00/manday; Sack - ¢500.00 each.

(v) Depreciation and interest payments were not included in the determination of annual operating cost due to the fact that, the major characteristic of the incremental net benefit stream or Incremental cash flow is that it includes, without differentiating, both the return of capital (that is, depreciation) and return on capital (that is, interest payments) (Gittinger, 1982, page 316).

(vi). One (1) maxi bag of cowpea grain is weighed 90 kilogramme (kg).

(vii). The value of cowpea to be treated was determined with harvest time selling price of ¢100,000.00 per 90 kg bag of the grain.

(viii). Total Revenue was computed with year 2001 lean season price of ¢160,000.00 per 90 kg bag of cowpea.

(ix). A zero percent loss of cowpea was assumed during storage.

APPENDIX V

SENSITIVITY ANALYSIS

Appendix Table 5A: Sensitivity Analysis Assuming 10 percent decline in the Price of Treated Cowpea.

YEAR	TR (¢)	TC (¢)	CF (¢)	DF @ 38%	PV_{TR} (¢)	PV_{TC} (¢)
0	-	342,000.00	-342,000.00	1.0000	0	342,000.10
1	1,599,840.00	1,436,780.00	163,060.00	0.7246	1,1592,244.06	1,041,090.79
2	1,599,840.00	1,470,620.00	129,220.00	0.5251	840,075.98	772,222.56
3	1,599,840.00	1,498,900.00	100,940.00	0.3805	608,739.12	570,331.45
4	1,599,840.00	1,498,600.00	101,240.00	0.2757	441,075.89	4133,164.02
5	1,599,840.00	1,498,600.00	101,240.00	0.1998	319,648.03	299,420.28
6	1,599,840.00	1,498,600.00	101,240.00	0.1448	231,656.83	216,997.28
TOTAL					**3,600,439.91**	**3,655,3226.38**

NPV	**-¢54,786.46**
IRR	-

Note:
Ten percent (10%) decrease in Selling Price of treated cowpea was assumed. That is a fall from ¢160,000.00 to ¢144,000.00 per 90 kg bag.

Appendix Table 5B: Sensitivity Analysis: Assuming a 10 percent increase in the Price of Untreated Cowpea.

YEAR	TR (¢)	TC (¢)	CF (¢)	DF @ 38%	PV_{TR} (¢)	PV_{TC} (¢)
0	-	342,000.00	-342,000.00	1.0000	0	342,000.00
1	1,777,600.00	1,546,780.00	230,820.00	0.7246	1,288,048.96	1,120,796.79
2	1,777,600.00	1,580,620.00	196,980.00	0.5251	933,417.76	829,983.56
3	1,777,600.00	1,608,900.00	168,700.00	0.3805	676,376.80	612,186.45
4	1,777,600.00	1,608,600.00	169,000.00	0.2757	490,084.32	443,491.02
5	1,777,600.00	1,608,600.00	169,000.00	0.1998	355,164.48	321,398.28
6	1,777,600.00	1,608,600.00	169,000.00	0.1448	257,396.48	232,925.28
TOTAL					**4,000,488.80**	**3,902,881.38**

NPV	**¢97,707.42**
IRR	**54%**

Note:

Ten percent (10%) increase in the value of cowpea to be treated was assumed. That is an increase from ¢100,000.00 to ¢110,000.00 per 90 kg bag.