STUDIES ON TECHNOLOGICAL INTERVENTIONS TO UPGRADE SELECTED INDIGENEOUS FOOD PROCESSES

BY

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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October 13, 1994

Date

CERTIFICATION

This thesis entitled "STUDIES ON TECHNOLOGICAL INTERVENTIONS TO UPGRADE SELECTED INDIGENEOUS FOOD PROCESSES" by Ali Mohammed Abdulkarim meets the regulations governing the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This work is dedicated to all those people that contributed in molding my character.

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I wish to express my profound gratitude and appreciation to my major supervisor Prof. R.N. Kaul for his immense contribution in stages of initiation and completion of this work. Generally, he has worked relentlessly to mold my scientific life. I have learnt not only engineering, but also hardwork, planning and perserverance. His contribution cannot be forgotten in my entire career.

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ABSTRACT

This study pertains to study of indigeneous milk and 'Fura' making processes with aim of introducing technological interventions to upgrade the existing methods.

Surveys were undertaken at Kano, Kaduna, Sokoto, Kebbi and Katsina States to find out what the existing practices are and various intricacies involved, studies were also conducted in the laboratory' to quantify the indigeneous processes. Using kinesiologic analysis and anthropometric principles, selective interventions were introduced to ease the identified constraint. The introduced changes were compared with existing for engineering performance and cost economy.

Studies of existing method of milk processing identified the task of agitation for butter extraction, as the major constraint. To upgrade the system, three approaches were used, Biomechanical studies showed that churning process was related to kinesiology of the body, and the process was improved by increasing the height through which the container (gourd) was raised. Time for churning was reduced by 46,2% when height of churning was increased by 40 cm. This also enchanced butter yield by 18.3%. Anthropometric analysis of user population identified the dimensions of gourd neck diameter to be 6,17 cm and neck height to be 21,12 cm which sets cri-teria for proper selection of such gourds. An agitator was developed to replace the the traditional gourd. Comparative tests between the

agitator and traditional method showed an average saving of 84,4% in time use and 349.4% in energy requirement. These three options represent possibilities of improving churning process to extract butter.

Study of Fura processing showed that dehulling and grinding were the major constraints. Dehulling and grinding are basically pounding process using mortar and pestle. Kinesiology studies of pounding showed that pounding is affected by weight of pestle, muscle force applied and angles between arm and body trunk. Anthropometric studies of pounding using user data fcecomrnends a pestle dia of 6.17 cm and length of 103.8 cm. Conventional motorized dehulling and grinding machines were tried as interventions. Comparative studies in different combinations with indigeneous process showed the possibility of selecting a system with over 50% savings in time and energy.

For an integral Fura and Npno enterprise, six systems were considered in different combinations. Time and energy requirements and costs were analysed between the systems. Results showed that systems can be chosen in line with certain parameters like volume, accessibility of technology and cost involved. A guideline was provided to facilitate choice for maximum output, minimum energy and maximum profit.

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CHAPTER ONE

INTRODUCTION

Improvement on existing systems using time and motion and related studies is a well known technique in conventional mechanical workshops and other industries. Such studies have led to improvements on time and energy requirements sometimes with a saving of up to 50% or more. Steps taken in such studies normally include a thorough study of the existing system to identify constraints within the system and then introduce ergonomic and other technological interventions to improve on performance and economic advantage. Unfortunately in agricultural sector major emphasis has been on introducing new technologies (usually western base) which are quite different from the traditional indigeneous processes and often are not assimilated in the system. This study is an attempt to take stock of few existing traditional processes and introduce improvements. Indigeneous food processing activities of milk processing and 'Fura' making were selected due to their importance in the local food consumption for application of this concept.

The traditional milk processing industry comprises of small units where milk obtained from traditionally kept cattle is processed into locally acceptable products. Under the traditional dairy system, some 10-14 million cattle are kept. Milk production under this system is approximated

at 715,400 tons per annum. It is from the traditional set-up that local milk products are made available to different parts of Nigeria for consumption by the teeming population. Operators of this system belong to a tribe known as Fulani; each family owns an average herd ranging between 40-60 cattle and average milk off-take per lactating cow per day is 3/4 litre (Water-Bayer, 1988). Women are the sole operators of the traditional milk industries and untensils used in the dairy processing and marketing are part of normal household equipment. The most popular product produced from traditional milk processing industry is 'Nono' (fermented butter milk) and butter. Traditional method of making Nono includes shaking whole sour milk in a gourd until butter grains form. For 4-5 litres of sour whole milk this process could last between 1-1½ hours, yielding butter of 120-150 gm.

In addition to the role of Fulani women as managers of the milk processing industry, they process cereals into 'Fura' to sell with Nono. Fura is a spicy dumpling made mostly from millet. Of the 715,400 tons of milk produced locally, 357,700 tons is processed into local products and distributed by the Fulani women. A study spanning a year on consumption of local milk products in Nigeria showed that Nono in Fura is most consumed

accounting for between 55%-90% by weight of total milk products depending on the month. Thus, Fura and Nono constitute a substantial industry though 'unseen' from industrial perspectives.

From 1 kg of millet grains, 1.7-1.8 kg of Fura could be made. A typical serving of Fura with Nono weighs 600 g with 240-250 gm Fura and 350-360 g milk (i.e. a ratio of 1 to 1.4-1.5).

The importance of the traditional milk industry to 'fulani' women, their households and to the nation cannot be over emphasized. First, the fulani supply about 50% of their milk offtake for home consumption. That provides the family with protein and energy requirements. Apart from this, the industry contributes to family income. Generally, the women use 2/3 of their income on food (like seasonings, condiments, oil, sugar, salt, etc). They also use their income to buy pots, jewelleries, clothings, etc for their family. The contribution of the fulanis to national economy is also immense. They distribute milk in form of Nono and Fura to different parts of Northern Nigeria and some parts of Southern Nigeria. It is estimated that within the traditional milk and cereal processing industries 583,333t of Fura and Nono is processed and distributed in a year.

One cannot fail to observe that the more than half a million tons of Fura and Nono mentioned above is processed with traditional tools. In fura making, main tool used are a mortar and pestle to dehull millet and to pound fura into a consistent mass. On the other hand, calabash gourd is the main tool used in milk processing to produce Nono and butter. All these tools are traditional and demand high energy and time. The mortar and pestle process has been described as inefficient, time consuming, and difficult and yields 1-1.5 kg of flour per hour (Perten, 1983). A survey (Waters-Bayer, 1986) revealed among others, the inefficiency of fura making and butter extraction. She described fura making as the most demanding processing activity done by women in terms of time and energy. Simmon (1975) found that fura making was very profitable, but entry to the business is restricted by the high physical exertion required. As a result of arduous nature of fura making, it is fast disappearing in cities. Those that still do it produce only on small scale. Thus it is a process that is fast on the decline.

It was the aim of this study to address above problems with a view to encouraging production and higher levels of processing of Nono and Fura.

More specifically, objectives of the study are stated as under:

1. To conduct a detailed survey of existing methods/tools for making fura and processing of sour milk (covering most major consumption areas).
2. To quantify the duration and energy requirement of the existing methods and identify areas of improvement.
3. To study ergonomics of methods and/or tools involved in each process (including anthropometry and keinesiology) and evolve a description of the process (involving variable parameters which could be manipulated).
4. Evolve/adopt improve methods and/or tools to reduce time and energy requirement thereby allowing increased productivity.
5. Compare the new methods and tools with existing methods and tools for engineering efficiency and economic savings.

JUSTIFICATION FOR STUDY

To achieve an impact on a system, there is need to fully understand present system and develop an intervention relevant to existing. With the help of some 2.6 million Fulani, 715,400 tons of milk is produced out of which 357,000 of milk is processed into local products and distributed to many parts of Nigeria. Similarly, 233,333 tons of fura is produced. Time required for processing these products is 205 million hrs. per annum. This is no doubt tremendous amount of time. An impact could be achieved if interventions at existing scale are found, which is the focus of this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Millet - Type, Production and Uses

Millet is the basic raw material for Fura. Millet and sorghum are staple food crops in many African and Asian countries where the dry, hot climate does not permit growing of wheat and rice. Millet is a cereal crop grown in many parts of the world and grow well in guinea and sudan savannah zones (Muller, 1970). Millet production world wide stood at 28.3 million tons in 1980. There are different varieties of millet. Some examples among them include: E. coracana and P. americanum.

Sorghum occupies almost 50% of the total land area presently under cereals in Nigeria and together with millet, they account for about 90% of the total land area under cereals. The estimated annual production of millet is 3.2 million tons. In terms of production, sorghum and millet account for about 70% of the total cereal production in Nigeria (Nwasike and Aba, 1986).

Millet is often reduced to flour for consumption. There are different techniques for doing this especially in the developed nations. The method is mostly traditional by the use of mortar and pestle. This method dates back to 2500 B.C. till date (Muller, 1970). Hand pounding has been described as inefficient, time consuming and a

hardwork and yields only 1-1.5 kg of flour per hour (Perten, 1983). Nonetheless, this method remains the dominant method of processing millet in most parts of the developing nations.

Millet is used for different purposes in different parts of the world. It is important to mention that although cereals (millet inclusive) are typical carbohydrate foods, their protein content is far higher than that of tubers. Whereas the latter have a protein content of the order of 2-3%, that of the cereals is about 10% (see Table 2.1), and they will generally sustain an adult but not growing children (Muller, 1970). In an international conference on sorghum and millet uses, cases of increased use of these two crops as traditional food, for industrial uses and feed were reported (ICRISAT, 1992). Crop uses vary from one location to another.

Table 2.1: Analysis of Various Grains Consumed in West Africa (%)

	Protein	Fat	Carbohydrate	Fibre
Maize (Z.mays)	10.0	4.5	71	2.0
Finger millet (E. Coracana)	6.0	1.5	75	3.0
Bullrush millet (P. americanum)	11.0	5.0	69	2.0
Sorgnum Spp.	10.4	3.4	71	2.0
Wheat (T. Vulgare)	11.5	2.0	70	2.0
Rice (O. Sativa)	8.0	1.5	77	0.5

Source: Food Science Lab, I.A.R., 1993

In Senegal, consumption of millet is generally in the form of porridge eaten with a vegetable and a meat sauce and in the form of millet couscous. Millet production in Senegal stood at 650,000 tons annually. In Sudan, millet is used in form of a thin pancake. Annual production of millet in Sudan was 500,000 tons (Perten, 1983). Cereal productions made from millet could be classified rheologically as beverages, porridges, dumplings and fried or baked products (Table 2.2). Looking at the tables, fura is not restricted to Nigeria alone and that the regular percentage quantities for processing is large.

Table 2.2: Classification of Some Typical Ghanaian and Nigerian Millet Products.

Beverages	Porridges	Dumplings	Baked or fried products
Kaffir beer	Ogi	Hura (Fura)	Bread
Pito	Køko	Eko	Atshomo
Burukutu	Ekuegbemi	Banku	Togbei
Kunnu tsaki	Tuo	Fula	
	Grain acha	Kenkey	
		Akporche	
Aliha	Ablemamu-akasa	Nsihu	
Iced kenkey	Kunnu tsamia	Kokui	
		'Abolo	
m.c. more than 94%	m.c. about 90%	Sweet kenkey m.c. 65-80%	

Source: Perten, 1983

In Northern Nigeria, millet is used for varied purposes. Among products obtained from millet include: Fura, Tuwo, Kunnu, Kunnu zaki. With dwindling foreign exchange earnings in Nigeria, and consequent ban on some crop import, many attempts were made to expand the traditional uses of millet and sorghum, as well as industrial food and feed uses. For example, millet and sorghum flour were used to make non-wheat bread, biscuits and sausages (Olatunji et al., 1992).

2.2 Pastoralism

Pastoralism is a production system in which people derive their livelihood mainly from herds of domesticated, herbivorous animals utilizing predominantly natural pasture. This is the main occupation of the Fulani. Either as herd owners or hired herders, they keep cattle and to a lesser extent sheep and goats from Cap Vert in Senegal to the Cameroon highlands and further through Central Africa as far as the Nile river in Sudan. Fulani can be found herding cattle even as far south as the Accra plains of Ghana (Hill 1970) and the coastal forest belt of Nigeria (Fricke, 1979). However, the vast majority of pastoralists in Nigeria live in the northern half of the country (Fricke 1979, LRM 1981). It has been estimated that 80-90% of Nigerian cattle are kept by the Fulani (Frantz 1978, Putt et al., 1980).

Generally, Fulani pastoralists are classified according to their mobility: e.g. nomadic, semi-normadic, semi-settled and settled (e.g. Van Raay, 1974).

A common pattern of movement was to take cattle south in the dry season, when nutritious forage was available in the tsetse infested sub-humid areas but when the danger of contact between animals and flies was at its lowest level, and to retreat to the north when the fly population extended with the on set of the rains. In a recent aerial survey conducted by ILCA in the dry season, total number of cattle in south west were 194,020, in south east 760,510 and in derived savannah 302,450 (ILCA Annual Report, 1988).

2.3 Role of Women within the Fulani Set-Up

A state of independence as head of a monogamous or polygamous family responsible for its own survival is what a Fulani man strives at. To achieve this state of independence, the family should be sufficient to take proper care of the herd, and the herd should be adequate to support the family (Stenning, 1958). As such, the first major responsibility for the Fulani woman is to bear children to permit household independence.

One of the economic pursuits of Fulani is to produce milk which is consumed directly and the rest exchanged for food and services. The women were responsible for milking, milk processing and marketing dairy products surplus to family needs. They gave minor health treatment to the calves in their care. In the case of sheep and goats, a woman's responsibility also included animal husbandry, purchase and sale (Dupire, 1963). For nomadic fulani, division of labour between men and women was not rigid: if the necessity arose, the men might assist in milking and the women in herding (Van Raay, 1974).

The women milked the cows, with calf at foot. As milkers, the women decided how much milk to extract and how much to leave for the calves. They also decided how much milk was given to the family to consume-more commonly fresh than curdled. Any remaining milk was sold by the women. Casn was used by the women mainly to buy clothing, ornaments, and small stock. Milk earnings were neither used to help husband pay taxes, not even for the wife's cattle, nor to cover production expenses for the herd (Dupire, 1962; St. Croix, 1944).

The role of women within the Fulani set-up change depending on whether they are nomadic, transhumant or settled. When a Fulani household settles, division of responsibility changes within the household. This is because, settlement is often preceded by increased involvement

in cultivation and regular participation in markets (for sale of livestock products and purchase of goods). Within normadic Fulani, the women were fully responsible for milking, this changes with sedentarization, when the men generally assumed responsibility for milking (St. Croix, 1944). Despite this changes, the household head gave the milk to his wife or wives, who still decided how much of the milk was consumed at home and how much was sold. They also retained rights over the sale proceeds.

Women's involvement in farming activities varied according to the extent of farming and also to the customary practices in the neighbourhood. The men did most of the work in grain cropping, although women might help, particularly at harvest, and also sometimes cultivated minor crops independently from the men (Delgado, 1979; Okaiyeto, 1980). Generally, the women helped in planting and harvesting cereals (Water-Bayer, 1986).

Marketing is the sole responsibility of women. The women sold not only at markets but also at other regular selling points in villages and on roadsides, at employment sites, schools, churches, farmhouses, door-to-door in town, and to customers who go to the Fulani home (Waters-Bayer, 1986).

Fura making was an integral part of milk marketing because the availability of Fura facilitated the sale of nono and allowed the women to gain a higher price for it. Fura was also an additional source of income (Waters-Bayer, 1986). It is the responsibility of the Fulani women to process and market fura.

2.4 Importance of Milk

Milk is secreted by the mammary gland of mammals to feed their offspring. Milk contains large amounts of essential nutrients and has rightly been recognised as nature's single most complete food (O'mahony, 1988). As a food, milk serves the purpose of growth, reproduction, supply of energy, maintenance and repair and appetite satisfaction. The functions of a food are served specifically through the various nutritionally important components, comprising proteins, carbohydrates, lipids, minerals, vitamins and waterthat constitute milk.

Milk provides more essential nutrients in significant amounts than any other single food. Milk is an oustanding source of calcium and phosphorus for bones and teeth, and contains riboflavin, vitamins B_6, A and B, in significant amounts. It also contains B_{12}, the antipernicious anaemia vitamin.

Fats supply the body with a concentrated source of energy: oxidation of fat in the body yields 9 calories/g. Proteins are an important naturally occuring compounds essential to all life processes. Protein has many functions ranging from providing structure to reproduction. Lactose is a source of energy, and provides 4 calories/g. Milk provides the body with some essential salts in small or trace amounts. Milk salts are mainly chlorides, phosphates and citrates of sodium, callium and magnesium.

2.5 Milk Composition and Processing

Quantities of milk constituents vary considerably depending on the individual animal, its breed, stage or lactation, age and health status. Herd management practices and environmental conditions also influence milk composition (O'mahony, 1988). Table 2.3 below gives composition of cow's milk.

Table 2.3: Composition of Cow's Milk

Main Constituent	Range (%)	Mean (%)
Water	85.5 - 89.5	87.0
Total solids	10.5 - 14.5	13.0
Fat	2.5 - 6.0	4.0
Proteins	2.9 - 5.0	3.4
Lactose	3.6 - 5.5	4.8
Minerals	0.6 - 0.9	0.8

Milk and milk products have been used by man since pre-historic times. Butter making was recorded as far back as 2000 B.C. It is believed that cheese making was discovered accidentally and initially developed in Iraq circa 6000 - 7000 B.C. and spread with migration of populations due to famines, conflicts and invasions. Fermented milks have been prepared for more than 2000 years (O'mahony, 1988).

The development of milk separator in the 19th century led to or made possible centralised milk processing. From the onwards, cream was separated from fresh milk and fresh skim milk was returned to producers. Later, the importance of skim milk was recognised and lead to processes to conserve milk solids. Casein and casein products were prepared, as well as lactose and dried milk.

In Nigerian traditional processing, fresh milk is freed from dirt and then left to sour naturally. Whole sour milk is either churned to get butter, or consumed without further processing, (Ali et al., 1991).

2.6 Principle of Churning

If milk is left to stand, a layer of cream forms on the surface. The cream differs considerably in appearance from the lower layer of skim milk. Under the microscope cream can be seen to consist of a large number of spheres of varying sizes (i.e. fat globules) floating in the milk. Each sphere is surrounded by a thin skin - the fat globule membrane - which acts as the emulsifying agent for the fat suspended in milk. The membrane protects the fat from enzymes and protects the globules coalescing into butter grains.

To make butter, milk or cream is agitated vigorously at a temperature at which the milk fat is partly solid and partly liquid. There are many tools and devices for agitation, ranging from traditional to modern types. Churning efficiency is measured in terms of the time required to produce butter granules and by the loss of butter fat in the butter milk. Efficiency is influenced markedly by churning temperature and by acidity of the milk or cream.

In churning, cream is agitated in a partly filled chamber. This incorporates a large amount of air into the cream as air bubbles. The resultant whipped cream occupies a larger volume than the original cream. As agitation continues the whipped cream becomes coarser. Eventually the fat forms semi-solid butter granules, which rapidly

increase in size and separate sharply from the liquid butter milk. Thereafter, the remainder of the butter making process consists of removing the butter milk, kneading the butter granules into a coherent mass and adjusting the water and salt contents to the levels desired.

In the churning process, the following factors are worth noting: First, air is thought to be necessary for the process, but some researchers have demonstrated that milk or cream can be churned in the absence of air, although it takes longer.

Secondly, about one half of the stabilizing material is liberated into the buttermilk during churning. It is thought that during churning the fat globule membrane substance spreads out over the surface of the air bubbles, partly denuding the globules of their protective layer, and that a liquid portion of the fat exudes from the globule and partly or entirely covers the globule, rendering it hydrophobic. In this condition the globules tend to stick to the air bubbles. Free fat destabilises the foam, causing it to collapse. The partly destabilised globules clinging to the air bubbles thus collect in clusters cemented together by free fat. These clusters appear as butter grains.

The amount of cream to be churned should not exceed one half the volumetric capacity of the churn.

A number of factors (as reviewed by O'mahony, 1988) influence churning time and recovery of butter fat as butter:

1. Effect of acidity: Fresh milk is difficult to churn - churning time is long and recovery of butter fat is poor. Milk containing at least 0.6% lactic acid is easier to churn. Acidity higher than 0.6% does not significantly influence churning time or fat recovery.

2. Effect of temperature: Sour milk is normally churned at between 15 and 26 ^{o}C, depending on environmental temperature. At low temperatures churning time is long; butter grain formation can take 5 hours or more. As churning temperature increases churning time decreases. This becomes marked at temperatures above 20 ^{o}C, but as little as 60% of the butterfat may be recovered as butter at 26 ^{o}C. Control of temperature is therefore critical.

3. Degree of agitation: Increasing agitation reduces churning time.

4. Extent of filling the churn: Churns should be filled to between a third and half their volumetric capacity. Filling to more than half the volumetric capacity increases churning time considerably but does not reduce fat recovery.

2.7 Milk Production, Consumption and Marketing

Milk Production - Milk is mostly obtained from cattle in Nigeria. FAO estimate of cattle population was 10,859,000 as at 1966 (FAO Nig. Report, 1975). Later in the year 1986, cattle population was put at 14 million (ILCA, 1988). Production figure for milk as at 1966 was 446,000 tons per annum. From the population figure of 14 million in 1986, production figure is estimated at 715,000 tons per annum. It is estimated that 96 percent of the cattle are found in the northern states. The rest are in the south of Nigeria.

Because of the great variations in rainfall, milk production is subject to pronounced seasonal fluctuations. Figures obtained from the Jos Plateau area have shown that over 80 percent of the year's production is produced during the seven month's rainy season from May to November (FAO Nig. Report, 1975).

Milk Consumption and Marketing in Nigeria - The total marketing volume of milk and milk products is estimated at 546 million kg of milk equivalent, which can be divided roughly into two main sectors, namely traditional and organized marketing, and the latter further into two sub-sectors on the basis of milk origin (Table 2.4).

Table 2.4: Estimated Volume of Marketed Milk and Milk Products in Nigeria in 1986

Items	Traditional marketing	Organised Marketing		Total
		Based on domestic milk production	Based on imports	
Million kg of milk or milk equivalent	226	1	319	546
Percent breakdown	41.6	0.2	58.4	100

In a study of rural and urban areas in Oyo State and Kaduna States of Nigeria, preliminary data analysis shows that marketing and consumption of import based dairy products do not vary much from one part of the country to another. However, there are differences in consumption patterns of domestically produced dairy products and this relate to proximity to Fulani herds or settlements and to ethnic and cultural differences in food tastes and habits. As such consumption differ markedly between northern Nigeria, where most of the Fulani and their cattle are found, and the south, where trypanosomiasis has limited cattle production. However, the increasing interaction of the Fulani and the south-west has led to processing of surplus milk into cottage

cheese (wara) for sale by the local Yoruba women. Northerners resident in the south continue to follow traditional habits and consume sour milk (nono) and butter (manshanu). In the same way, the Yoruba in the north show a continued preference for cottage cheese.

Two distinct systems of dairy consumption and marketing appear to operate in Nigeria, the domestic and the import-based systems, with little overlap between them. Almost all domestic milk is produced by the Fulani, who process it in different ways in difrerent parts of the country depending largely on the characteristics and preferences of the ethnic groups with whom they are in contact. The marketing of imported dairy products is mainly in the hands of the Yoruba, who control the marketing system not only in the south-west but also in Northern Nigeria (ILCA, 1988).

Type of product consumed and frequency of consumption differ markedly between ethnic groups, urban and rural populations. Indigenes of south-east, Nigeria do not consume local dairy products. In contrast, 80% of indigenes in the south west consume wara, a local soft cheese and some consume fresh or sour milk or butter. People in rural areas consume local dairy products more often than do those in urban centres (ILCA, 1989).

Milk Consumption and Marketing in West Africa - A study of consumption pattern in West Africa has shown that consumption of dairy products is on the increase. Many factors on both the demand and supply side are responsible for promoting dairy consumption in the region. These factors include: Population growth, urbanisation, changing consumer preferences, plentiful world supplies of dairy products and favourable prices and, in some countries, increasing incomes (ILCA, 1988).

For West Africa as a whole, total demand for milk and milk products in 1988 was estimated at 3.1 million tons of liquid milk equivalent (LME). When demand is disaggregated by product type and origin (local or imported), by ecological zone (dry or moist) and by rural/urban categories, it was found that per capital dairy consumption is higher in the dry (arid and semi-arid) than in the moist (humid and subhumid) zone. However, total demand is almost equally distributed between the dry (51%) and moist (49%) ecological zones.

The zones differ markedly, however, in the proportion of dairy demand met by local production and in the proportion of total dairy demand that occures in urban areas. In the

dry zone, 72% of demand is met by local production, mainly fresh milk and yoghurt, compared with only 38% in the moist zone. This reflects the lower milk production base of the moist zone. Urban demand accounts for only 21% of total demand in the dry zone, compared with 60% in the moist zone. In the dry zone, 22% of urban demand is met by local products, compared with only 5% in the moist zone.

Data from F.A.O. indicate that annual consumption of milk and milk products in West Africa increased from 15 kg per person in 1974-76 to 18 kg per person in 1983-85 but fell to only 12 kg per person in 1985-87. Milk production increased only slowly during the 1970s and 1980s and even declined in drier areas of the region. In contrast, imports increased rapidly during the 1970's but subsequently declined, their share of total consumption falling from 45% in 1983-85 to 36% in 1985-87 (ILCA, 1989).

Recently with world market prices for dairy products rising and financial pressures on African governments increasing, imports have been falling pushing down domestic dairy consumption. Strong demand coupled with falling imports creates good opportunities for domestic producers.

2.8 Role of Women in Agriculture

It is important to note that what concerns generality of women could also be linked to Fulani women. Studies have shown that many Fulani women partake in Agricultural activities and related processing activities (Ali et al., 1991).

Many studies have been conducted world wide, which reveal the important role women play in the task of food production.

According to the United Nations economic commission for Africa, women provide between sixty and eighty percent of the agricultural labour in many parts of Africa. They are the principal producers of nearly all the basic food crops and engage in most farm activities which include: planting, weeding, harvesting, processing of food crops and marketing (Janelid, 1975).

FAC (1979) review of studies covering many parts of the world indicated that women in rural areas grow at least fifty percent of the world's food. They work in all aspects of cultivation, including planting, thinning, weeding, applying fertilizer and harvesting. In some parts of Africa, women provide upto ninety percent of the rural food. In Islamic countries, as well, many women are

involved in agriculture. In Pakistan, for example, about fifty percent of rural women cultivate and harvest wheat; in Jordan, sixty percent of the women weed crops.

Some tasks, especially seasonal ones such as clearing and preparing land are attributed to men, even then, women are found to be participating actively. In one area of Kenya, fifty eight percent of respondents to a survey reported that women were involved in clearing bush or ploughing (Okeyo, 1980).

Women often perform a dual role combining agricultural activities with childcare or housework, often doing both simultaneously. Because of the long day women work, quality of household diet has been found to deteriorate during the rainy season. Fig. 2.1 is a typical day in the life of a woman in rural Africa.

A study of African women labour input in agriculture shows that women put in more work-hours than men throughout the year in most African countries, and that the number of women engaged in agriculture among farming families was higher than that of men, to the extent that the study refers to such areas in Africa as having female farming system (Easther, 1970).

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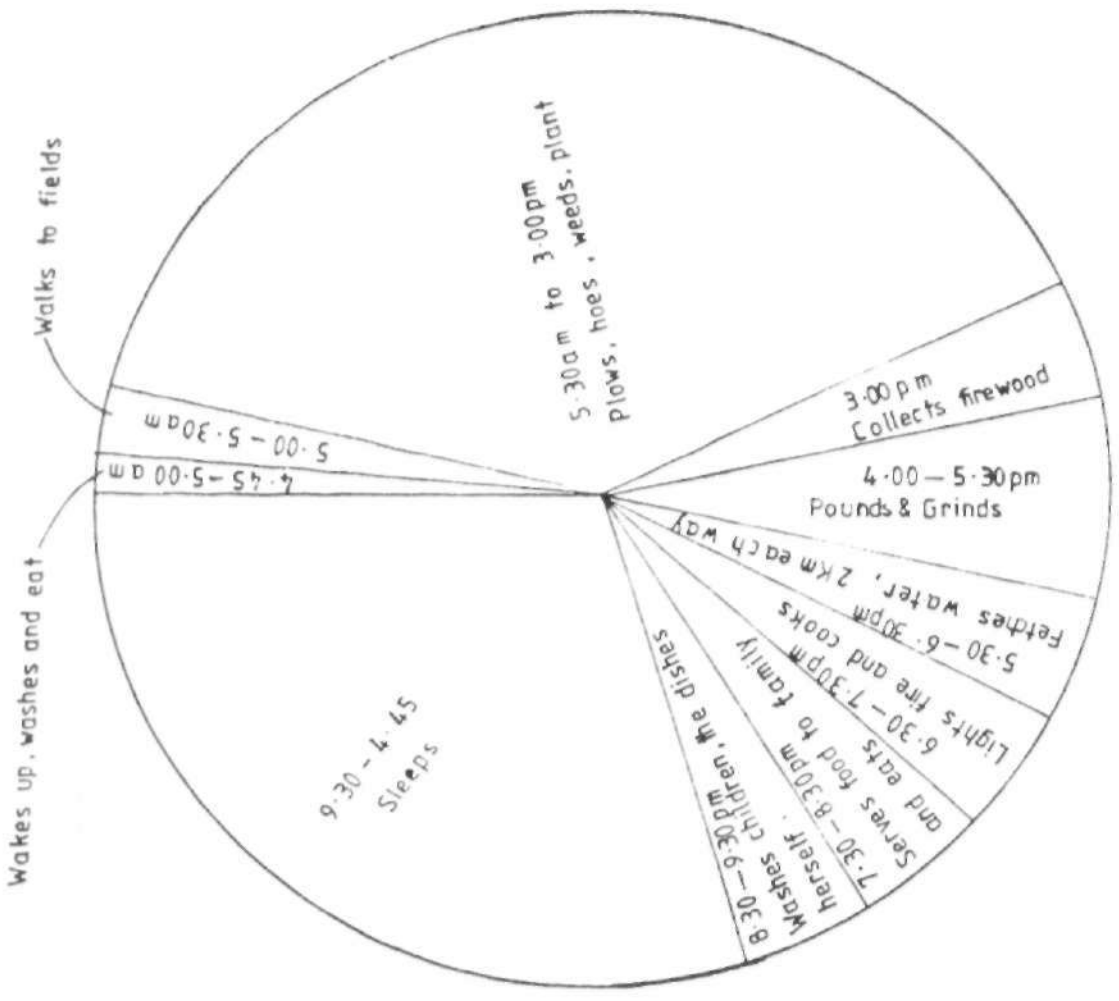


Fig. 2·1 A day in the life of a woman in rural Africa

Kaberry (1952) also observed similar trends, as above, in her study of Bamenda women. For apart from being mothers and wives, they also were responsible for hoeing, weeding, harvesting and transporting of the farm produce back home. Thereafter, they engaged in the processing of harvests, such as dehusking of grains in addition to food preparation both for home consumption and marketing.

In his study of rural women in Northern Nigeria, Brown (1979) showed that in Kaduna State women engaged in all aspects of agriculture and livestock production; and other income earning activities like petty trading, even in communities where women are restricted by religion.

In Pakistan and India, the trend is same as above. In a study of India's wheat producing Haryana State, women were found to do more than half the sub-continent's agricultural work, only assisted here and there by the men. Taking labour in both homes and fields into account the Haryana study found that the average working day for women was between 15.5 to 16.0 hours long (Chakravorty, 1981).

Tanzanian Census (1978) shows that 98% of the economically active women in that country are engaged in agriculture, compared with 79% of the economically active men. Among the Tiv in Nigeria, women perform over eighty

percent of the labour inputs for yam, maize, cassava and cowpeas while also participating in the production of cash crops like beniseed (Burfisher et al., 1983).

In Zimbabwe, women are solely responsible for sweet potatoes and groundnuts and have a dominant role in the production of millet and maize (Muchema, 1977).

Patel et al. (1973) studied the socio-economic activities of the wives of tobacco farmers in two administrative divisions of former Western Nigeria. They found that contrary to the belief that Yoruba women do little farmwork, ninety eight percent of the women studied worked on farms for crops such as yams, maize, tobacco and cassava.

Adeyokunnu (1978) studied the involvement of Nigerian women in agriculture. The study involved numerous respondents from the different parts of Nigeria (ie. west, south, and north). He discovered that about forty percent of all the women studied could be classified as farmers, twenty eight percent as processors and fifty two percent as traders. He discovered that the women who are farmers undertake most farm operations themselves, including the more difficult ones such as land clearing and land preparation for planting. When necessary, they use supplementary family and hired labour.

2.9 Source of Energy for Muscle Work

Human being has been compared to an engine, with energy conversion efficiency ranging between 20-25% at optimal conditions (Christensen, 1976; Karpovich et al, 1971). Manual task is performed by an individual through contraction and relaxation of the muscles. For this and maintenance of the body, energy is required. The energy for muscle contraction is supplied by anaerobic breakdown of high energy bond compounds while energy for resynthesis of these compounds is supplied by aerobic desintegration of food substances in body muscles. Two high energy compounds that play an important role in supplying energy for muscle contraction are adenosine triphosphate (ATP) and creatine phosphate (CP) (Morehouse et al., 1959). Foodstuffs involved in resynthesis process are carbohydrates, fats and proteins. The main sources of energy are carbohydrates and fats, with protein being essential for growth and maintenance of the body (Haggard et al., 1977). These reactions may be summarized as follows:

1. ATP $\rightarrow$ ADP + P + energy for contraction
2. CP $\rightarrow$ C + P + energy for resynthesis of ATP
3. Carbonhydrate + O_2 $\rightarrow$ CO_2 + H_{20} + energy for resynthesis of CP.

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2.10 Capacity for Work

Provision of energy for work depends on the operation of many body systems viz: respiratory system, blood circulation system, Digestive system, etc. These systems have inherent capacities at any one time, even though this could be increased by training. For example, rate of oxygen supply for muscle work is affected by several factors. These include: oxygen carrying capacity of the blood, rate of unloading of oxygen at the tissues, minute volume of the heart and ventilation capacity of the lungs. These factors should be properly coordinated and integrated with work of the muscles if the body is to attain optimum efficiency (Karpovick, 1971). Thus, the supply of energy for work is limited, and this imposes a limitation on the amount of work a person can perform.

The aerobic capacity of a normal healthy human being under temperate conditions is about 5 kcal/min. Within this level, continious work is possible, and above this level rest periods have to be provided to avoid fatigue (Sutton, 1974).

Energy demand beyond the aerobic limit incurs 'oxygen debt.' Continuous exercise beyond the aerobic limit leads to lactic acid accumulation which progressively reduces contraction capability of the muscles until fatigue sets in and work ceases (Karpovick, 1971).

Christensen (1976) proposed a scaling of work using physiological indexes (Table 2.5) which could be valuable in assessing need for modification or adequacy of rest periods.

2.11 Energy Expenditure Studies in Agriculture

Energy demand of the different Agricultural tasks has been investigated by numerous researchers with a view to improving the task and/or machine for greater efficiency and performance.

Gupta et al. (1980) investigated the vibration effect of back mounted power equipments, as in sprayers, using a vibration exciter. He discovered that operations at high speeds, and vibration in transverse direction were less streneous.

Vos (1966) investigated human effort involved in stacking of bales of straw on standing and on a jarking and rolling wagon. The total energy expenditure ranged from 4.5 to greater than 11 kcal/min and heartrate from 88 to greater than 130 beats/min. Considering Lehman criterion, it was suggested that workload should not exceed on an average 5.5 bales/min (120 kg/min) on a stationary trailer and 4.0 bales/min (90 kg/min) on a travelling one.

Table 2.5: Scaling of Work by Physiological Indexes

Physiological variables	Physiological Workload					
	Very light	Light	Moderately heavy	Heavy	Very heavy	Extremely heavy
Oxygen uptake (Lit/min)	<0.5	0.5-1.0	1.0- 1.5	1.5- 2.0	2.0- 2.5	>2.5
Calories per minute	<2.5	2.5-5.0	5.0- 7.5	7.5-10.0	10.0-12.5	>12.5
Heart rate per minute (beats)		75-100	100-125	125-150	150-175	>175
Rectal temperature (°C)			37.5-38.0	38.0-38.5	38.5-39.0	>39.0
Sweating rate (ml/hr) average for 8 hr work day			200-400	400-600	600-800	> 800

Sutton (1974) compared four methods of winnowing cereal grains as regards winnowing performance and energy demand on operators. Results showed that a pedal driven winnower with basic screen separation and horizontal air flow was better considering all the performance indexes.

Vos (1973) compared physical load of different working postures while varying frequency of forward movement and working level, as in planting, picking and transplanting operations. He found less streneous postures for different situations.

Different methods of picking oranges were studied to quantity the physiological costs of each method. For each method, a comparative analysis of physiological costs data as regards conventional method of general picking, was undertaken. Methods were evaluated on the basis of an index of output per unit input of energy (Schertz, 1967).

Nwuba (1981) studied human energy demand of agricultural handtools used in different tasks. Energy demand for all tasks studied was high. Variation of energy demand between tools for same task was observed, with modified long handle tools having least energy requirement. Since blades of the tools were same, difference was attributed to the different postures employed in operating the tools. It was found that the spinal muscle force and the lumbosacral joint

reaction while using the traditional hoe modified with a 150 cm handle were only 20% and 38% of those of the short handled hoe (Nwuba et al, 1986).

Phillips (1954) compared the energy costs of different agricultural tasks using seven Nigerian subjects. Tasks considered were: grass cutting, bush clearing, hoeing, head panning, log carrying, tree felling and wood sawing. It was observed that energy requirements of most of the tasks were high, and they could not be continued for long periods without rest.

Singh et al. (1972) reported the human energy requirements of selected farm operations like spading, spraying and some manual methods of load transport. Spading and manual methods of load transport were found more demanding physiologically than spraying.

Curfs (1974) studied the physiological demands or the walking tractors at the International Institute for Tropical Agriculture, Ibadan. He concluded that the walking tractors were inadequate for use in Nigerian soils since they increased the pulse rate of the operator by more than 30 beats/min which was recommended as tolerance limit.

Nwuba et al. (1985) tried to improve the traditional shadoof irrigation through ergonomic studies. They succeeded in reducing the energy expenditure from 100 watts to 71 watts, a level at which a farmer could work for prolonged period without a need for rest.

Studies were carried out on water transportation, oil processing, and agricultural processing among women in Northern Nigeria (Adeoti et al., 1991; Ali et al., 1991; Nalumansi et al., 1993). As a result of time involvement of such tasks or drudgery involved, improvements were designed.

2.12 Energy Measurement

Several methods for measurement of energy expenditure are available. One method is the direct calorimetry. This involves putting a subject in a special chamber called a calorimeter. Heat liberated is absorbed by water circulating around the chamber. For known amount of water, and if temperature of the water is known when entering and leaving the system, total heat liberated by a subject can be calculated (Karpovick, 1971). This method is often not feasible, especially for tasks of short duration. Hence, other methods have been devised for human energy measurement. These methods are based on the relationships between energy expenditure and certain physiological indexes, which have been established through numerous studies. These physiological indexes include: oxygen consumption, pulmonary ventilation, heartrate, sweat rate, and rectal temperature.

2.12.1 Oxygen Consumption

Linear relationship between energy expenditure and oxygen consumption has been established within a certain range (Suggs et al., 1958; Christensen, 1976). Wyndham et al. (1959) has shown that at low rates of work, relationship between oxygen consumption and workrate is linear. However, at high work rates, the curves tend towards an asymptote. From this relationship, an indirect method of energy measurement was devised based on the oxidation processes of the body.

2.12.2 Heart Rate

A linear relationsnip exist between oxygen consumption and heartrate. And, since, relationship between oxygen consumption and energy expenditure is linear, it then follows that heartrate can be related to energy expenditure (Suggs et al., 1958). Body fuels and oxygen are transported by the blood stream to the muscles where mechanical energy is released. Increasing the energy expenditure rate, therefore, demands a corresponding increase in blood flow, hence increase in heartrate.

Advantages of using heartrate as an index of energy expenditure has been outlined by many researchers (LeBlanc, 1957; Datta et al., 1969; Christensen, 1976). It eliminates the need for time consuming methods of energy measurements, and equipments used for heartrate evaluation are less interfering with work. As explained earlier, use of oxygen as measuring index involves connecting an operator to a measurement and sampling device which could be restrictive. However, heartrate represents a less obstructive method. A simple method often used for monitoring heartrate is the telemetry system where electronic devices incorporating electrodes are mounted on the body to detect electrical impulses of vascular muscles. Amplified signals of these impulses are transmitted to a radio set.

When an individual begins work from a rested condition, the heartrate immediately increases and approaches equilibrium with the task within a relatively short time. For light to moderate tasks, equilibrium is reached in three minutes or less (Suggs et al. 1958; Karpovick et al. 1971). From energy and heartrate data of nine volunteers, Datta (1969) obtained highly significant relationships.

Correlation constant was 0.88 indicating that heartrate gives an acceptable estimate of energy expenditure. Similarly, Le Blance (1957) obtained high correlation between heartrate and both intensity and duration of work. However, when temperature was increased, heartrate also increased without increase in oxygen consumption. Christenson (1976) also stated heartrate as an indicator of total strain.

A telemetry study of heartrate of versity swimmers showed that heartrate increased rapidly during the initial stages of race and then climbed progressively towards a maximum as the race proceeded. Longer swimming events resulted in higher heartrate values than shorter events (Magel, 1969). These studies show that for same environmental conditions, relationship between heartrate and energy expenditures is linear until maximum value of heartrate is attained and thereby remains constant. However, for varying environment, heartrate reflects total strain on the body rather than energy expenditure.

Heartrate can be measured by palpation, use of stethescope, telemetry systems or by use of cardiotachometers.

2.12.3 Pulmonary Ventilation

Pulmonary ventilation is another physiological index used for indirect energy measurement. Pulmonary ventilation or breathing is the rate at which a person inhales air into the lungs.

Linear relationship between ventilation rate and rate of oxygen consumption upto overload has been well established (see Fig. 2.2). Ventilation rate can therefore, be used to appraise an activity of normal load (Karpovick et al., 1971). Using nine volunteers performing different tasks, Datta (1969) obtained data on energy expenditure and pulmonary ventilation, with correlation constant of 0.9. Ford et al. (1959) presented a method for determining energy expenditure from pulmonary ventilation. Using the method under field situations they obtained regression equation which was similar for all age groups. These studies all show that correlation between energy expenditure and pulmonary ventilation is high, and the relationship can be represented by a linear equation.

Pulmonary ventilation can readily be measured with use of a gasmeter, and corresponding energy values can be obtained from tables, equations or graphs.

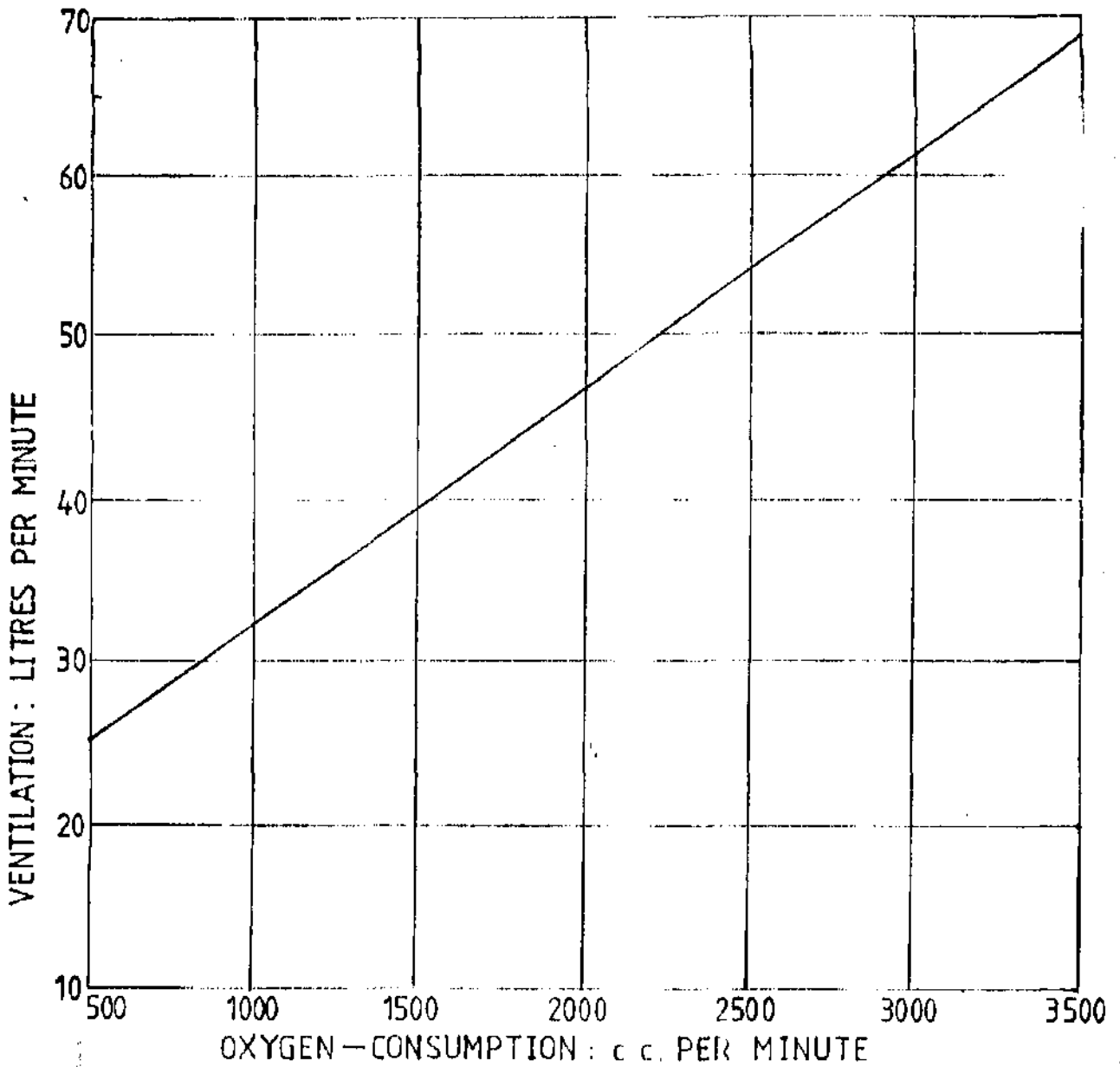


Fig. 2.2 : Graphical relationship between ventilation and oxygen consumption (Source : Karpovick et al., 1971).

2.12.4 Sweat Rate and Rectal Temperature

Other indexes used for human energy determination include sweat rate and rectal temperature or oral temperature. Rectal or oral temperature can be used as indicators of workload. Limitation of these indexes is their failure to reflect sudden changes in workload. This can be partly explained by the relatively large heat capacity of the human body (Christensen, 1976).

Under adverse conditions, sweat rate reflects total physiological strain on a subject. The sweat rate is determined by measuring fluid intake during the span of a shift and weighing the worker at the beginning and end of the shift (Christensen, 1976).

2.13 Measurement of Muscular Work

Measurement of muscular work involves evaluating amount of physical work performed by a person. A direct method involves the computation of forces exerted by man in performing a particular task multiplied by distances of the respective forces (Suggs et al., 1958; Barham, 1978). However, due to the difficulty of evaluating forces acting with their respective distances during work, other ways and methods had to be devised. Devices commonly used for

work measurement include: Ergometers and Treadmills. Ergometers are in difrerent forms, and selection depends on the muscle groups to be evaluated.

2.13.1 Bicycle Ergometer

Bicycle Ergometers are in different forms depending on what type of resistance is used. Resistance can be provided by spring, weight, friction or magnetic pull. A common type of bicycle ergometer is the friction type, shown in Fig. 2.3 and Plate 1. In friction type ergometer, one of the bicycle's wheels is turned into a flywheel. A friction belt around the flywheel is attached at one end to a weight hanger and the other end to a scale. When the flywheel is at rest and operator's feet off the pedals, reading on the scale is same as the weight on the hanger. The reading on the scale is reduced, however, when the ergometer is being pedalled. Difrerence between weight applied and reading on scale reflects frictional resistance (F) imposed on the flywneel. Work performance (W) after n revolutions of the flywheel is given by:

$$W = 2\pi r n F \quad \ldots\ldots\ldots\ldots \quad 2.1$$

or $$W = F r \theta \quad \ldots\ldots\ldots\ldots \quad 2.2$$

where, θ is the angle flywheel moves in radians and

r is radius or the flywheel.

n is no of revolutions of flywheel

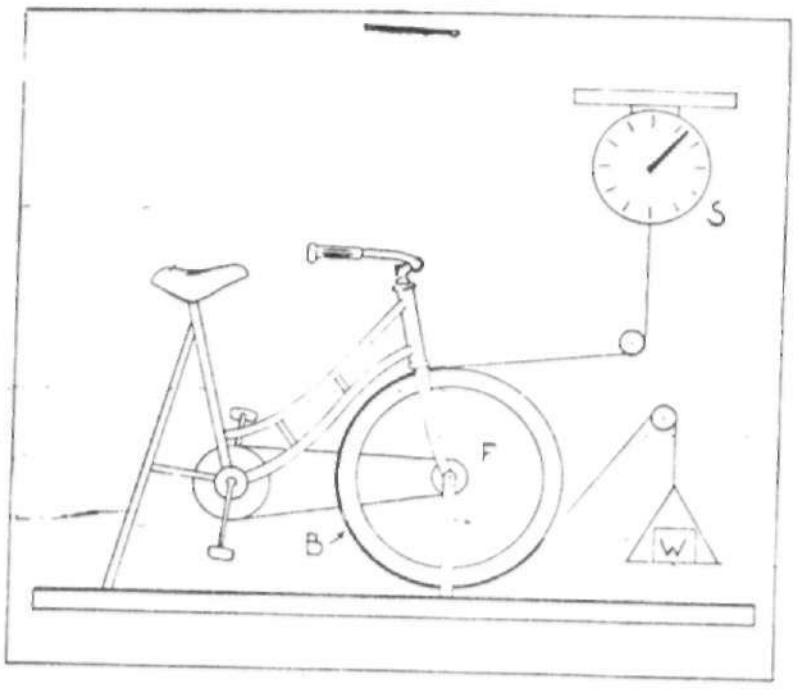


Fig. 2.3: Bicycle Ergometer (Source: Karpovick et al., 1971).

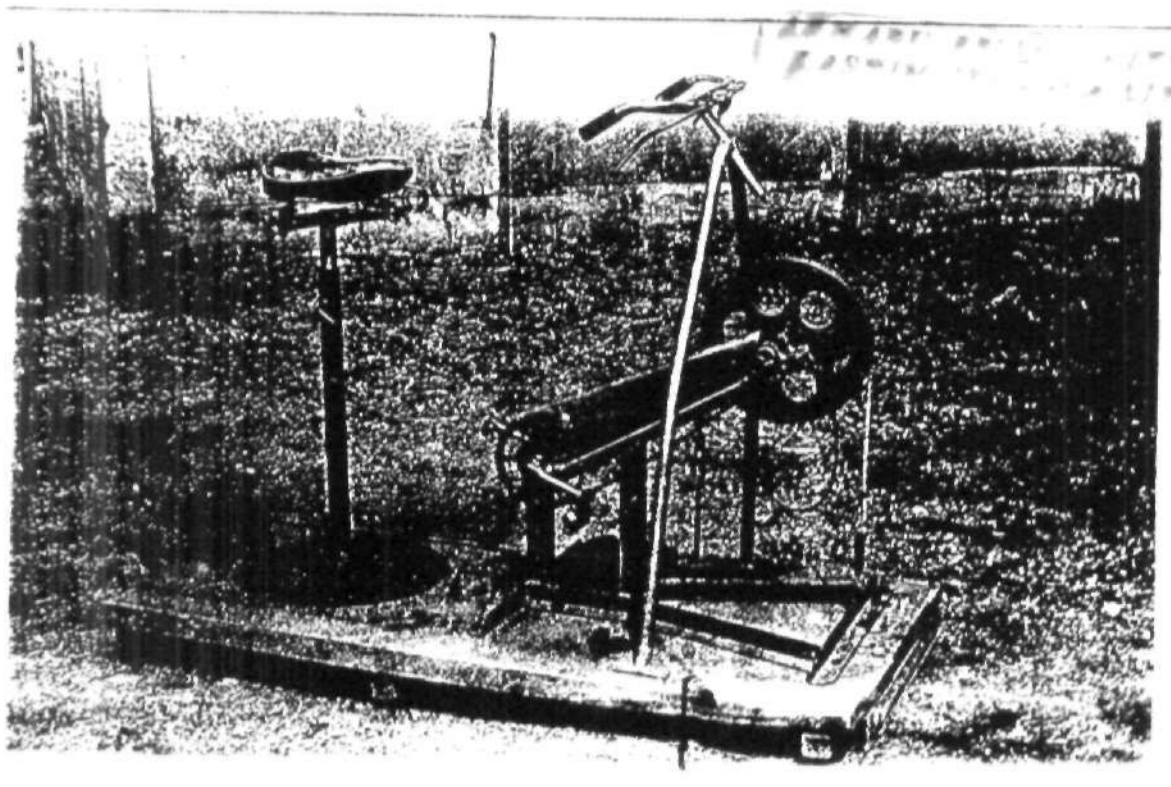


Plate 1: Friction-Type Bicycle Ergometer.

The bicycle ergometer has been used for physiological studies and for fitness tests. Fig. 2.4 shows a typical calibration graph obtained with an ergometer, which could be used for field work assessment.

2.13.2 Hand Ergometer

Hand ergometer, as depicted in Plate 2, is used for evaluating external work of the upper limbs. It consists of a bracket on which a flywheel is mounted. The bracket is also used to attach the assembly to a rigid support. A friction belt is partially wound around the flywheel's periphery. One end of the belt is attached to a weight hanger, while the other is attached to a spring scale. A crank handle is provided on the flywheel. The handle is used to effect rotation of the flywheel about the bushing fixed on the bracket (Plate 3), and difference between applied weight and scale reading gives friction force (F) imposed on the flywheel. Work performed (W) is calculated as in equations 2.1 and 2.2

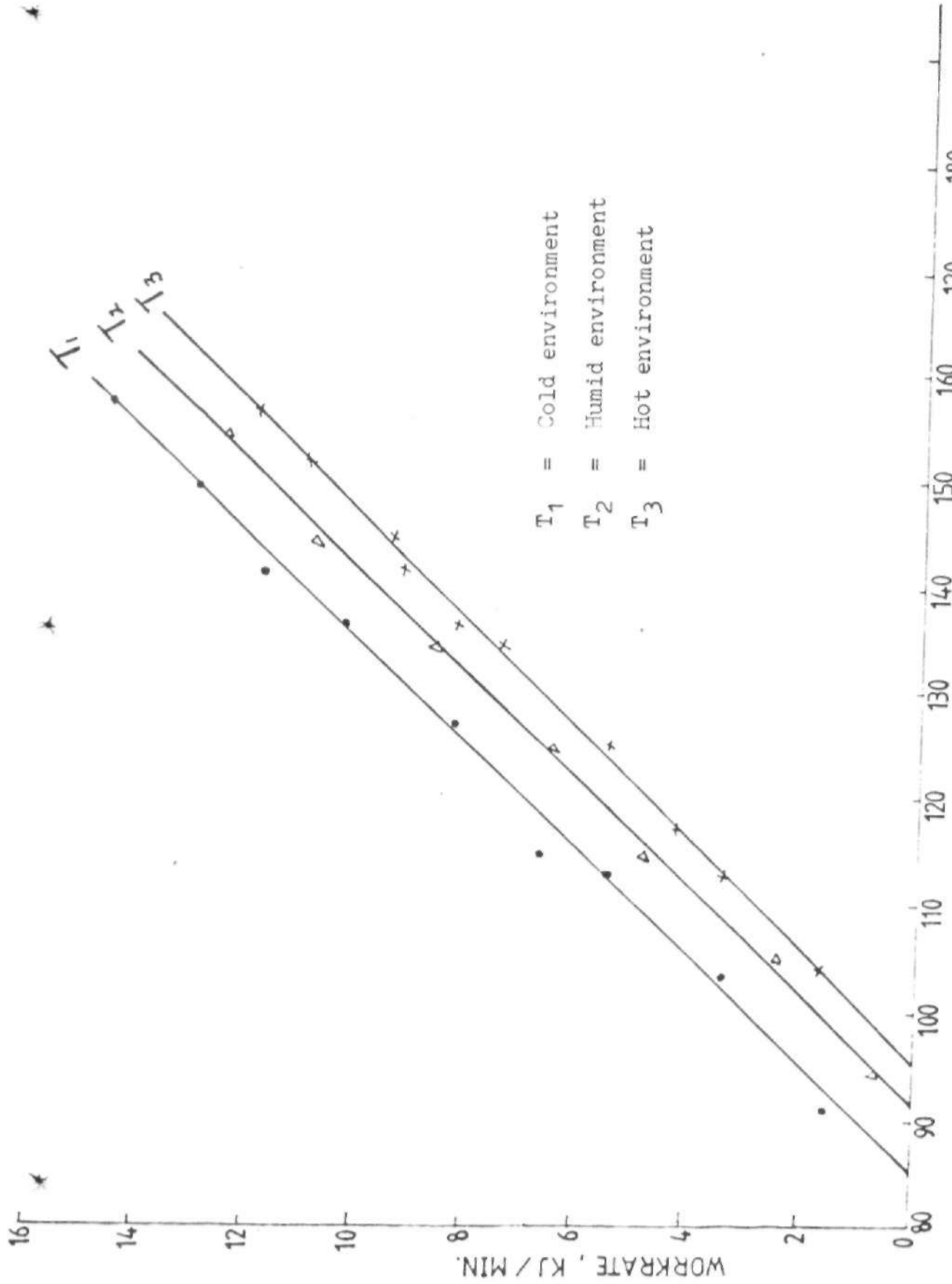


Fig.2.4. Relationship between workrate and heartrate for different environments

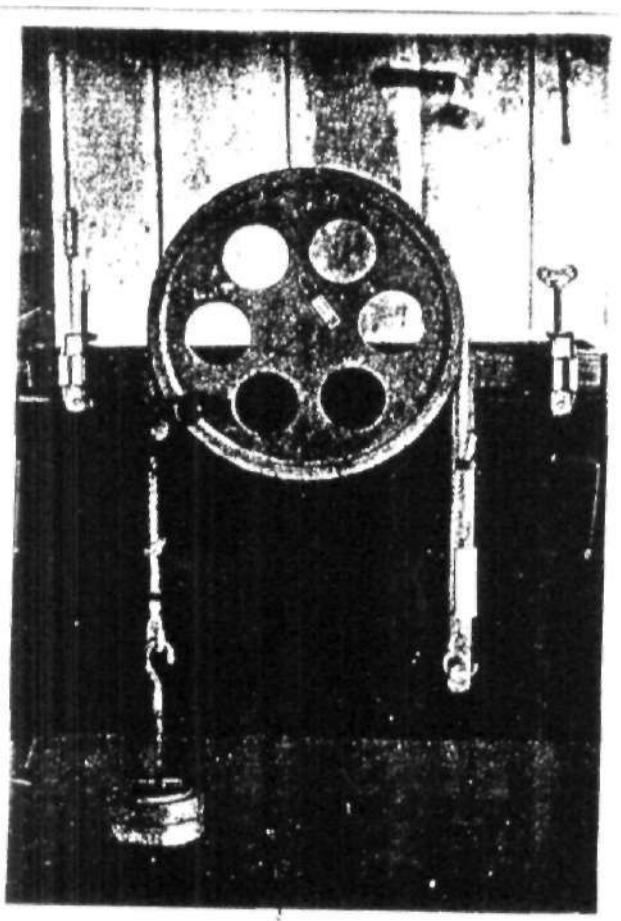


Plate 2: Hand Ergometer



Plate 3: Cranking of Hand Ergometer

2.13.3 Treadmill

A treadmill essentially consists of a conveyor belt driven by a motor, through rollers. The belt is usually inclined to allow quantification of work involved in walking or running for specified time at known belt speed. In operation, a subject runs or walks on the inclined belt, and therefore does work against gravity, and the force or gravity is given by the body's weight. Speed of movement is determined by belt speed. Horizontal work is zero, since there is no movement in the horizontal direction. If a person with weight (W) walks or runs on a belt moving at a velocity (V) and inclined at an angle (θ) to the horizontal, then work (W) performed after a time interval (t) is given by:

$$W = WV + \sin\theta \quad \ldots\ldots\ldots\ldots\ldots\ldots 2.3$$

Treadmill has been used before now for work measurements and exercise. It has also being used extensively in human physiology studies and also in studies involving animals. Mingate-Hill (1970) developed a treadmill used in exercising pigs to discover the relationship between exercise and food intake of the pigs. Jette et al. (1969) constructed a motor driven treadmill for exercising small laboratory animals with ten compartments in two adjoining sections.

2.13.4 Other Methods

Most methods of work measurement have limitations either in form of time delay, error or non-consideration of varying body efficiency and/or inability to isolate work measurement desired. A method for direct, instantaneous recording and measurement of the work output of any muscle or muscle group to circumvent above limitations was developed by Kittredge et al. (1968). This involves use of electrodes on relevant muscle groups which produce electromygram during dynamic work. Workrate is obtained from the electromygram.

2.13.5 Physiological Indexes and Work Measurement Methods

Work measurement devices described in sections 2.13.1-2.13.2 represent specialized equipments that are used directly in evaluating work done in a particular pattern. For example, the amount of energy required to pedal a bicycle under certain load conditions, and the amount of energy required for cranking or running uphill or downslope. However, in situations where work is performed in the open using tools or machines as obtains in agriculture, work devices become unhelpful. Fortunately, linear relationship exists between physiological indexes and rate at which work

is performed. Therefore, any type of work could be measured indirectly by employing the following two steps.

1. Use a work measurement device to calibrate between workrate and any convenient physiological index for a particular worker.
2. Then use the calibration graph obtained in step 1 to evaluate work in the field after obtaining the relevant physiological index of the worker during or after completion of actual work.

2.14 Effects of Environmental Factors

Environmental factors that are known to influence a working subject can be divided into two groups: Thermal factors and non-thermal factors. The thermal factors of an environment include: temperature, humidity, and rate of air movement.

2.14.1 Temperature Factor

The body gains heat from:

a) Basic metabolism of the body (M)

b) Muscular activity of the body (W)

c) Radiation from the sun, artificial primary sources and secondary sources (R).

d) Conduction and convection (C) from surrounds.

On the other hand, the body loses by: evaporation (E) in form of sweat, radiation, convection and conduction. For body temperature to be maintained at optimal value, there should be balance between the sources, mathematically represented as follows:

$$M + W \pm C \pm R - E = 0 \quad \ldots\ldots\ldots\ldots\ldots 2.4$$

Upward deviation from optimal heat value is counteracted by increasing sweating rate and by increased blood below the skin, with these consequences affecting body metabolism. It should be noted that, humidity and air velocity of the surround affects the evaporation process of the body (Matthews et al., 1971).

Since early times, it has been realized that men are affected by the climate in which they live. Quantitative studies abound that show the effect of temperature, humidity and air speed on the working man. Bedford (1954) stated that industrial workers efficiency and safety are affected by high temperatures. Vernom (1919) showed the effect of temperature on output in a tin plate manufacturing company. Hot weather output was found to be considerably smaller than output in cold weather. Similar findings were reported by Nwuba (1981) in a study of human energy expenditure for selected agricultural tasks.

Apart from effect on output, high temperatures also influence the physiology of the human body. Incre sed heart rate sweat rate and energy expenditure with rise in temperature has been reported (Nwuba, 1981; Suggs, 1961; Christensen, 1954). Christensen (1954) observed that an otherwise easy work could be streneous if performed under high temperature. Comparatively, moderate energy demanding tasks gave high heartrate, temperature and fluid discharge as a result of prevalent adverse thermal conditions.

Bedford (1954) reviewed earlier works on effect of thermal factors, and cases were cited that showed increase in accident frequency with unfavourable values of thermal factors. Moreover, those workers who do heavy work in great heat and who are liable to sudden changes of temperature are liable to suffer more from rheumatism and respiratory diseases than those who are not exposed to changes.

Studies, greatly, showed that an environment with excessive temperature, moist and stagnant air cause decline in output and poses potential health hazards (Vernom, 1919; Farmer et al., 1923; Ireland, 1921). Other studies have shown that improvement of these adverse conditions improve output and efficiency (Davies, 1922; Matthew, 1971; Christensen, 1954). To avoid negative health effects, suggestion by Bedford (1954) entails that conditions should be created such that the average worker can carry on his occupation efficiently and safely throughout his working life. Matthews (1971) stated that, for optimum comfort and performance conducive environment should be created in design of work places and in the design of farm buildings and plants. Human body performs optimally when its temperature is approximately 98^{o}F (36.6^{o}C) when

measured below the tongue. Christensen (1954) suggested three methods of rationalization for tasks performed under adverse thermal conditions:

1. Reduction of the rate of work
2. The normal rate of work is maintained but the periods of work are made relatively short and alternating with regular cooling pauses.
3. The climatic conditions be modified.

2.14.2 Humidity Factor

High relative humidity tends to increase the energy expenditure requirement of a task (Suggs et al., 1958). The body loses heat by: evaporation in form of sweat, radiation, convection, and conduction. Humidity of the environment affects processes of evaporation in form of sweat. For high humidity, evaporation from the surface of the skin will be relatively low. This leads to rapid increase in body temperature (Matthews et al., 1971).

There is an interacting relationship between temperature and humidity. For a given environmental condition, increase in temperature will lower humidity and vice versa.

An environment with excessive temperature, moist and stagnant air has been shown to cause decline in output and poses potential health hazards (Vernon, 1919).

2.14.3 Other Factors Affecting Performance

Noise, dust and vibration are known to affect both mental and physical capability of man. Knapp (1966) observed that mental strains of getting a job done and preoccupation with weather and markets coupled with physical factors such as heat, dust, vibration, and noise reduce the mental capabilities of man.

Noise has potential health hazard on machinery operators. Hearing tests on tractor drivers indicated that exposure to tractor noise for long periods caused a typical early loss of hearing at 4000 HZ (Chen et al., 1971). Scientific investigations have indicated that a sound level of 90 db or higherwas considered excessive (Diener et al., 1965). Huang et al. (1968) investigated the effect of noise on tractor operator performance. Even though tractor noise did not affect steering task and problem solving, it had significant effect on tracking performance, with better performance at lower noise levels. Heartrate was found to increase for steering and problem tasks as noise level rises.

Due to increasing concern shown by farmers, Ryland et al. (1970) have sought to develop and evaluate noise reduction treatments for agricultural tractors. Stangl et al. (1973) developed a technique for evaluating potential means of reducing exhaust noise.

Hung et al. (1967) studied the vibrational effects of different field operations on tractor operator in vertical, longitudinal and transverse directions. They cited vibration as one of the most important factors in the total environment that affect man-machine systems. Vibration is not only related to mechanical factors but has significant effect on extent of fatigue and similarly affects sensitivities and reaction rates of the human operator in a man-machine system. Abrams et al. (1969) studied the characteristics of chain saw vibration to reduce the severity of the vibration impacted on the hands and arms, which has been found to have potential disabling effect.

Other studies conducted have shown negative effects of vibration on output, comfort and health of the operatives (Manby, 1963; Rossegger et al., 1960).

Dust is known to be hazardous to the respiratory system. However, extent of damage depends on quantity, size and composition of particulates (Bundy et al, 1975).

Numerous researchers have demonstrated the deleterious effedt of bad posture on performance and health (Vos, 1973; Gupta et al., 1981; Nwuba, 1981; Nagami, 1983). Vos (1973) investigated the physical load for different postures at different working levels and rate of forward movement.

Physical load and performance was found to vary between the different combinations. To reduce bad working posture with implements mounted behind a tractor, OJOFLOT (1980) suggested the use of big convex mirrors which will give clear view of tractor rear.

Other factors which affect performance and comfort in varying degrees include: lighting intensity, control arrangements, work place design and quality of display (Woodson, 1964).

2.15 Anthropometry

2.15.1 Concept of Anthropometry

Anthropometry is a discipline or human engineering that deals with measurement of human subjects. Roebuck et al. (1975) defined Anthropometry as follows:

> 'Anthropometry is the application of scientific physical measurement methods to human subjects for the development of engineering design standards and specific requirements and for evaluation of engineering drawings, mock-ups, and manufactured products for the purpose of assuring suitability of these products for the intended user population.'

Often, cause of badly designed equipments has been traced to inconsideration of prospective users, or inability to fit an equipment to likely user population. Anthropometry, as a discipline of human engineering, aims at solving this problem by aiding to achieve compatability between a product and its users. Absence of this compatability between product and user, has resulted in unnecessary fatigue, low productivity, health hazards, accidents, unsuitable posture, and discomfort (Morant, 1954; Akerblom, 1954, Murrel, 1954; Woodson, 1964; Roebuck et al. 1975; Wagami, 1983).

2.15.2 General Approach to Problems in Anthropometry

For any practical design purpose, anthropometry requires that the 'user population' be defined. This includes all persons who will likely use the product during its useful life. Description can either be explicit, or ill described as to allow only gross approximations to their anthropometric measurements (Roebuck et al., 1975). Then relevant data, with respect to conceived design are obtained. Data could be simple segment dimensions, strength, limit of joints' movement, reach, visibility, etc.

Many methods exist for analysing these data to evolve practical design criteria. Designers and researchers have used/or evolved methods depending on experience, requirement and peculiarity of a situation. Woodson et al. (1964) has suggested that, for efficient use of available data for practical purposes, dimensions should be considered from a functional point of view. This implies that, short or lesser dimensions should be used for defining reach limits, and long or greater dimensions should be used for defining clearances. In addition to above, Clement (1954) recommended that joint movement and posture should also be considered.

In what could be considered as a general trend, Roebuck et al. (1975) suggested defining a 'user population' as a first step towards evolving a design criteria. From the population, a representative sample is selected, as it is economically undesirable to measure every individual in a population. Relevant data are evaluated, and statistical methods are employed to develop design criteria, specifying the range of each parameter for which a product must be designed.

Anthropometry has important branches, that deal in depth with measurements of certain characteristics of human subjects. An important example of these branches of engineering anthropometry that deals with kinetics and

kinematics of the human body is known as Biomechanics. Roebuck (1975) defined Biomechanics as an interdisciplinary science of mechanical structure and behaviour of biological materials. This branch is concerned with dimensions, composition and mass properties of body segments; joint types and their mobility; mechanical reactions of body to external forces; and mechanisms of voluntary actions of the body.

A related subdivision to Biomechanics is kinesiology. Barham (1978) defined kinesiology as the study of human movement in all its ramifications. This study is important in integration of movements of operators and work.

2.15.3 Some Applications of Anthropometry

Bad work place design has often resulted in low productivity. And the need for compatability between dimensions of the equipment and the operator has been realised. This awareness and the need to curb effect of negative effects as regards bad designs has resulted in the development of general principles and procedures supported by a special series of anthropometric application techniques and devices for engineering design and analysis (Roebuck, 1975). A work place envelope must be compatible

with the anthropometric dimensions of the particular population of workers who will be using the proposed equipment. Dimensions of the large worker should be used to determine limits of reach. Apart from above consideration, it is also important to lay out the work space according to the way it will be used. This requires consideration of psychological factors such as procedural logic, naturalness of relationship and standardization to minimize learning time (Woodson, 1964). A problem of cockpit dimensions in a single-seat fighter was solved by method of 'expirimental trials.' This included collection of data, erection of mock-up and test for suitability (Morant, 1952).

For handtools, the key man-machine interface is the handle. Therefore, tool handle should be made to fit the hand, either resulting in a contour interlocking or allowing relative movement between hand and tool. For effective transfer of energy between hand and tool, knurling or grooving or assymetrical shaping of the handle are often used. Functional use of tool should be compatible with motion inventory and strain capacity of the human body (Roebuck, 1975). In addition to above requirements, there is need for dimensional compatability between operator and a hand tool obtained by anthropometric applications.

Nwuba (1981) conducted human energy studies on selected agricultural hand tools. He discovered that for all considered tools, tool type had significant effect on 'response variables', (i.e. heartrate, energy expenditure/ output, physical output). Moreover, it was discovered that most tools were short handled and modified types based on anthropometric considerations were better in performance and energy demand. Wagami (1983) conducted a survey to collect anthropometric data of farmers and existing tools used by them. The survey covered three zones around Zaria. After analysing the data and collating with data obtained from tool collected, he discovered that the tools were dificient in design. He, then, evolved design criteria based on data obtained, and made other useful recommendations so as to enhance productivity and lesser health hazards on operators of the hand tools.

Studies by Ali et al., 1986 showed that there is need to develop different tools for women separate from that of men. Using anthropometric dimensions of women, design criteria was developed for weeding hoe, ridging hoe, pestle and threshing stick.

CHAPTER THREE

EXPERIMENTAL METHOD AND EQUIPMENT

To carry out objectives as stated under introduction, the following methodologies were adopted:

3.1 Surveys

3.1.1 Milk Processing Survey

To fully understand the present practices of the Fulanis in the dairy industry and to have an indepth knowledge of their socio-cultural activities a survey was undertaken around Zaria, Dambatta, and at Falgore. The states where these locations are found are shaded on Fig. 3.1. Method employed was to administer structured questionnaire on respondents. Questionnaire used is given in Appendix I.

3.1.2 Fura Processing Survey

To have a grasp of state of the art practices in areas known for 'Fura' production and consumption and to understand fully variation in methods for different locations; a survey was undertaken to Sokoto, Kebbi and Katsina States and within Zaria (Kaduna State). Areas covered are shown on Fig. 3.2. Two methods were used in this survey: a structured questionnaire and a work programme (involving historical documentation, quantification of process and detailed data collection). Questionnaire used is shown in Appendix V.

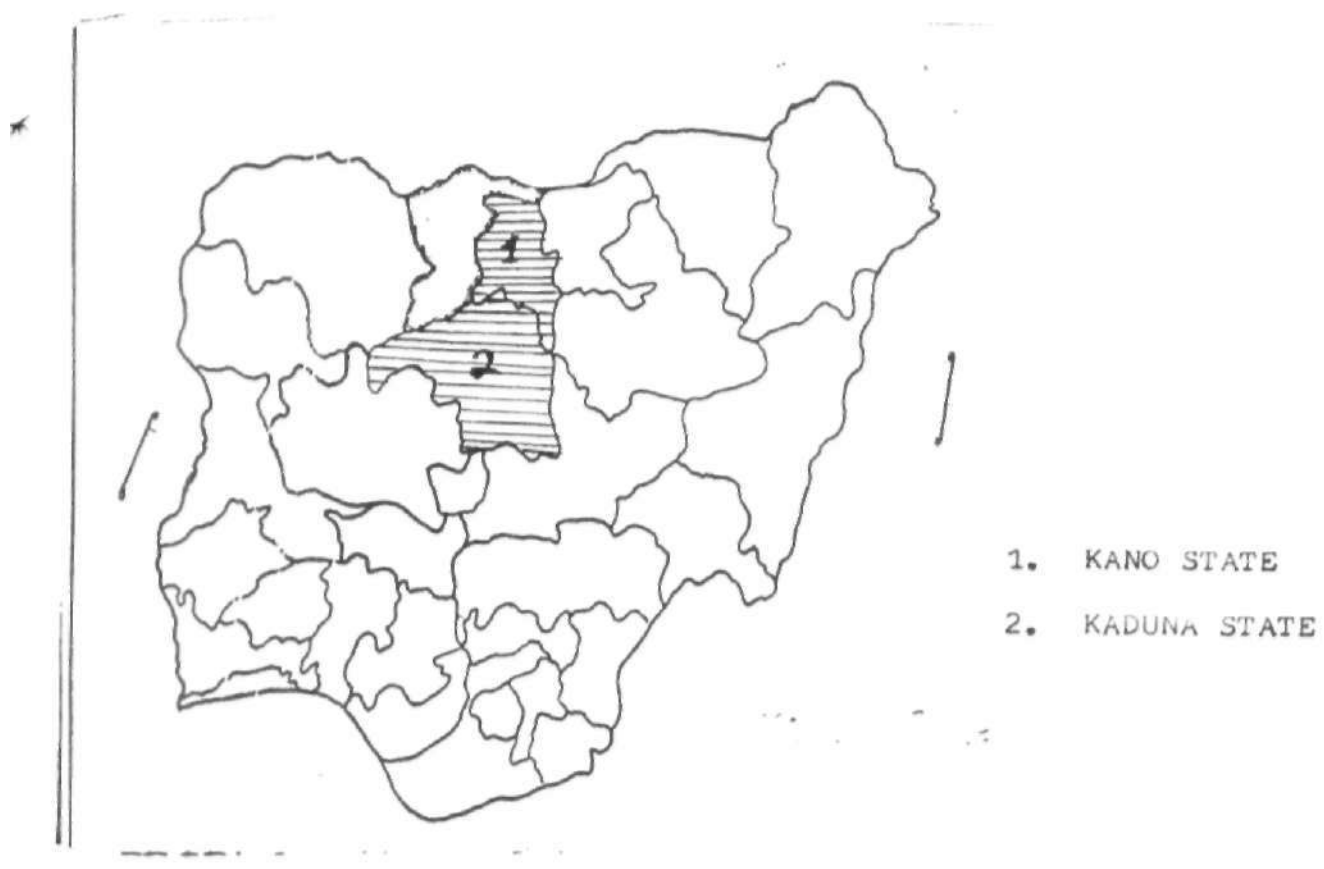


Fig. 3.1: Map Showing States Covered in Milk Survey.



States Covered in Fura Survey

Fig. 3.2: Map Showing States Involved in Fura Survey

3.2 Studies on Existing Practices

Studies on existing practices involved detailed quantification of what is done presently for both churning and 'Fura' making. For churning, the process is repeated at different volumes and the following parameters were taken: Sequence, Time, Human energy requirement, weight of butter extracted, temperature and P.H. Samples were also taken for composition analysis.

For 'Fura' studies, the process was evaluated for different quantities of millet. The following were documented from the studies: Time requirements, human energy requirement, sequence of operations.

For each of the two systems, the process was watched carefully to quantify time and observe all intricacies involved.

3.2.1 Equipment

Equipment used for both churning and 'Fura' studies include: Calabash gourd, mortar and pestle, P.H. meter, stethescope, stop-watch, tachometer, hand ergometer, Bio-mechanic protractor, wet and dry bulb thermometer, weighing scale, anthropometric height scale, measuring scale, measuring cylinders, setofsieves, various laboratory devices for composition analysis. Most of the equipment listed above are common. As such, they will not be described.

Equipment that are uncommon are described below:

Hand Ergometer

Hand ergometer, as depicted in Plate 2, is used for evaluating external work of the upper limbs. It consists of a bracket on which a flywheel is mounted. The bracket is also used to attach the assembly to a rigid support. A friction belt is partially wound around the flywheel's periphery. One end of the belt is attached to a weight hanger, while the other is attached to a spring scale. A crank handle is used to effect rotation of the flywheel about the busning fixed on the bracket (Plate 3), and difference between applied weight and scale reading gives friction force (F) imposed on the flywheel. Work performed (W) is calculated as in equations 2.1 and 2.2.

Mortar and Pestle

Though mortar and pestle (Plate 4) is a common tool, detailed description of type used is as follows:

Table 3.1: Dimensions of Mortar

Upper most Diameter (cm)	Diameter at mortar bottom (cm)	Total heignt of mortar (cm)	Heignt of mortar bottom from floor level (cm)
36.5	12.7	51.0	12.0
35.5	12.5	53.0	12.0
36.5	12.9	52.0	12.0
Average 36.17	12.7	52.0	12.0

Table 3.2: Dimensions of Pestle

Weight (kg)	Diameter of handle (cm)	Impact surface diameter (cm)	Total length (cm)	Handle length (cm)
3.0	5.26	9.31	110.0	64.0
3.0	5.01	9.15	110.0	64.0
3.0	5.17	9.11	110.0	64.0
Average 3.0	5.15	9.19	110.0	64.0



Plate 4: Mortar and Pestle

Gourd

Gourd is a calabash material shaped as shown in Plate 5. It is grown like any other crop. A matured gourd contains seeds inside it, which after cleaning the inside of the gourd could be removed and kept for planting. Gourd is naturally shaped to have a cavity of certain volume, and then it shapes up with a narrow neck upwards. In churning, after putting the sour milk inside, the mouth is plugged with a corn cob and then the gourd is held by the neck with both hands for the upward-downward motion referred to as churning exercise.

3.2.2 Experimentation

The existing process was evaluated as follows:

Energy Studies - Three female subjects were selected for this study. Age of subjects varied between 20 to 30 years. This age bracket was used as survey showed it represents age of most Fura and milk processors. Subjects chosen were experienced in processing. As the object of the study was not to compare subjects, but tasks, energy expenditure was given as average for the three subjects for all systems considered. Each subject was calibrated

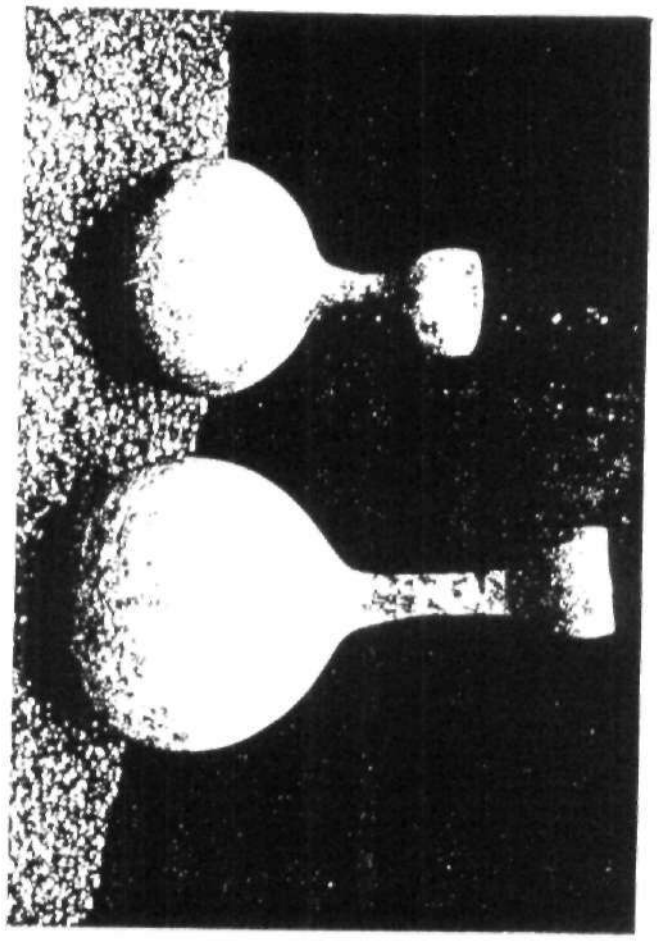


Plate 5: Commonly used gourds

on a bicycle ergometer using heartbeat as a physiological index. To get energy cost of doing a task, a subject's heart beat was obtained and energy cost was obtained from the calibration graph.

Human energy requirement to churn different volumes was obtained. This was done for the two systems considered in churning study. The volumes of milk for which energy was quantified varied from 2 to 10 litres increasing each time by 1 litre. For each volume, all component activities of butter extraction were quantified to get total human energy requirement.

For Fura processing, energy requirement was obtained for one tiya (2.5 kg) and two tiyas (5.0 kg). Each component activity in Fura making was quantified and total energy for the process was equal to summation of energy for component activities. Energy quantification was done for three systems considered in Fura study.

The volumes used represent range of raw materials used by processors. This was found in survey of existing processes.

Timing of Tasks - For each component activity of a process, a stop watch was used to obtain time from beginning of an activity to the end. For example, in milk processing, component tasks timed include: pouring sour milk into gourd, churning, pouring into a calabash container, stirring, extraction of butter, washing and kneading. Each of these activities was timed from the beginning to the end. Total time for a task is the sum of time for all component activities.

The same volumes as for energy studies were used in time quantification.

Kinesiology Studies - This entailed close observation to understand the nature of task and the arms, angles and forces involved. Movements were traced out on a board for different positions for detailed study.

1. Kinesiology relationship in churning. This was done by moving gourd through different distances. Distances used include: 10 cm, 30 cm, 40 cm and 50 cm. For each height, position of the arms was traced on a board at initial and final positions. Thereafter, angles of the arms at initial and final positions were carefully measured. For each height, a subject churned two litres of milk. Apart from angles above, other parameters evaluated include: Time to butter extraction, heart-rate of subject, Total distance through which gourd was moved, weight of butter and human energy expenditure.

2. Kinesiology relationship in pounding. This exercise was done by moving the pestle through different heights. Heights used include: 80 cm, 90 cm, 100 cm, 110 cm and 120 cm. For each height, position of the arms was traced on a board at initial and final positions. For each trial which lasted one minute, 150 gm of millet was used and a set of sieves was used to evaluate quality of pounding. Other parameters quantified include: Heart rate, total distance through which pestle was moved, and energy expenditure.

Anthropometric Study - A survey was conducted around Zaria to collect anthropometric data of user population. Method used was to use a tape rule to obtain different body dimensions. Dimensions obtained include: overall height, height (eye level), chin level, shoulder height, shoulder width, upper arm, lower arm, hand length, chest width, upper arm, lower arm, hand length, chest width, breast width, height (breast level), pelvic height, total leg length, ankle height, foot length, foot breadth, pelvic width.

Tool dimensions were measured by use of tape rule and vernier calipers. To get existing dimensions, a number of existing tools were collected and measured. Dimensions obtained include: gourd length, gourd diameter, pestle length, pestle diameter.

3.3 Technological Intervention

After identification of constraints from analysis of existing practices, a two prong approach was adopted to improve on the existing methods/tools. These include: Improvement on existing method/tool; and adoption/development of technologies.

3.3.1 Improvement on Existing Method/Tool - This comprises of anthropometric studies and kinesiology studies (section 3.2.2). From kinetic and kinematic analysis, factors that affect the processes were identified and effort was made to develop relationship between the factors and process. This relationship was helpful in explaining how to explore the factors for process manipulation. In anthropometric studies,

guidelines for achieving compatability were used to calculate tool sizes for compatability with anthropometric data of user population. These data were compared with that of existing tools for appropriate recommendation.

3.3.2 Adoption/Development of Technologies

i) Adoption - Technologies relevant to solving constraints were chosen. These were compared with existing process for time and energy requirement.

In Fura processing, available motorized technologies for dehulling and grinding were selected as intervention on the existing process. To compare adopted technologies with existing proces time and energy studies, described earlier were used.

ii) Development - Engineering principles were used to develop simple devices. To fit the user population, ergonomic provisions were taken into consideration.

A churner was developed using available materials. Constraints of existing were studied carefully and appropriate solutions were incorporated in development. Time and energy studies, which were earlier described, were used to compare developed device and existing process.

3.4 User Trials

Effort was made to involve users in development and trials of developed technology. Most of these users were initial respondents to our survey. When churn was developed it was put with users; they then used it and offered suggestions for modification. Suggestions were analysed for relevance and incorporated in suggestions.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Background Survey on Overall Activities of the Dairy Practitioners

This survey was undertaken to know socio-cultural activities of Fulani set-up and the role of women. Three areas of Fulani concentration, i.e., Falgore (Kano State), Dambatta (Kano State) and Zaria (Kaduna State) were covered. Questionnaire used is given in Appendix I.

a) **Family Set-up**

The set-up of the Fulanis is such that large families live together. Normally a household head lives with his immediate family, occassionally with his grown-up children who may be married. Table 4.1 below gives statistics of family characteristics in two selected sites of Dambatta and Zaria. The Fulani men could marry up to four wives. However, findings show that majority get married to only one wife. The number of wives affect the distribution of milk within the wives. However, there is always correlation between number of wives and the herd size. As such, only affluent or large herd owners marry multiple wives.

Table 4.1: Characteristics of Families in Zaria and Dambatta.

No. of Wives	Zaria		Dambatta	
	No. of families	Percentage (%)	No. of families	Percentage (%)
1	30	54.5	10	32.3
2	17	30.9	11	35.5
3	1	1.8	9	29.0
4	7	12.7	2	3.2

In Dambatta, average number of people in a family were 9,7,5 and 10 for Yammawa, Koguna, Renial and Baro towns respectively. The same distribution was observed for settlements around Zaria.

b) Level of Education

Level of education among the Fulanis was found to be low in all locations. Milk activities (i.e. churning etc.) are done without any formal training. Education could be divided into two distinct types: Koranic and western education. In Zaria, 69.1% of total respondents were illiterates in both western and koranic education. Level of koranic education was 41.8% in Zaria, 22.6% in Dambatta.

For western education, it was 14.5% for Zaria, while in Dambatta the percentage was 3.2%. Many reasons could be adduced for the low level of education among the pastoralists Fulanis. One might be due to their mobility which make it difficult to have a formal training; plus the fact that while on the move their primary interest is more on the animals than any other thing, education inclusive. Second reason might be due to lack of educational facilities where the Fulanis are found. However, this could not be said of Dambatta where there are primary and secondary schools. Theirs (i.e. low level of education) could be attributed to apathy to education. Their explanation was the girls get married easily and the boys have to keep with herding and other related aspects.

c) Animal Population

Animal population in these locations is summarized in Table 4.2. Generally, the population of cows is more than that of the bulls. This emphasizes the reasons for which Fulanis keep animals- for reproduction mainly and then milk production to meet day to day requirements of the family. Most Fulanis never had fattening as an aim of their pastoralism.

Table 4.2: Animal Population

A	B	C	D	E	F	G	H	I
1 - 10	80.0	16.4	0 - 4	58.3	0 - 4	68.2	0 - 4	72.0
11- 20	10.9	15.4	5 - 9	33.3	5 - 9	27.3	5 - 9	28.0
21- 30	1.8	20.0	10-14	4.2	10-14	4.5	10-14	
31- 40	3.6	30.0	15-19					
41- 50	3.6	18.2	20-25	4.2				

Key:
A - No. of Animals
B - Percentage of respondents (for bulls)
C - Percentage of respondents (for cows)
D - No. of Animal (cows)
E - Percentage of respondents
F - No. of animals (sheep)
G - Percentage of respondents
H - No. of animals (goats)
I - Percentage of respondents

The animals are herded by the men and their male children. Each morning, the herders release the animals from their encampments and lead them to where they can obtain both feed and water. The cows kept by Fulanis feed on fallow fields, upland range, riverine areas, grass regrowth, crop residues, and browse. The women, on the other hand, are responsible for all activities within

the homes. Table 4.3 shows extent of assistance by men in tasks performed by women.

Table 4.3: Percentage Participation of Men in Different Tasks

Task	Zaria		Dambatta	
	No. of homes out of 55	Percentage participation for men (%)	No. of homes out of 30	Percentage participation for men (%)
Rearing of animals	30	54.5	30	100.0
Milking	22	40.0	0	0.0
Firewood collection	19	34.5	23	76.7
Purchase of foodstuff	16	29.1	15	50.0
Water fetching	6	10.9	15	50.0
Washing of clothes	1	1.8	0	0.0
Milk marketing	0	0.0	0	0.0

d) Womens' Role

The women are completely in charge of dairy activities. In some places they milk the cows themselves (i.e. Zaria) while in others the men milk and bring the milk to the women for further processing. When milk is received, some is consumed fresh by family members while the rest is kept in a suitable container where it ferments by next morning. It is then poured into a gourd and shaken until butter grains separate. This is then poured into an open calabash container and a stirrer used to further bring the globules together. The fat is then removed with hand or a calabash spoon. Table 4.4 shows average amount of milk processed each day by the women during the year. It is important to note that milk production which forms back-bone of economic activities of women is not constant throughout the year. It is lower in dry season compared to rainy season (Table 4.5). In all locations, most respondents produced between 0-2 litres in the dry season. The situation was better at Falgore where 62.5% of respondents obtained between 4-6 litres during rainy season. Most processors collected milk for 2-3 days before processing. Processing volumes per day vary from 2-10 litres during the year.

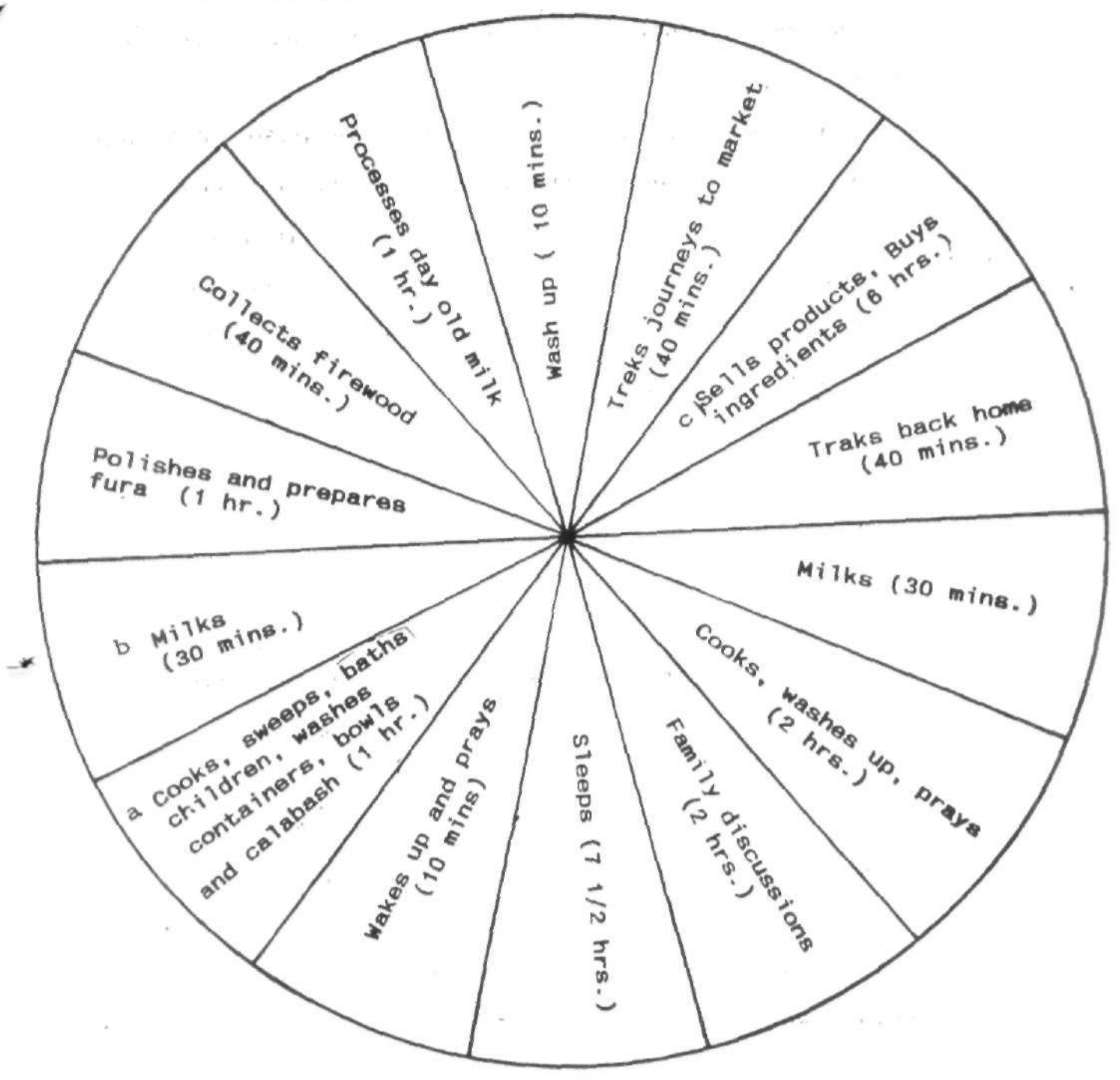
Apart from milking, other activities carried out by women include marketing of products, preparing fura, trekking to and from market, cooking, firewood collection, fetching

water and washing. It is estimated that women work for 16.5 hours everyday. (Detail of activities is represented by pie chart, Fig. 4.1).

Table 4.4: Quantity of milk Processed Daily

Quantity of milk processed (litre)	Number of respondents	Percentage (%)
0 - 1	1	1.8
1 - 2	5	9.0
2 - 3	3	5.5
3 - 4	11	20.0
4 - 5	5	9.0
5 - 6	9	16.3
6 - 7	5	9.0
7 - 8	2	3.6
8 - 9	2	3.6
9 - 10	5	9.0
10 - 16	1	1.8

Fig 4.1: PIE CHART INDICATING ACTIVITES OF A FULANI WOMAN



a Some activities are performed simultaneously

b Schedule of this activity changes with time of season.

c Depends on distance and number of stops on the way to sell. 'fura' and 'none'.

Table 4.5: Milk Production during Two Seasons

Location	Volume	Percentage of Respondents	
		Rainy Season	Dry Season
Zaria	0 - 2	21.8	47.3
	2 - 4	29.1	30.9
	4 - 6	20.0	9.1
	6 - 8	18.2	1.8
	8 -10	0.0	7.3
	10 -12	9.1	0.0
	14 -16	0.0	3.6
	20 and above	1.8	0.0
Dambatta	0 - 2	32.2	96.6
	2 - 4	64.5	3.3
	4 - 6	3.2	0.0
Falgore	0 - 2	0.0	50.0
	2 - 4	12.5	50.0
	4 - 6	62.5	
	6 - 8	25.0	

In all locations studied, women market their products themselves (Table 4.6). Marketing apart from being a commercial activity also serves a social function. Plate 6 shows some market scenes at Falgore. If affords the women opportunity to meet and discuss with each other (see Plate 7). As per mode of transport, some of the women trek long distances to get to market; others trek partially before joining transport to market. There are those that are lucky to have a motorable road up to their houses making it possible to go from home to market on buses. Findings showed that the women spend not less than 4-5 hours in the market. When coming back home, they make some purchases for the family which includes food items and toiletries. It was found that women spend-up half of their money on food for the family (Waters-Bayer, 1988).

The traditional milk industry is operated using household utensils. It is the same facilities that are used for cooking for the family. Except for the gourd, which is an exclusive churning device, all other tools could be used for normal household work.

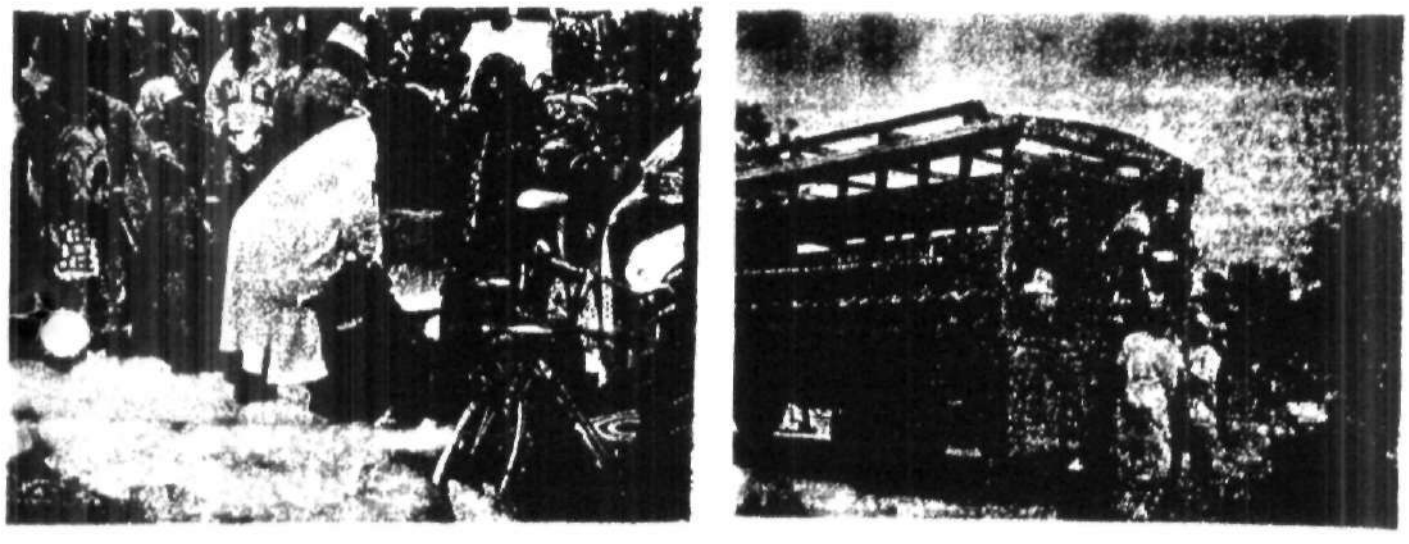
Plate 6 : FALGORE MARKET SCENES



Fulani's bringing milk products to the market on foot or on public transport



Women & Children scouting for traders to give least price



Traders are equally busy collecting milk product and transport same to Kano for retailing

Plate 7: **FULANI WOMEN ACTIVITIES**







Typical market scenes showing Fulani selling their milk products

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Table 4.6: 'Nono' Transactions between Dealers and Fulani Women (in Falgore Market)

Detail of activity of a dealer buying from Fulani women	Month					
	Sept. 91	Oct. 91	Nov. 91	April 92	June 92	July 92
Total weight, kg	416.0	416.0	332.8	540.8	416.0	416.0
Total volume, lit.	320.0	320.0	256.0	416.0	320.0	320.0
No. of suppliers	16	17	15	23	17	13
Average weight supplied by each woman, kg.	26.0	24.5	22.2	23.5	24.5	32.0
Average price+ per litre, ₦	1.30	1.53	2.38	2.55	1.73	1.78
Average amount+ earned by a Fulani per day, ₦	26.00	28.70	40.70	46.00	36.60	43.70

+ 1991 - 92 prices.

e) Constraints in Traditional Dairy

The Fulanis were requested to enumerate their constraints without any limitations. Table 4.8 below shows those aspects of their animal husbandry which were listed as constraints in maintaining and increasing production. Notable among the constraints were lack of tools and tedious nature of tasks; lack of adequate feed which appeared to be a general problem and lack of storage facilities for milk. Other limitations include lack of drinking water for animals and tedious nature of butter extraction, which is a product that gives them high returns.

Table 4.7: Constraints in Animal Husbandry and Processing (as found in one Location Only)

Constraint	% of respondents*
Tools/tasks	47.0
Lack of adequate feed	90.9
Lack of drinking water	21.8
Grazing difficulties	5.5
Lack of drinding water	21.8
Cold temperature	7.3
Strength of grass	5.4
Problems of butter extraction	18.2
Lack of storage facilities	43.0

* Out of 55 respondents

Table 4.8: Felt Constraints of Fulani Women of Falgore

Constraint	% of respondents
Transportation	50.0
Marketing of milk	0.0
Grazing area and water	50.0
Water fetching	40.0
Milking	50.0
Churning	60.0
Drugs for animals	70.0
Cooking	80.0

Variation between Locations (i.e. Zaria, Dambatta and Falgore) is discussed in a tabulated form below.

Table 4.9: Variations Between Locations

Aspect		Variation
1.	General	
	Literacy	In all locations level of western education is low. However, Zaria has literacy level of 14.5%, while Dambatta has only 3.2%.
	Family Characteristics	In all locations the Fulani reside in an extended family compound system. Most of the compounds are made of corn stalk. However, at Dambatta there are more permanent structures than at the other locations.
	Animal husbandry	The male members of a family herd the animals to feed on grass, stubbles, etc. Animal holding per person was higher in Zaria than at Dambatta. At Dambatta due to intensity of cropping around the settlements, herders have to use 'Takun Kumi*, on the animals from their settlements to grazing fields.

* 'Takun Kumi' is a netting material tied to the mouth of the animal.

Table 4.9 Continued

Aspect		Variation
2.	Milk and Dairy Products	
	Role of Women	The women are responsible for dairy activities in all locations.
	Volume	In two locations (i.e. Zaria and Dambatta) most respondents produced between 0-2 litres in dry season. The situation was better at Falgore with 62.5% producing 4-6 litres in same period.
	Storage	In Zaria, Fulani women market their products daily. As such there is little or no need for storage except for left-overs. At Falgore and Dambatta, due to spaced market days, milk products have to be kept for days to await a market day. As such they are kept in calabash containers and stored in an airy part of the room.

Table 4.9 Continued

Aspect	Variation
Type of Dairy Products	Main dairy products at Dambatta and Falgore is 'kindirmo' (whole sour milk). Popular product at Falgore is skimmed milk. Main products at Zaria are Nono and butter. While churning is an important activity at Zaria and Falgore, it is not a common feature at Dambatta.
Milking	Milking in all locations is the traditional squating method. What differs is the relative role of men and women in milking. At Dambatta and Falgore, milking is almost exclusively a woman activity; at Zaria both men and women participate in milking.

4.2 Description of Traditional Method of Butter Extraction

In the survey, it was found that the whole spectrum of traditional churning involves: keeping fresh milk in a suitable container over night; next morning, pouring the soured milk into a gourd; rinse out container and pour into the gourd; shake rhythmically up and down; pour out into a wide-mouthed calabash container; use a wooden stirrer to further bring globules together; then use hand calabash spoon to bring out fat and then collect in a container. The process is completed by washing the butter and kneading. Most Fulanis finally cut into units of sale.

Milking is done, as earlier stated, by men and women depending on location. When fresh milk is obtained from the cow, some is kept for instant consumption mostly by children, or boiled before consumed, The remaining milk, which is mostly between 2-6 litres (but not more than 10 litres) is sifted and then poured into a wide calabash container. For those that process milk every day for sale, it is from this container that sour milk would be taken the next morning for churning. Others however do accumulate milk for some days (i.e. 2-3 days) before processing. As such milk is accumulated for the number of days in the container until processing day. During this period, the milk does not spoil, but the sour level increases.

To sour, the milk would have reached a P.H. of 0.96%. Especially during hot season, the acidity of the milk could be more. Souring rate reduces during the cold weather, because the activity of the causative bacteria is slowed down. For such period, souring might be well after 24 hours.

Detail step by step process of churning as observed closely is as follows:

1. Souring: When fresh milk is received, it is freed from dirt by use of sieve. It is then poured into a clean container to stay overnight. By next morning, the milk sours by process of natural fermentation.

2. Churning: To churn, the sour milk is transfered from the container into a gourd. Because of the narrow neck or the gourd, it has to be filled gradually. Once the milk is transferered, the mouth is then plugged with a maize cob or any suitable cover or cork. The gourd is then held by the neck and repeatedly shaken up and down (Plate 8). From time to time, check is made to ascertain if the butter grains have formed.



Fig. 8: Traditional churning process in which the gourd is shaken up and down rythemically.



Plate 9 : Stirring the churned cream.

3. Removal of butter: When the grains have formed, the contents of the gourd are poured out into a calabash container. A stirrer is used to swirl the millet thereby bringing together fat globules (Plate 9). The butter is then removed using a spoon or bare hands (Plate 10).

4. Washing and Kneading: Once in a container, water could be used to wash the butter. This is repeated until the water comes out clear.

Complete tools used by Fulani women for milk processing are depicted on Plate 11.

4.3 Time Requirement for Existing Practice

Survey among dairy women has revealed that quantity of milk processed per day ranged between 2-10 litres (see Table 4.4). As such, time requirement for these different volumes was obtained and given in Table 4.9. Total time from pouring sour milk into gourd to washing and kneading of butter (including rest periods) were obtained. Total time increased from 17.5 minutes for 2 litres to 65.6 minutes for 10 litres. However, there are variations in the trend. For example, 41.6 minutes was required to extract butter from 5 litres, the same operator used 36.6 minutes to churn 6 litres of sour milk. This shows that efficiency of same subject could change.



Plate 10: Draining of butter



Plate ||: Tools used by Fulani women for milk processing.

Comparing the component tasks involved in butter extraction, percentage time requirement for churning was highest. For all volumes, this percentage was not less than 50%. It ranged from 53.6% to 68.6%. Time wise, major focus for intervention is the churning component (the agitation process). Other activities that follow churning include pouring sour milk into gourd; pouring out and rinsing gourd and extracting out butter. Percentage contribution of pouring sour milk into groud ranged from 5.8% to a maximum of 10.0%. Pouring out and rinsing gourd ranged from 5.5% to 8.7%. Removing or scooping out butter varied from 3.0% to 12.6% total time used.

It is worth commenting that for a particular component task, variation exist between repetitions. This shows that there is room for improvement within the present practice without the need for introduction of a tool or a different method. This could be achieved by standardization of the tasks.

Rest periods gradually increased from no rest to six minutes for ten litres. More rest indicates strain on the body and possible exhaustion of body energy reserve. This situation implies that at high volume, there is obvious need for improvement. At low volumes, i.e. 2-4 litres, the energy expenditure is such that an operator could do the the agitation task for a long period without exhaustion.

Table 4.9: Volume and Time Relationship during Traditional Butter Making

	Activity	Vol (lits)	2	3	4	5	6	7	8	9	10
			Time (in mins.)								
1.	Pouring sour milk into gourd		1.6 (9.1)*	1.8 (9.6)	2.0 (9.2)	2.4 (5.7)	3.6 (9.8)	2.7 (6.0)	4.0 (9.0)	5.6 (9.4)	6.0 (9.0)
2.	Rinsing of container and pouring into gourd		0.5 (2.9)	0.7 (3.7)	1.2 (5.5)	2.0 (4.8)	1.2 (3.3)	1.7 (3.8)	2.0 (4.5)	2.2 (3.7)	2.5 (3.8)
3.	Churning		12.0 (68.6)	10.0 (53.5)	13.0 (59.9)	25.4 (61.1)	20.0 (54.6	26.3 (58.4)	26.0 (58.4)	35.0 (59.0)	39.5 (59.6)
4.	Pouring out and rinsing gourd.		1.0 (5.7)	0.8 (4.3)	1.6 (7.4)	3.6 (8.7)	2.4 (6.6)	2.7 (6.0)	3.2 (7.2)	3.4 (5.7)	4.1 (6.2)
5.	Stirring in a calabash		0.7 (4.0)	1.4 (7.5)	1.0 (4.6)	1.5 (3.6)	1.4 (3.8)	1.5 (3.3)	1.5 (3.4)	2.1 (3.5)	2.3 (3.5)
6.	Extracting out butter		0.8 (4.6)	2.0 (10.7)	0.9 (4.1)	4.5 (10.8)	2.5 (6.8)	4.6 (10.2)	1.8 (4.1)	2.3 (3.9)	2.3 (.35)
7.	Washing and kneading		0.9 (5.1)	2.0 (10.7)	2.0 (9.2)	2.2 (5.3)	2.5 (6.8)	2.5 (5.5)	2.7 (6.1)	2.9 (4.9)	3.7 (5.6)
8.	Rest during churning		0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	3.0 (8.2)	3.0 (6.7)	3.0 (6.8)	6.0 (10.1)	6.0 (9.0)
	TOTAL TIME		17.5	18.7	21.7	41.6	36.6	45.0	44.2	59.3	66.3

*Percentage over total time.

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4.4 Energy Requirement for Existing Practice

Table 4.10 gives energy expenditure for different volumes of sour milk. Total human energy expenditure required to extract butter from different volumes of sour milk ranged from 16.2 kJ for 2 litres to 90.5 kJ for 10 litres. In terms of food value, 16.2 kJ is equivalent to 1 gramme of dietary carbohydrate food, and 90.5 kJ is equivalent to 5.66 gramme of dietary carbohydrate or 5.32 gramme of dietary protein food. Note that a gramme of dietary carbohydrate or protein is not the same as one gramme of food. Every food consists of water, nutrients and waste substances. For example, 100 gramme bread contains 49.6 gramme carbohydrate, 1.7 gramme fat and 7.8 gramme protein (Haselgrove, 1981). Local meal preparations contain much higher a mounts of water.

Correlation between human energy requirement and volume of sour milk processed was high. This shows that human energy expenditure is proportional to volume of sour milk churned. Percentage contribution of churning component compared to total energy varied from 58.2% to 81.5%. As such, simplifying churning (or agitation) operation will help to reduce the drudgery involved in butter extraction.

Table 4.10: Energy Expenditure (kJ) in Traditional Churning for Different Volumes

	Activity	Vol (lits) 2	3	4	5	6	7	8	9	10
		Energy Expenditure (kJ)								
1.	Pouring sour milk into gourd	0.1 (0.6)*	1.6 (6.1)	1.8 (4.9)	1.4 (2.9)	3.2 (6.0)	3.5 (5.6)	3.6 (5.0)	5.0 (6.4)	3.8 (4.2)
2.	Rinsing container and putting into gourd	0.4 (2.5)	1.2 (4.6)	0.6 (1.6)	1.4 (2.9)	2.4 (4.5)	1.9 (3.1)	1.2 (1.7)	3.7 (4.7)	1.6 (1.8)
3.	Churning	13.2 (81.5)	15.6 (59.3)	25.1 (68.0)	33.0 (68.9)	32.0 (60.0)	39.5 (63.7)	49.4 (68.0)	45.5 (58.2)	61.5 (68.0)
4.	Pouring out into container	0.1 (0.6)	1.6 (6.1)	1.5 (4.1)	3.0 (6.3)	3.1 (5.8)	3.0 (4.8)	2.9 (4.0)	4.9 (6.3)	3.2 (3.5)
5.	Rinsing gourd and putting into container	0.6 (3.7)	1.7 (6.5)	1.1 (3.0)	1.5 (3.1)	3.4 (6.4)	2.9 (4.7)	2.3 (3.2)	5.2 (6.6)	2.8 (3.1)
6.	Stirring	0.4 (2.5)	0.2 (0.8)	0.6 (1.6)	0.9 (1.9)	0.4 (0.8)	0.8 (1.3)	1.2 (1.7)	0.7 (0.9)	3.8 (4.2)
7.	Removing butter into container	0.6 (3.7)	2.6 (9.9)	3.9 (10.6)	4.5 (9.4)	5.3 (9.9)	6.4 (10.3)	7.7 (10.6)	7.8 (10.0)	8.4 (9.3)
8.	Washing and kneading	0.9 (5.6)	1.8 (6.8)	2.3 (6.2)	2.2 (4.6)	3.5 (6.6)	4.0 (6.5)	4.4 (6.1)	5.4 (6.9)	5.4 (6.0)
	TOTAL ENERGY	16.2	16.3	36.9	47.9	53.3	62.0	72.7	78.2	90.5

* Percentage over total time

4.5 Kinematics and Kinesiology of Churning

Close observation of churning or agitation process shows that it is achieved by the movements of the arms and the gourd. Normally, this is an up and down movement of the gourd. The arm is moved up and down about the shoulder joint (see Fig. 4.2). Usually angles θ and α vary at initial and final positions. The movement of the gourd is a simple up and down movement represented by letter h (Fig. 4.3). Agitation of the sour milk which is the essence of churning is largely achieved by the sudden jostling of the gourd contents during the downward movement.

For every height, h achieved due to difference between arms' angles, there is a speed which depends on the operator. As such the agitation process is governed by h (which is a function of α_f, θ_f and α_i, θ_i) and speed, s of the arms, which depends on applied force, F_a (Fig. 4.4).

Looking at kinetics and kinematics of churning, the relation can be described as follows:

$$\text{Churning process} = f(h, \theta_f, \alpha_f, F_a, F_w) \quad \ldots\ldots 4.1$$

All the factors have a correlation with churning process. Any of the factors increased, increases the agitation process. Increasing agitation reduces churning time and increases butter yield (O'Mahony, 1988).

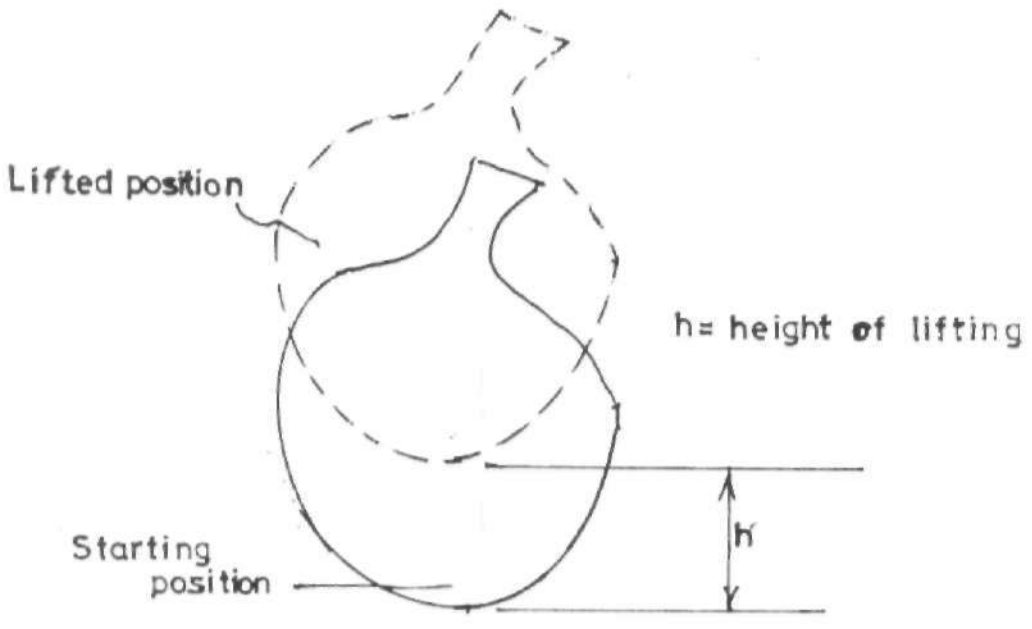
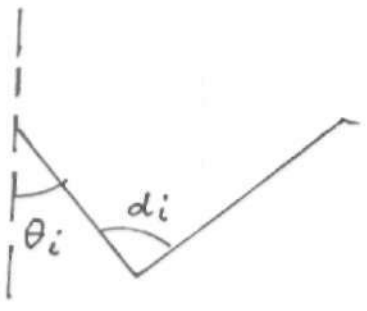
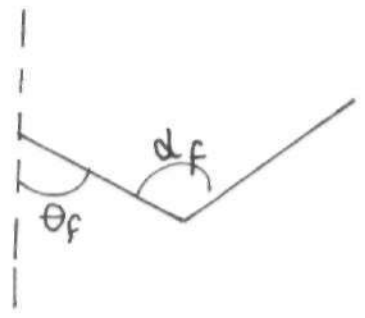


Fig. 4·3 Kinematics of tool



Initial position



Final position

Fig. 4·2 Kinematics arms

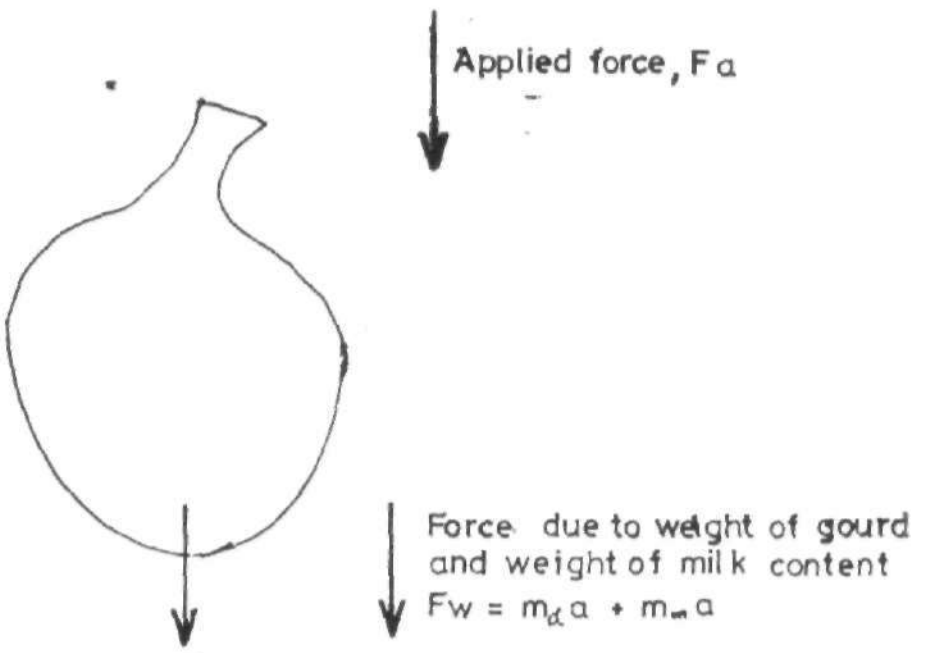


Fig. 4.4: Kinetics of churning.

To validate this mathematical assumption, data was generated and is presented in Table 4.11. Procedure used was to churn two litres of milk at different heights (i.e. h as illustrated in Fig. 4.3). Time, energy data, biomechanical angles, weight of butter and number of strokes during the entire duration were then taken. Results show that with increasing height, time required to extract butter reduced, heartbeat increased and force and work rate increased. In addition, butter extracted increased. For example, time for churning two litres reduced from 13 minutes when h is 10 cm to 7 minutes when h is 5 cm; correspondingly, energy expenditure increased from 12.0 kJ to 32.9 kJ. Butter extracted increased from 104 gramme to 123 gramme, an increase of 18.3%. Total distance through which milk product moved also increased when height was increased. This shows that there is correlation between biomechanical factors and churning process.

The graph shows that time for churning reduced as human energy expended in agitation increased. Table 4.11 shows that as energy expenditure increased, applied force and distance through which gourd was moved also increased. This implies that these kinesiology factors are related to each other, on one hand, and to the churning process on the other.

Table 4.11: Biomechanic Data of Traditional Churning

No.	Height h in cm	θ_i	α_i	θ_f	α_f	A++	B	C•	D+	E	F	G	H
1	10	28	58	94	127	1909	13.0	106	38.18	104.0	0.9	12.0	314.3
2	30	28	58	92	105	991	10.0	120	59.46	113.0	2.3	23.0	386.8
3	40	28	58	92	118	939	9.0	133	75.12	120.0	3.6	27.5	431.3
4	50	28	58	104	106	609	7.0	144	60.90	123.0	4.7	32.9	540.2

• Initial heart rate was 97 beats/min
+ Total movement of gourd during churning
++ No. of strokes from beginning of the operation until butter was extracted.

KEY

A = No. of Strokes
B = Time to butter extractions (mins)
C = Heart rate (beat/min)
D = Total distance (metres)
E = Weight of butter (gm)
F = Work rate (kJ/min)
G = Work (kJ)
H = Force F in N.

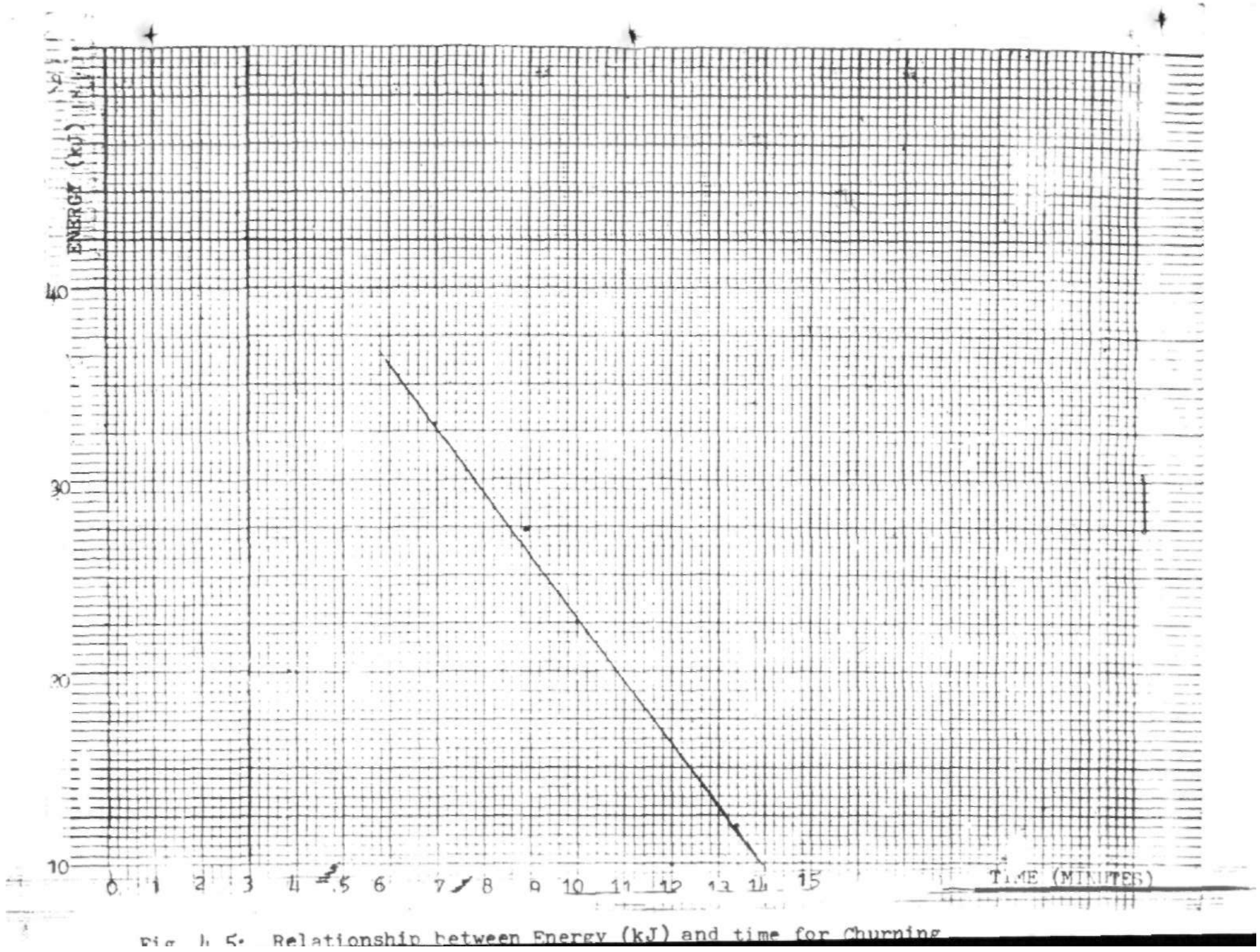


Fig 4.5: Relationship between Energy (kJ) and time for Churning

This study points to the fact that within the existing churning process, improvement is possible with least intervention - namely, by optimizing the kinetics and kinematics involved in the work.

4.6 Anthropometry of Subjects and Dimensions of Tools

In Zaria area, a survey was conducted to obtain vital anthropometric dimensions of selected Fulani women. Data obtained is given in Table 4.12.

In any hand tool, proper areas of interface between the hand and tool is important for enhanced operability, safety, convenience and comfort. In traditional churning, the areas of interface of importance include:(i) gourd neck - important dimensions include diameter and length; ii) stirrer handle - length of the handle is important; iii) gripping area of calabash spoon.

1. Roebrick et al. (1975) defined power grip as that in which the total inner hand surface is grasping an often cylindrical handle. For the diameter of the handle, Roebrick et al. (1975) recommends consideration of hand length, and thumb space. As such, the circumference of the gourd neck could be equated to hand length.

Table 4.12: Anthropometry of 46 Fulani Women

S/No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	171	153	150	128	13	28	26	16	8.1	11	21	120	96	46	6	26	12	27
2	166	145	142	130	14	27	24	17	10.1	15	27	105	75	40	7	23	16	28
3	156	140	138	122	14	27	25	15	9.7	12	20	105	80	35	7	20	16	23
4	173	155	153	131	15	31	30	19	9.5	14	24	122	99	48	7	28	15	30
5	172	154	152	130	15	30	29	18	9.0	13	23	120	98	48	6	27	13	28
6	156	150	140	132	17	32	17	16	8.8	30	32	122	99	49	8	24	18	32
7	157	139	136	125	15	29	26	18	8.9	20	32	116	87	42	10	26	14	29
8	156	138	135	124	13	28	25	16	9.0	17	30	115	85	40	9	25	12	28
9	153	146	137	129	13	28	14	12	9.5	26	28	119	96	46	5	25	15	28
10	176	160	155	140	13	28	25	18	8.5	15	35	127	100	50	7	25	15	30
11	154	150	140	135	14	28	25	15	10.0	11	28	125	100	54	4	23	14	28
12	160	148	140	125	22	30	26	17	9.5	15	30	123	90	47	8	25	12	30
13	155	149	139	130	15	30	16	15	9.0	29	30	120	98	48	7	23	17	30
14	162	149	143	127	14	33	28	19	9.0	17	30	124	92	48	9	26	13	32
15	153	148	139	134	13	27	24	14	8.0	10	29	124	98	53	4	22	13	28
16	177	160	150	136	15	30	29	15	8.2	12	26	125	103	49	8	25	17	20
17	170	148	146	130	13	30	27	18	9.9	18	30	120	94	40	7	20	15	29
18	167	144	143	128	11	28	23	16	8.6	15	28	130	90	38	7	13	18	28
19	155	134	130	120	12	26	25	15	8.8	17	20	157	83	40	7	20	13	20
20	172	149	144	129	18	25	26	17	10.0	19	32	112	98	43	7	23	13	31

Table 4.12 Cont'd.

21	169	153	149	140	10	34	30	20	9.4	15	27	115	95	45	10	24	13	27
22	153	139	129	118	11	27	26	19	10.5	15	25	108	84	48	10	23	15	25
23	152	133	130	118	10	28	25	17	9.1	15	25	94	83	39	10	23	15	30
24	172	149	144	129	18	25	26	17	9.4	19	32	112	98	43	7	23	13	31
25	168	147	145	133	17	29	24	17	9.5	15	30	108	78	52	10	26	18	32
26	156	140	140	145	15	24	27	17	9.0	29	31	106	95	44	3	22	12	25
27	158	138	132	127	14	28	30	27	10.4	19	22	159	85	42	9	22	14	23
28	158	137	130	127	17	29	30	27	8.5	12	22	159	85	42	9	22	15	24
29	154	140	135	99	16	30	30	21	9.6	19	17	130	80	40	12	25	14	30
30	158	150	144	80	15	35	35	16	9.0	12	30	105	98	45	10	25	13	30
31	171	151	134	70	27	30	34	20	8.0	19	22	122	99	49	10	25	16	29
32	172	150	140	132	15	33	30	20	9.7	20	30	120	83	45	10	22	15	29
33	160	156	153	140	19	30	35	19	8.7	17	19	128	95	45	12	25	16	30
34	154	147	130	119	15	30	30	20	9.6	15	20	91	89	44	10	20	13	30
35	167	159	156	143	18	35	39	23	8.4	20	21	130	98	48	14	29	19	34
36	156	142	130	129	11	26	28	15	8.2	14	25	108	84	43	10	17	14	28
37	154	139	134	103	15	24	39	15	10.0	16	15	117	83	45	13	28	14	30
38	156	140	137	105	15	26	30	17	10.4	16	19	117	85	45	12	29	15	29
39	165	147	143	127	11	30	19	20	9.1	19	18	120	90	44	9	25	15	26
40	168	147	145	130	13	31	29	20	10.2	14	26	112	90	43	12	24	14	26

Table 4.12 Cont'd

41	165	152	148	139	10	30	29	19	9.2	13	29	116	90	44	12	26	16	30
42	164	148	144	132	12	30	20	19	9.2	12	22	104	96	44	12	23	14	26
43	167	147	145	130	12	30	29	19	9.6	13	25	112	90	43	10	24	14	25
44	156	136	133	123	15	27	23	16	8.9	15	20	110	81	37	4	24	15	27
45	170	147	145	132	15	29	25	16	8.3	25	27	119	93	48	4	22	13	32
46	164	143	157	127	13	27	25	17	9.8	24	28	108	86	39	4	21	14	30
	162.3	146.5	141.0	125.7	14.3	29.0	26.9	17.8	9.2	16.9	25.7	118.5	90.7	44.6	8.4	23.7	14.6	28.2

Key to Segment Link

1. Total height
2. Height (eye-level)
3. Chin level
4. Shoulder height
5. Shoulder width
6. Upper arm
7. Lower arm
8. Hand length
9. Hand width
10. Chest width
11. Breast width
12. Height (breast level)
13. Pelvic height
14. Total leg length
15. Ankle height
16. Foot length
17. Foot breadth
18. Pelvic width

$$\therefore D = \frac{C}{\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.2$$

where D = diameter of gourd neck

C = circumference represented by hand length.

This relationship allows for effective grip.

Segment link ratio of hand length is represented by 0.11 H.

$$\therefore D = \frac{0.11\ H}{\pi} \quad \ldots\ldots\ldots\ldots\ldots\ldots 4.3$$

From anthropometric data of Fulani, H = 176 cm

(representing 95th percentile value of height).

$$\therefore D = \frac{0.11 \times 176}{3.14} = 6.17 \text{ cm} \quad \ldots\ldots\ldots 4.4$$

2. Gourd Neck Length - Plate 8 shows how gourd is held for operation. For effective grip as shown in the plate, gourd neck length should not be less than twice hand breadth.

In segment link ratios, hand breadth is represented by 0.06 H where H is 95th percentile value for heignt of prospective users.

$$L = 2 \times 0.06 \times 176 = 21.12 \text{ cm} \quad \ldots\ldots\ldots 4.5$$

Comparison between compatible dimensions of diameter with diameters of existing gourds (i.e. 3.5-6.5 cm) shows that selection would give a gourd neck which is adequate. Effort should be made always to select gourd with suitable size. Neck height was not given on Table 4.13. However, measurement of various sizes showed that the neck height ranged from 11 cm to 22 cm. This shows that while some are compatible, others are not. Thus there is need to educate users on appropriate selection. Possibility of breeders developing a variety to give good sizes could be explored.

Length of Stirrer - Generally lengths of existing stirrers are adequate for compatability. Plate 9 shows how the stirrer is used. Length equal to hand breadth is adequate for operation. However, as shown in the plate, the stirrer should be of adequate height to allow a processor comfortable sitting posture. A length of 57 cm is adequate for user population considered in this study.

- Knurling of Stirrer and Handle for Calabash Spoon - In anthropometry, knurling is recommended to ensure effective grip or transfer of force from the arms to a tool. Stirring is by applying rotational force on the stirrer. To effectively achieve this, it is recommended that the gripping area or contact area should be knurled.

Some makers of stirrers do knurl it, but others do not. This should be a recommendation to extend to the concerned artisans.

Knurling also applies to contact area on calabash spoons. When knurled, it ensures effective grip between fingers and spoon.

Comparison between compatible dimensions with dimensions of existing tools shows that length of stirrers is adequate for compatibility. Knurling along the length of the stirrer should be encouraged. Knurling increases interlocking between the hand and the stirrer thereby enhancing transfer of applied force.

4.7 Constraints in Traditional Churning

In existing milk processing, the task identified as a constraint was the agitation process. The agitation process required not less than fifty percent of the total time and energy requirements for the whole process. Kinematic and kinetic analysis of agitation process shows that weight of sour milk being churned acts through the subject. This imposes a load on the subject proportional to weight being churned. It appears that if the agitation could be done with the weight either resting on the ground or something else other than

the operator, the energy expenditure could be reduced tremendously. Time requirement is reduced by increased agitation. As such any device that could enhance agitation will reduce time utilization.

It was also discovered that with high volume of sour milk, churning takes place in batches in the traditional system. This increases time and energy expenditure. A system which could allow churning at a time for a wider range of volume is desirable.

4.8 Attempt to Improve on Traditional Churning and Comparisons with Tradition

4.8.1 Introduction of New Devices

The main principle involved in butter extraction is agitation to break butter membrane to release butter grains. The butter initially appears like wheat grains, slow agitation makes it increase in size as the grains combine together. Traditional method of butter extraction from sour milk involves putting the milk in a calabash gourd and shaking vigorously up and down until butter grains form. To reduce time and energy requirement, as found in sections 4.3 and 4.4, a design was conceived on how to achieve fast agitation on sour milk. This design consisted basically of a shaft which could be rotated about a vertical axis. Note that one of the ergonomic constraints recognized from traditional method of butter extraction is that the weight of sour milk is supported by the subject during churning (Plate 8). To correct this, the present design allows for the milk to rest on the ground. The design of the churn is given in Fig. 4.6. It consists of a frame, agitation shaft, a container, a rope arrangement and a sitting stool (Plate 12). All these materials are easily available and are affordable. To operate, a woman puts



Plate 12: IAR Improved Churner

sour milk in the calabash and puts on the lid. Thereafter, she assembles the shaft on the horizontal frame member. She sits on the stool, and pulls on the shaft rope back and forth.

The force applied through the rope (Fig. 4.7) is a reciprocating type. This force applies a rotational movement on the shaft. When force is applied on one side of the rope, it moves round in clockwise direction. When it is pulled the other side it gives a counter clockwise rotation. As such the contents of the gourd is subjected to vigorous agitation within the container.

Vital dimensions of the churn were informed by the anthropometric dimensions of the users. The churn height was such that while seated, the hands could be stretched straight to hold the operating handles. The handles at end of rope were dimensioned to give maximum contact with the hands - length of the handle was equal to 95th percentile value of hand breadth for prospective users. Dimensions of parts are given in Fig. 4.6.

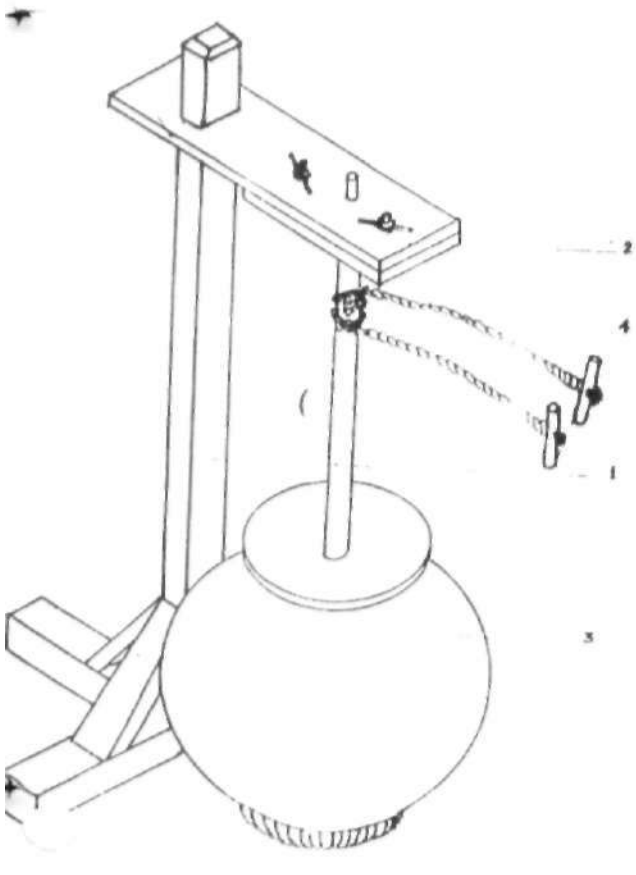


Fig 4:6 An assembly of IAR improved milk churner

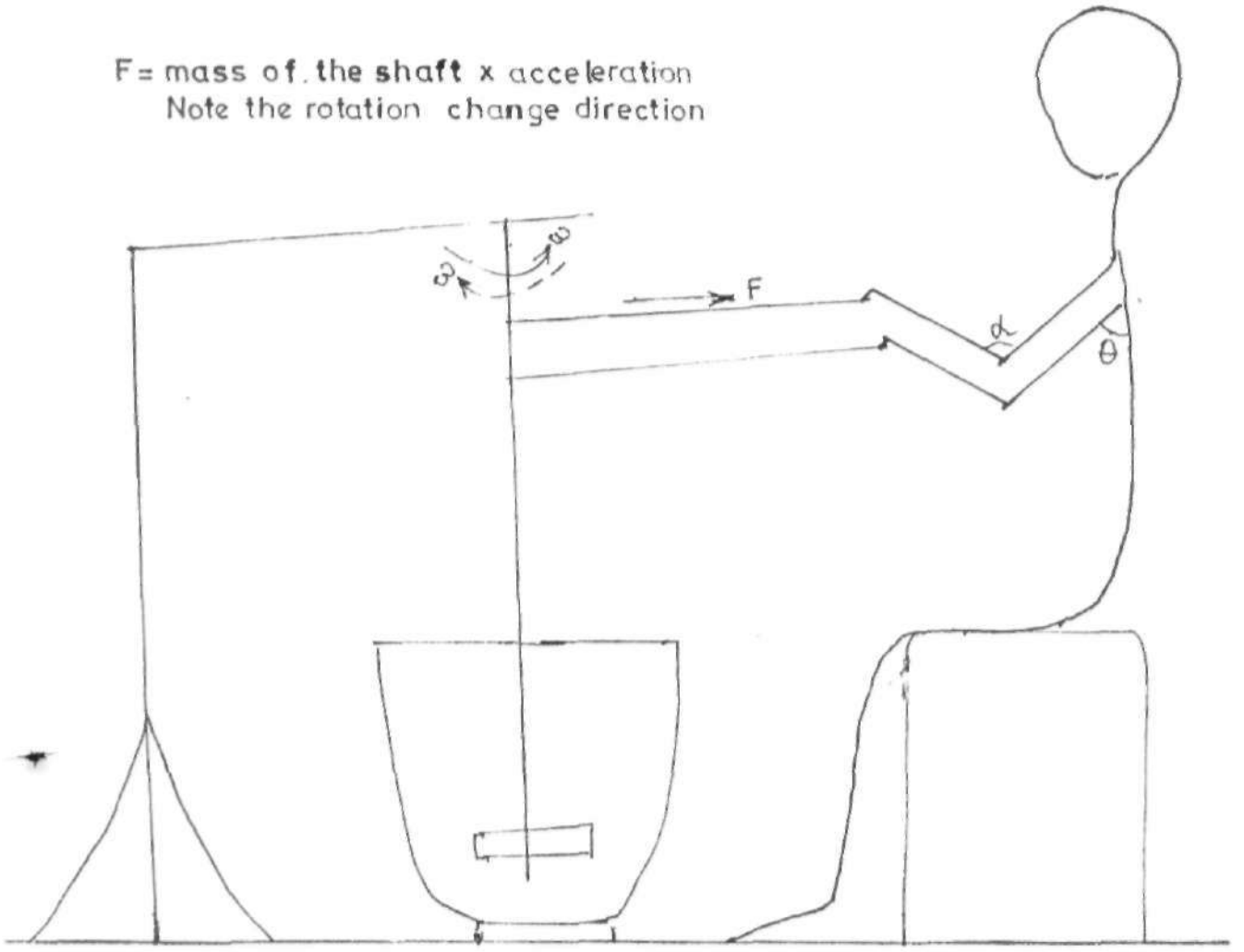
Important Dimensions of Churner Components

No.	Component	Material	Overall Lenght (cm)	Height (cm)	Width (cm)	Thickness (mm)
1	Vertical member	Wood		94	65	40
2	Horisontal member bearing	Wood Metal (standard) No 6204		48	140	
3	Calabash (pot) shaft	Wood DIA 4-9		74		
4	Rope		160			

Note: One or more dimensions might be irrelevant for a component

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F = mass of the shaft x acceleration
Note the rotation change direction



θ = Angle between arm and body
α = " " arms

Agitation, using the churn, depends on:-

a. θ
b. α
c. mass of shaft
d. speed of rotation

Fig. 4.7 Analysis of forces involved in operating churn.

4.8.2 Collaboration with Users

To achieve a good design, the churn was put with users at Kano, Kaduna, Niger and Plateau states for usage and suggestions for improvement Table 4.14 gives an example of data from user trials. Numerous suggestions in relation to material, height of parts and fastener types were obtained. Specific examples of suggestions received include:

1. Container was initially a clay pot, changed to a calabash container and then to a plastic container. There is a cultural stigma attached to clay pot amongst the Fulani.

2. Change of churner height to conform with anthropometry of users.

3. Simplification of fastening method of the agitation shaft, such that fastening could be done by hand without using a tool. This suggestion entailed making a wing nut which can easily be screwed by bare hand.

4. Change of method of holding churner to ground. Initial frame made was not very stable leading to accidents in churning. The present unit consist of a rigid frame which is pinned to the ground.

Table 4.14: User Feedback on Use of Churn from Two Locations

Location	Approx. quantity processed per week (lit)	Approx. time requirement (min/lit)	Approx.* time requirement for traditional (min/lit)	Advantage over traditional (%)	Total saving of time per week (hrs.)
Kachia	120	2.00	8.8	300	12
Sabon Gida Kanar boda	210	2.75	8.0	190	18

* Average figures obtained using different operators on a traditional gourd.

Source: Ali and Kaul, 1993.

4.8.3 Comparative Evaluation

To assess performance of design, churn was compared with traditional method for time requirement and energy requirement. Results are given in Table 4.15 below.

Results show that there is saving of time (22.2 - 165.2%) and energy (136.0%-470.0%) when improved churner is used. Time saving differs depending on volume. At low volumes, difference in time is small (i.e. between 20-30%). However, at high volumes, percentage saving in time is as high as 165.2%.

Table 4.15: Comparative Evaluation of **Traditional Gourd** and Improved Churn.

Volumes	Time (mins)			Energy (kJ)		
	Traditional churning	Improved churning	% saving	Traditional churning	Improved churning	% saving
3	18.7	15.3	22.2	26.3	5.8	353.4
4	21.7	16.6	30.7	36.9	10.1	265.3
5	41.6	23.5	77.0	47.9	20.3	136.0
6	36.6	25.4	44.1	53.3	10.1	427.7
7	45.0	23.9	88.3	62.0	12.2	408.2
8	44.2	23.4	88.9	72.7	18.7	288.8
9	59.3	22.9	159.0	78.2	13.7	470.8
10	66.3	25.0	165.2	90.5	16.6	445.2

A laboratory analysis was performed to compare the efficiency of extraction between the traditional gourd and the churn. For each method, a sample was taken from the sour milk before agitation and also after agitation. Therefore, efficiency of extraction was calculated. Table 4.16 gives comparative extraction efficiency between traditional gourd and the churn. From the results, it could be seen that efficiency of extraction is same at low volumes (i.e. 3 and 4 litres). Thereafter, efficiency of extraction by gourd decreases, while that in improved churn peaks. While churning 10 litres, difference in efficiency between the two methods is 6.81%.

Table 4.16: Laboratory Evaluation of Churning Efficiency

Volume (lit)	Amount of fat in whole milk, % (before agitation)	Percent of fat extracted		Fat left, %		Efficiency	
		Trad. gourd	Churn	Trad. gourd	Churn	Trad. gourd	Churn
3	4.26	2.86	2.86	1.40	1.40	67.14	67.14
4	4.26	2.86	2.86	1.40	1.40	67.14	67.14
5	4.20	2.80	2.84	1.40	1.36	66.67	67.61
6	4.20	2.66	2.84	1.54	1.40	63.33	67.61
7	4.20	2.66	2.84	1.54	1.40	63.33	67.61
8	4.26	2.65	2.94	1.61	1.32	62.21	69.01
9	4.26	2.67	2.94	1.59	1.32	62.68	69.01
10	4.26	2.66	2.95	1.60	1.31	62.44	69.25

4.8.4 Cost of IAR Improved Churner

A complete assembly of improved churner costs about ₦1,000.00 (as at 1994). Breakdown of cost is as follows:

No.	Item	Cost (₦)
1	Frame (wood)	400.00
2	Bearing	210.00
3	Plastic bucket or calabash with support	160.00
4	Labour	230.00
	TOTAL COST	₦1,000.00

With any enterpreneur making many units, cost of the churner will come down. All materials for making the churner are available in most Nigerian markets, and unit can be fabricated by any skilled carpenter. It should be noted that it is relatively cheaper compared to output and other advantages.

4.9 Description of Existing Practice of 'Fura' Making

Fura making is an integral part of milk usage in most parts of Nigeria. As stated in section 3.2, surveys were conducted in areas known for high consumption of Fura. Results of the survey are discussed in three parts as follows:

1. Full description of process as observed in Zaria.
2. A table (4.17) showing variations and intricacies of fura making at different locations.
3. Information from survey on existing method of fura making.

Full Description of Process

The process as observed at Zaria is as follows:

a) Dehulling - Millet grains are placed in a mortar, water is added, and the millet is pounded continuously. Pounding is done until the skin (i.e. epidermis) of the millet is removed completely (Plate 13).

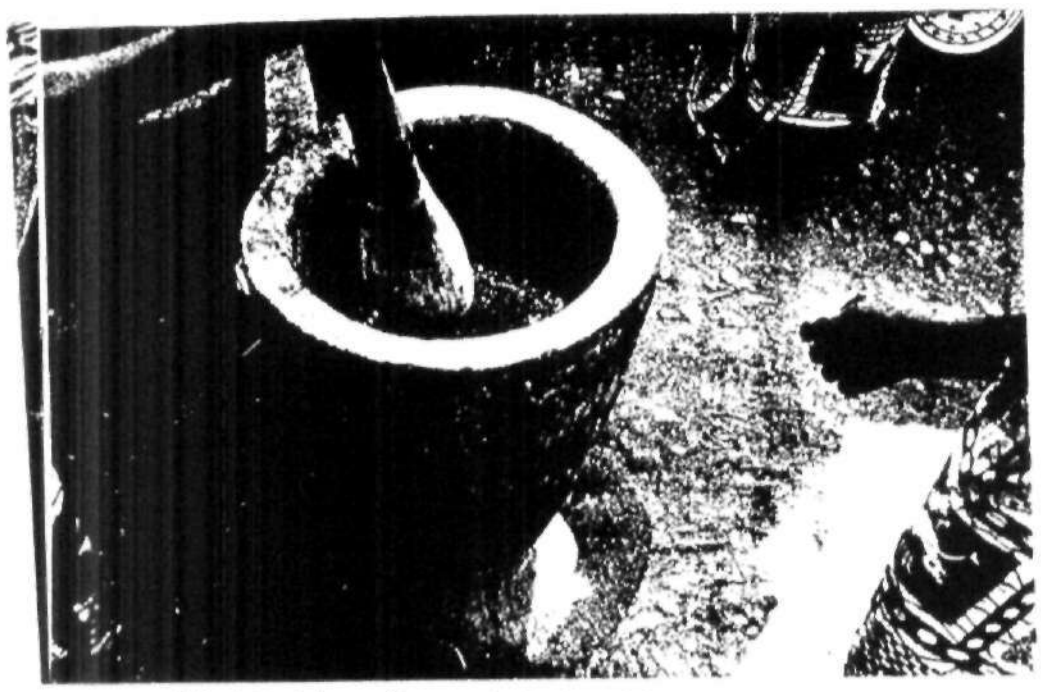


Plate 13: Manual Dehulling



Plate 14: Packing millet into Calabash after dehulling.

b) Washing, Covering and Drying - Dehulled millet from (a) is transferred into a bucket or calabash containing water. The millet is rubbed between two hands. This detaches millet skin to float on the water. The husk/skin is decanted with the water, and clean water is then added to further wash the millet (Plate 15). When clean, the millet is left in a calabash and covered. After a while, the millet looks dry and crushes when rubbed between fingers. Spices are then added (Plate 18).

c) Pounding and Sieving - Pounding is done to break millet grains to flour. After pounding for a while, sifting is done to get fine flour. Sifted coarse part is returned to mortar for additional pounding. These two processes are repeated until the dehulled millet grains are converted to fine flour (Plate 17 and 19).

d) Washing - The coarse part from (c) is put in water, to allow trash and other dirts float. These are removed, and the clean wet part is added to fine flour in mortar. Millet grains are also added into the mortar.



Plate 15: Washing dehulled millet to separate stones and skin.



Plate 16: Millet covered in a calabash to soak in moisture.



Plate 17: Manual pounding



Plate 18: Addition of spices.



Plate 19: Sieving



Plate 20: Putting big balls in boiling water to cook.

e) Pounding - The combination of fine flour and some added coarse part is pounded until it sticks to the hand.

f) Formation into big balls - Big balls are formed by cutting a sizeable chunk from pound millet (e above) and rolled into a ball by the side of the mortar.

g) Cooking - The big balls are placed in a pot of boiling water. The pot is covered until the balls are cooked (Plate 20).

h) Pounding Cooked balls - The cooked balls are returned into mortar and pounded very well (Plates 21 and 22) to give Fura.

i) Formation into small balls - Selling units in form of small balls are formed by rolling by side of mortar.

j) To prevent the balls sticking to each other, fine flour of millet is sprinkled to cover the balls.

This process can be vividly represented by a line process chart below. Henceforth, the process described above is referred to as system C or existing method of fura making.

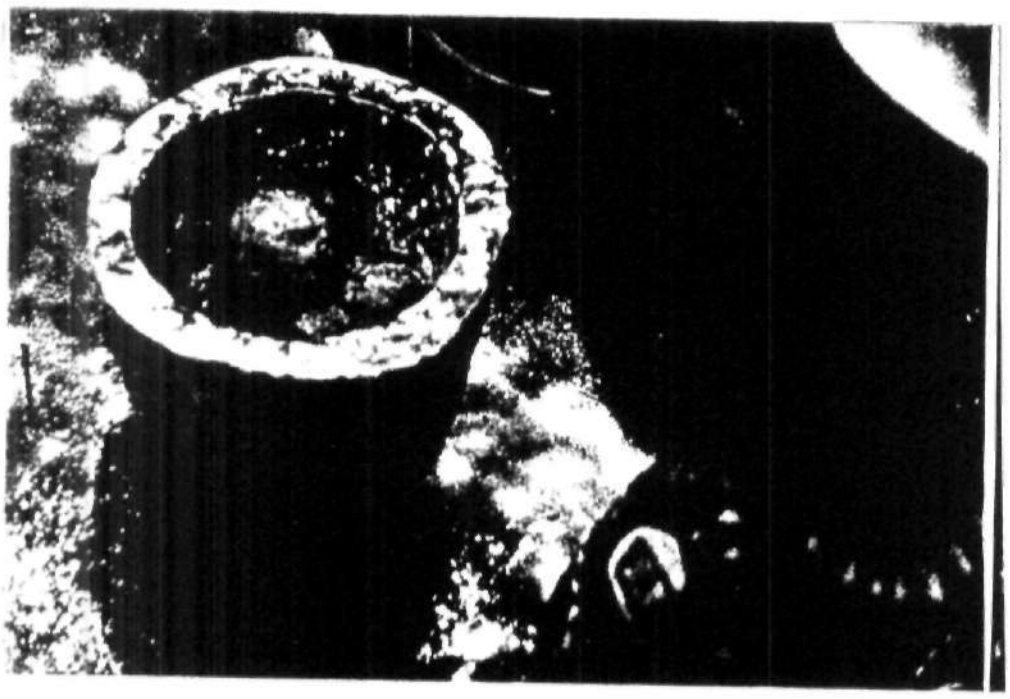


Plate 21: Cooked big balls transferred to motar.



Plate 22: Pounding of big balls.



Plate 23: Small balls formed after pounding/ market scene.

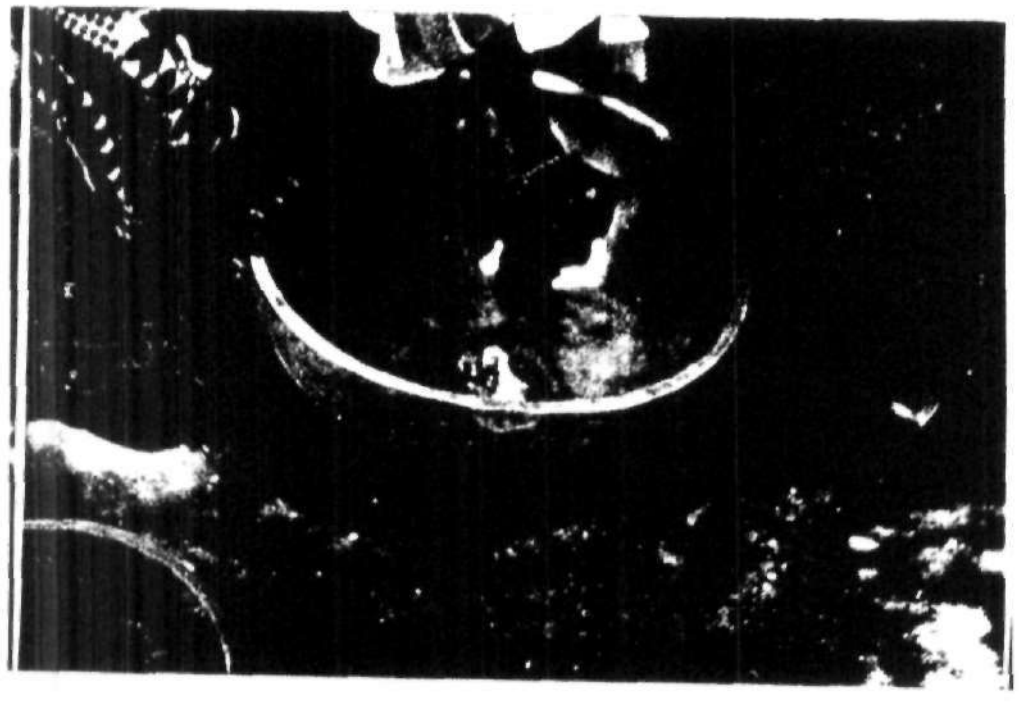


Plate 24: Mashing Fura in Nono to make a drink

Line Process Chart for Traditional Fura Making

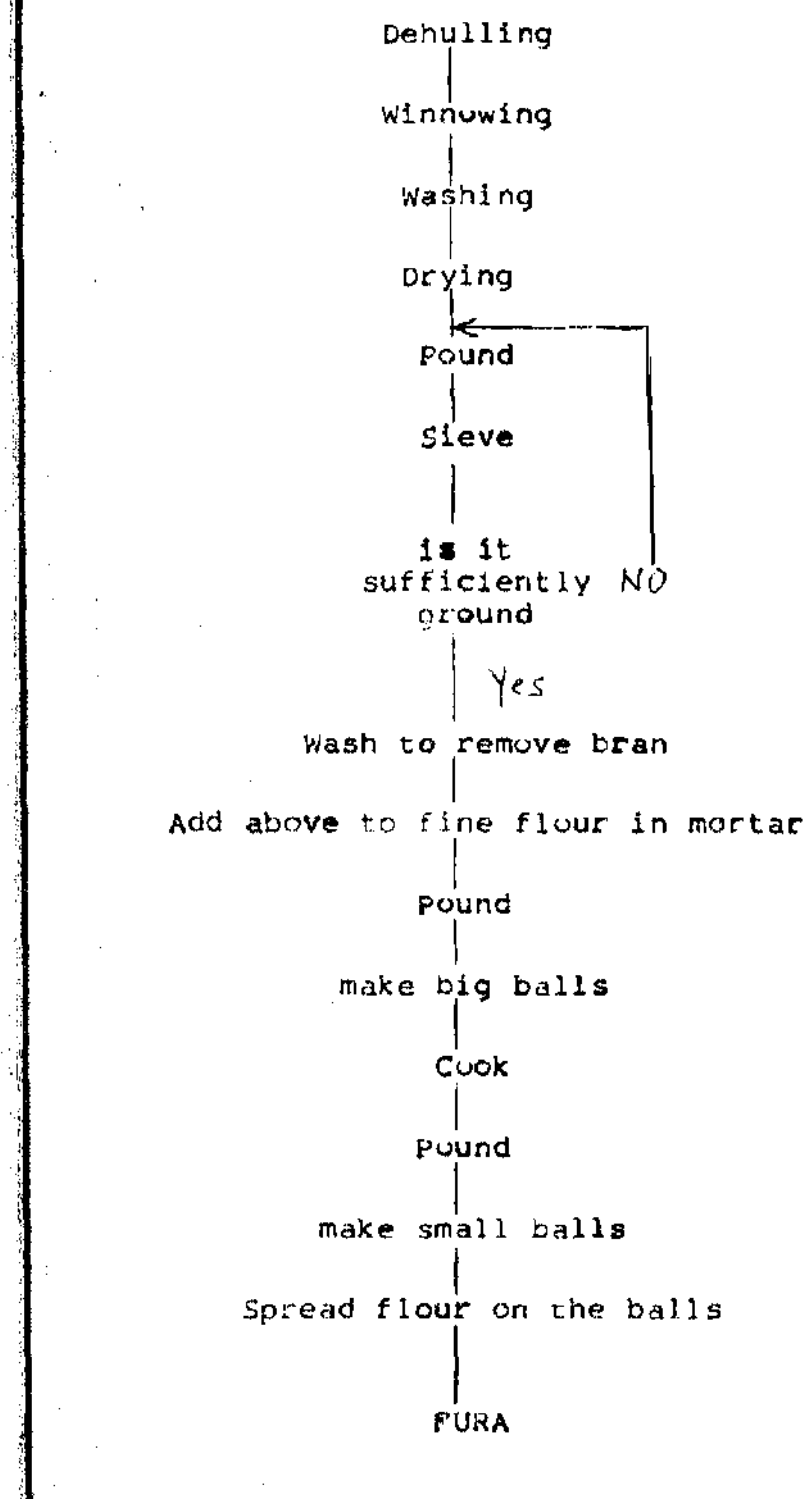


Table 4.17: Variations and Monitoring Parameters in Fura Making at Different Locations

Process	Traditional methods of monitoring completion of Process/Remark	Variation
Dehulling	When dehulling is complete, millet forms a wall which heightens by mortar and then it collapses. Visual inspection also shows that the skin is removed.	This process is same everywhere In fura making used for ceremonies this process is eliminated - reducing drudgery and time for this task. This process was prevalent at Biye, Zaria.
Washing, soaking and draining	Water is continuously added into millet, and the top decanted until the water comes out clear witnout skin in suspension. Draining is assessed as complete when the millet appears separated with appearance of dryness. Draining is essentially an absorption process. Moisture from washing is absorbed into the grains.	In places like Katsina, water is not used for separation. Instead after dehulling, it is winnowed to extract out the back. With this, there is no need for allowing time to drain. Immediately, winnowing is completed, grinding could start. For a tiya or millet i.e., 2.5 kg, time saved is about 22 minutes.

Table 4.17 Cont'd.

Spices	A combination of spices is used, each with a definite role. While one (tattasai) gives a pepperish taste, the other three give flavour to the Fura. Apart from this, two (Kaninfari and masoro) add or enhances the pepperish taste of tattasai. Level or spicing is crucial. If it is too much some customers might not be able to consume it. If it is too low, the effect might not be noticeable. Our observation/judgement is 0.8 kg per 2.5 kg of millet.	Stage of adding spices is different in different locations. While it is added to millet grains before pounding at Zaria; in Katsina and Sokoto it is added to cooked fura just before pounding. In Katsina and Sokoto, the spices are pounded manually and sieved. Still others add just before making big balls.
Formation of big balls	Cooking of these balls is considered completed, when they give a reddish appearance. This judgement was consistent that during repetitive trials, for same quantity of millet, timings were close. Others say it is considered cooked if hitting or tapping a cooked ball gives a deep dim-dim sound.	This varies - in constrast to big balls small balls are formed in some places. In Sokoto, though they make big balls, but make a hole to the centre of the ball, using a finger or any suitable tool. An entirely different method from above exist whereby no balls are formed. The flour is steamed in a perforated calabash placed over boiling water. The boundary between pot and calabash is sealed for effective and fast steaming.

Table 4.17 Cont'd.

Pounding and Sieving	This applies to pounding and sieving after dehulling. This combination of processes could be repeated four to seven times. This depends on level of fineness achieved and quantity of sifted part. The need or otherwise of repeating pounding/ sieving after a subsequent one is determined by whether there is white colour flour or not in the remnants sieved out. As such how often this process is repeated is not rigid but determined by situation which is gauged by eye.	
Formation of small balls	This is not the same size throughout the year. It is always modified to allow small returns on investment. Effort is also made to be competitive. A technology developed in this respect should encompass this vital step that determines profit of the business.	In Sokoto and Kebbi, it is not always that they make small balls. If the fura is meant for home consumption or for sale in kiosks, then when cooked and pounded it is left to cool. Thereafter, Nono or water is used to prepare the 'fura da nono' drink.

Table 4.17 Cont'd.

Cooking	Temperature is important because the fura balls are always put in boiling water. Before the water boils, the fura balls might absorb rather than cook.	
Water requirement	Level of water added while dehulling is crucial. Same goes for water addition during pounding of cooked fura. For example, water requirement at dehulling is such that the millet absorbs - should not be above what could be absorbed wholly. That makes the millet soft such that the skin could detach, without the grain breeking. With experience, the fura makers are able to assess right quantity of water. In case of 4.5 kg of millet, 640 ml was adjudged as adequate.	When fura is intended for storage or travelling, water is not added when being pounded after cooking. This type of fura is common in Katsina, Sokoto and Kebbi States.

Other Information from Survey on Existing Method of Fura Making

1. Historical account on Fura - In the survey conducted at Katsina, Sokoto, Kebbi and Zaria, the origin of Fura varied between respondents. The different versions are as follows:

One version of historical origin has it that Fura originated from travellers. In the past, due to exigencies of travelling when people have to trek for days, travelling needed food that could be prepared fast and with ease while on the move. In the search for such a food, fura was invented and since then has been widely used by travellers. Workers/farmers have also been associated with fura. The Fulani, as travellers, have also been linked with fura from time immemorial. When they move with their animals from one place to another, fura serves as their readily available food whenever they are hungry.

Others have it that fura originated from the need to have a cool and calming refreshment for warriors. In days of tribal and religious wars, fura was prepared and kept in earthen pots under trees. By the time warriors return from war front, it would have become cold. This is

then served to them to cool them down. This was prefered to the conventional food (i.e. Tuwo) which is eaten hot.

Still others believe that fura might have originated from the people of the far north, especially Sakkwatawas and Katsina people. Probably due to their harsh climate, fura was invented in a search for cold and readily available refreshment. To date, fura is highly consumed in these areas. In most households in Sakkwato area, this product is always available for consumption any day, any time.

2. Expectation of Fura Consumers - The response in all locations has been the same. The qualities consumers look for include: good spicing, clean preparation (devoid of sand particles), and proper dehulling. Spices used in Fura making include: 'Barkonu,' 'Citta,' 'Kaninfari,' and 'Masoro.'

3. Preparation Preference - Do people prefer making fura at home or buy from hawkers? The answer to this question varied. In high consumption areas, families prepare their own fura. It is normally mixed with nono or only water and stored in earthen pots. At any time, you could go and take for consumption.

However, even in these places, there are exceptions to this rule. Bacherlors, visitors, immigrant workers patronize hawkers very well. Note that fura making is arduous and time consuming. As such this category of people, for obvious reasons, cannot prepare fura in their homes.

In Zaria, most people (i.e. 90%) get their fura from sellers. Note consumption here is not as much as Katsina, Sokoto and Kebbi States.

4. Formation of Fura into Balls - Many reasons were given for this:

i) It allows the fura makers to know what quantity of fura they have. It readily affords them the opportunity to know whether they made profit or loss.

ii) Another reason advanced is that making it in balls allows fair sale. In the past, fura is put in a selling bowl as solid mass. In the market, the selier used her discretion to cut from the mass the worth of a buyers money. With time, buyers became dissatisfied because sometimes those buying find out that there is little or no difference even though they gave different amounts.

iii) Some respondents said making it in balls prevents or delays drying up.

5. Quantity Processed - From all respondents of the survey, quantity of millet processed into fura ranged from ½-3 tiyas (1.2-7.5 kg) per day (most fall within 1-2 tiyas). Every processor has a reason for the quantity she produces. Some are limited by market, others by ability to produce.

6. Storage - All fura processors interviewed did not have a conventional fridge for storage. They store temporarily in either calabash or bowl. With this method, they claimed, they can successfully store for two days. In terms of storage, some leave it open throughout. Others leave it open during the day and then put a lid in the night. Yet others put water in the bowl and then immerse the fura in the water. It is this water that is renewed daily to keep the fura fresh.

All respondents, especially in Katsina and Sokoto states, claimed that the best way to keep fura for a long period is to dry it after cooking and pounding. Thereafter, it is ground into a flour. This can keep for a year or more. Whenever, it is needed you only need to put some hot water to soak and then use nono to mix to taste.

7. Tools - It is same tools used in all locations visited. Most of these tools are part of household tools. The tools used in Fura making include: mortar, pestle, sieve, calabash, flat tray,local wood stove, pot, small bowls. All these tools were same in all locations except pestle. The pestle in Sokoto and Kebbi look different from that of Zaria. The difference is depicted in Plates 25 and 26.

There is no gain saying the fact that mortar is an important tool in fura making. What decisions inform the choice of fura makers when they go to buy? Response include:

i) Width and depth of the mortar

ii) quality of wood used

iii) Absence of cracks on the body

8. Economics of Fura Making - The table below gives examples of costs and profits for different quantities of fura produced.



Plate 25: Pestle (type used in Zaria)



Plate 26: Pestle (type found at Sokoto and Kebbi States).

Table 4.20: Economics of Tura Making

No. of 'Tiyas'*	One	Two	Two and Half	Three
Cost of fillet (N)	14.00	26.00	37.00	42.00
Number of Tura balls made	40	40	60	90
Total selling price (N)	30.00	40.00	60.00	90.00
Profit realised (N)	12.00	14.00	19.50	26.00

* Tiya is approximately 2.5 kg

It could be seen that the more tura produced the more the profit. In addition to above finding, large production has advantage of capital costs of using tools (oven, storage net ...) when taken into account by processing point less per unit of production.

Table 4.9: Time requirement for maize

Data using Existing Process (System 2)

	Activity	Average time requirement (in minutes)	
		2.5 kg (1 tin)	5.0 kg (2 tins)
1.	Detailing	28.5	32.4
2.	Packing from store into a container	2.9	1.3
3.	Winnowing	3.7	4.7
4.	Washing	9.9	7.7
5.	Drying	26.0	30.1
6.	Pounding (milling manually)	22.6	34.3
7.	Sieve	6.6	15.6
8.	Pound	16.6	21.3
9.	Sieve	6.6	8.6
10.	Pound	9.8	15.4
11.	Sieve	4.0	8.7
12.	Pound	7.8	15.1
13.	Sieve	4.6	7.3
14.	Pound	6.7	12.3
15.	Sieve	3.4	3.2
16.	Pound	-	-
17.	Sieve	-	-
18.	Sort and clean grain	3.0	3.0

Table 4.19 Continued.

19.	Add to ... flour into bowl;	0.2	8.8
20.	Found	4.8	5.3
21.	Form ... ball	4.7	5.1
22.	Place ... boiling water	2.1	1.7
23.	Cook	10.6	4m.1
24.	Remove ... bowl; ... mortar	0.6	1.0
25.	Found	9.4	19.4
26.	Form ... balls	21.2	21.7
27.	... flour ...	0.4	0.9

... | ... | ... | ...

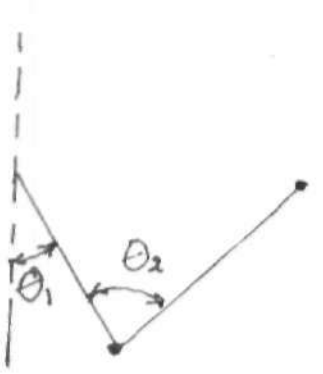
4.11 Energy Requirement in Existing Fura Making (System C).

Energy requirement for existing method of making fura is given in table 4.20, To process a 'tiya' of millet (2.5 kg), a processor expends a total of 503.2 kJ; to make same product from 2 'tiyas' of millet (5.0 kg), the subject uses 777.8 kJ. Activities for which high energy were expended include: dehulling, pounding, cooking, pounding cooked balls and formation of small balls. For instance, in making 2 tiyas of fura, 145.8 kJ was expended in dehulling; pounding to turn millet grains to flour required total of 351.6 KJ; cooking 73.8 kJ, 66.0 kJ was expended in pounding cooking balls and 47.7 kJ in making small balls. Two activities of high energy expenditure are pounding millet to flour and dehulling. Expenditure of energy on cooking is more of heat stress than muscle drudgery. This was not quantified but was based on subjective feeling. This can easily be avoided by sitting for away from heat source once the cooking has commenced. The five activities listed above together account for 88.1% of total energy expended. The activities are ranked in Table 4.21.

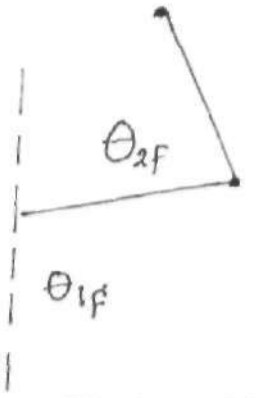
An energy value of 505.2 kJ required to process 2.5 kg of millet is equivalent to 31.5 g of dietary carbohydrate or 29.6 g of dietary protein. Similarly, 777.8 kJ required to process 5.0 kg of millet is equivalent to 48.6 g of dietary carbohydrate or 45.8 g of dietary protein. Note that a gramme of dietary carbohydrate is not the same as eating a gramme of food. Cost of energy to process 2.5 kg is ₦11.07; while cost to process 5.0 kg is ₦17.11 (see Appendices XVIII and XIX).

4.12 Kinematics and Kinetics of Existing Method of Fura Making

Close observation of the pounding operation shows that the essence of it is lifting the pestle up and bringing it down with force on the mortar contents. Usually, the pounding operation involves only movements of the arms. However, in order to increase the impact force on contents of mortar, some women do stoop a little forward. Kinematics of pounding involves lifting arms by rotation about the shoulder joint and then brought down until the pestle lands on the mortar contents. Fig. 4.8 gives detail of kinematics of arm, trunk and tool during pounding.

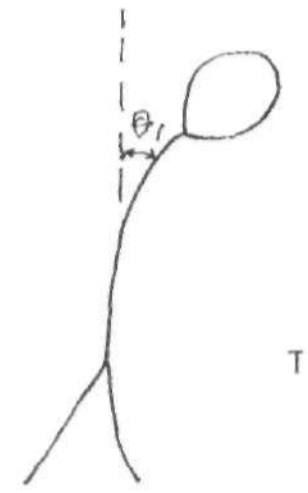


Initial position

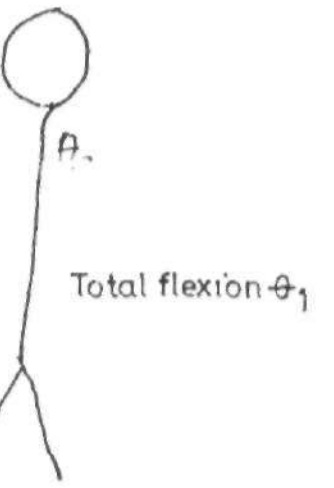


Final position

KINEMATIC OF ARMS

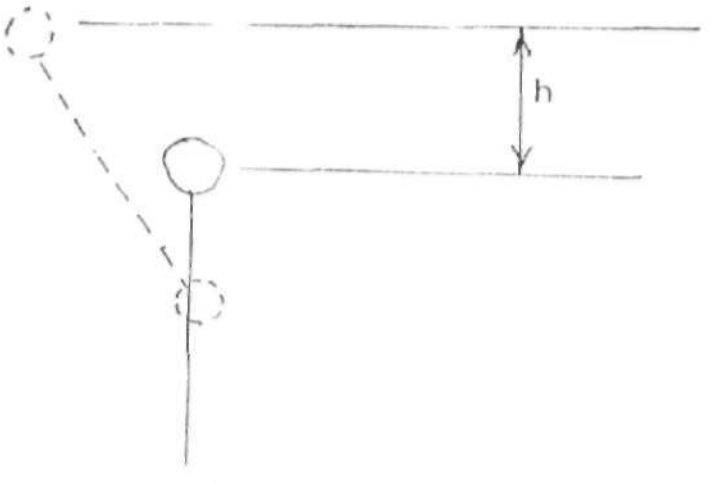


Initial position



Final position

KINEMATICS OF TRUNK



KINEMATICS OF TRUNK

Table 4.20: Energy Requirement by Existing Method of Fura Making (System C)

	Activity	Average Energy Requirement (in kJ)	
		2.5 kg (1 tiya)	5.0 kg (2 tiyas)
1.	Dehulling	83.3	145.8
2.	Packing from mortar into a container	9.8	1.4
3.	Winnowing	3.7	4.7
4.	Washing	16.8	13.1
5.	Drying	0.0	0.0
6.	Pounding (milling manually)	91.0	120.1
7.	Sieve	5.9	14.0
8.	Pound	58.1	81.6
9.	Sieve	5.9	7.7
10.	Pound	34.3	53.9
11.	Sieve	3.6	7.8
12.	Pound	13.3	52.9
13.	Sieve	4.3	6.6
14.	Pound	23.5	43.1
15.	Sieve	3.1	2.9
16.	Pound	-	-
17.	Sieve	-	-
18.	Wash out bran	3.8	3.0

Table 4.20 Cont'd.

19.	Add 18 plus fine flour into mortar	0.2	9.7
20.	Pound	5.6	10.6
21.	Form big balls	6.2	7.1
22.	Place big balls in boiling water	3.2	2.6
23.	Cook	48.9	73.8
24.	Remove cooked balls into mortar	0.5	0.9
25.	Pound	32.0	66.0
26.	Form small balls	46.6	47.7
27.	Spread fine flour onto the balls	0.4	0.8
	Total Energy (kJ)	503.2	777.8

Table 4.21: Ranking for System C

Operations	Time ranking	Energy ranking	Combine ranking
Dehulling	6	2	3
Packing from mortar into a container	9	8	8
Winnowing	10	11	10
Washing	7	7	7
Drying	3	16	9
Pounding (milling manually)	1	1	1
Sieve	4	6	5
Wash out bran and add coarse part to fine flour in mortar	11	12	13
Pound to mix flour with coarse part	12	10	11
Form big balls	13	9	11
Place big balls in boiling water	14	12	14
Cook	2	3	2
Remove cooked balls into mortar	15	14	15
Pound cooked balls	8	5	6
Form small balls	5	4	4
Spread fine flour onto the balls	16	15	16

Kinetics of pounding is illustrated by Fig. 4.9. The advantage of pestle weight in this operation is glaring. When lifting, during operation, force is applied to overcome the weight of the pestle. However, when lowering little force is applied, greater proportion of impact force is due to momentum due to the weight of pestle and by virtue of position. The process could be discribed as follows:

Pounding process = $f(h, \theta_1, \theta_2, F_w, F_a)$ 4.6

where h = heignt of pestle

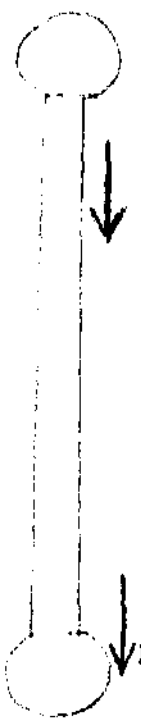
θ_1 = angle between arms (shown in Fig. 4.8)

θ_2 = angle between arm and body trunk

F_w = weight of mortar

F_a = force applied by the hand

To study the effect of these factors further, pounding trial was conducted at different heights for same quantity of millet. Number of strokes per minute and heart rate were taken. Sieve analysis was conducted on the product to quantify fineness. Results got are given in Table 4.22. Height was increased from 80 to 120 cm (from bottom of pestle to mortar bottom); as a result, amount of work done per minute increased by 355.6 percent, and force on the



$F_w = ma$

m is usually high, therefore F_w is high. Total force at impact = $F_a + F_w$

Fig. 4.9: Kinetics of Pounding

Table 4.22: Biomechanical Data for Pounding Operation

No.	Height (h in cm)	θ_i	α_i	θ_f	α_f	No. of strokes per min.	Heart rate	Total distance (m) per min	Work rate kJ/ mins	Energy/ work kJ	Force (Newtons)	Sieve Analysis 4.0	2.0	1.0	0.5	0.25
1	80	49	90	97	95	63	108	10.1	1.8	1.8	178.2	7	118	23	7	1
2	90	49	90	102	107	55	116	9.9	2.6	2.6	262.6	8	101	29	11	2
3	100	49	90	111	114	54	124	10.8	3.4	3.4	314.8	6	89	39	14	2
4	110	49	90	117	122	54	136	11.9	4.6	4.6	386.6	12	78	43	15	2
5	120	49	90	132	147	51	136	12.2	4.6	4.6	377.0	7	87	39	15	3

products also increased by 111.1 percent. Sieve analysis results show that the material became finer as the height of pounding was increased. Note the weight collected on sieve no. 0.5 increased from 7 gm to 15 gm indicating finer products with greater height of pounding.

This study indicates that to get fine flour fast from pounding, the height of operation could be increased. On the alternative, a pestle of greater weight could be used. However, rate of energy expenditure increased as height increased. But even at 120 cm, the rate of energy expenditure was still within level for continuous work (i.e. 4.5 kJ/min).

4.13 Anthropometry of Subjects and Tools for Fura Making

As earlier reported (Section 4.6), anthropometry of Fulani women was obtained in Zaria area (Table 4.12). Mortar and pestle are used for dehulling and grinding in Fura making, and they represent the most important tool in Fura making. The interface between the tool and an operator is that between the hand and the pestle handle.

Thus, it is important to evolve criteria to enhance compatability between the pestle and hands of prospective female users. In this study, this was done by taking into consideration percentile values, segment ratios and cultural practices. Specifically, aim of this was to obtain a good posture and grip for comfort and performance of basic intended target.

a) Diameter of pestle handle - From Section 4.6, in line with recommendation for power grip by Roebuck et al., 1975, pestle diameter (D) should be equal to $\frac{C}{\pi}$, ... 4.7

where, D = diameter of tool handle

C = circumference which represents handle length.

From segment ratios, handle length of the Fulani sample population is found as 0.11 H.

$$D = \frac{C}{\pi} = \frac{0.11\ H}{\pi} = \frac{0.11 \times 176}{\pi} \quad ..... \quad 4.8$$

= 6.17 cm

b) Pestle handle length - To avoid stooping in pounding and dehulling, length of pestle should be such that the pestle could be satisfactorily and effectively gripped and operated in the standing position. Pelvic height is a satisfactory location that could be reached by both arms without bending. It is therefore recommended that pestle handle length should not be less than the pelvic height of a population.

e.g. for Fulani processors,

$L = 0.59\ H$ 4.9

where, (H is the percentile value for height of a population).

$L = 0.59 \times 176 = 103.8$ cm

Table 4.22a: Comparative Data for Existing and Recommended Dimensions for Pestle

Dimensions	Existing	Recommended
Diameter	3.5-6.0	6.2
Handle length	90-115.0	103.8

4.14 Constraints Identified in Fura Making

The main constraints in fura making include high energy usage and tremendous amount of time involved. When this is further super-imposed on responsibilities of the women processors within the household and society, then the need for improvement is fully appreciated. Looking at pie chart for activity of a Fulani woman (Fig. 4.1), it is seen that even when they process fura and milk for only two hours sleeping and leisure time is just 9½ hours. When they have to process more volumes of milk and fura to enhance income, this sleeping time is further reduced. Note also that with long hours of work and drudgery, the quality of food produced for the family deteriorates. This finding was reported by some studies on rural women during the rainy season (FAO, 1979).

It is important to state that the energy and time levels reported in Tables 4.19 and 4.20 are just for low production (i.e. 5 kg). With increased consumption and the desire to improve on production, exploration of other methods becomes imperative. Already, ILCA (1988) has shown increased trend in consumption of dairy products. To meet this demand, this implies more involvement for the processors who serve as both source of control and power.

It is important to understand that fura processors do not have big capital to invest in technologies. Thus, this imposes a constraint in whatever improvement programme is contemplated. Surely improvement should not be capital intensive.

Tasks of high energy expenditure and time requirement include dehulling, pounding to turn millet grains to flour and pounding cooked fura. When watching the chain process of making fura, it is obvious that it is during these component tasks (mentioned above) that the processors exert greatly. This is further corroborated by scientific data as reported in Sections 4.10 and 4.11. Other activities of reasonable time duration, but low energy expenditure include: drying, cooking and formation of small balls.

Repeated timings obtained for same subject varied. That shows that there is no standardization or process and different results are obtained for same process.

Biomechanics of pounding and subject present a potential/possibility of improvement of existing process without the need for any improved tool. This possibility is not known to the fura makers, and the results on approach taken is given in Section 4.12.

4.15 Various Systems to Improve on Fura Making and Comparisons with Traditional

As stated in Section 3.4, two different approaches were used in attempts to upgrade indigeneous fura making. First was adoption of technologies that are available, and the second was development of simple devices. Development is discussed in Section 4.17. Among technologies available, two possibilities exist: First, settlements where there are grinding machines, but there are no dehulling machines. With this possibility, fura could be made as given in Fig. 4.10. This method is referred to as system D in this text. The other possibility is a settlement where there is a dehulling machine and a grinding machine. This makes it possible to prepare fura as given in Fig. 4.11. This method is referred to as System E subsequently.

4.15.1 System D

This method is represented in Fig. 4.10. Time and energy requirement is given in Table 4.23. The difference between this method and System C is use of motorized grinding mill (Plate 27) instead of alternate manual pounding and sieving of System C.

Ranking of the process is given in Table 4.24. For combine ranking, dehulling ranks first, followed by cooking and forming small balls both ranking in second place.

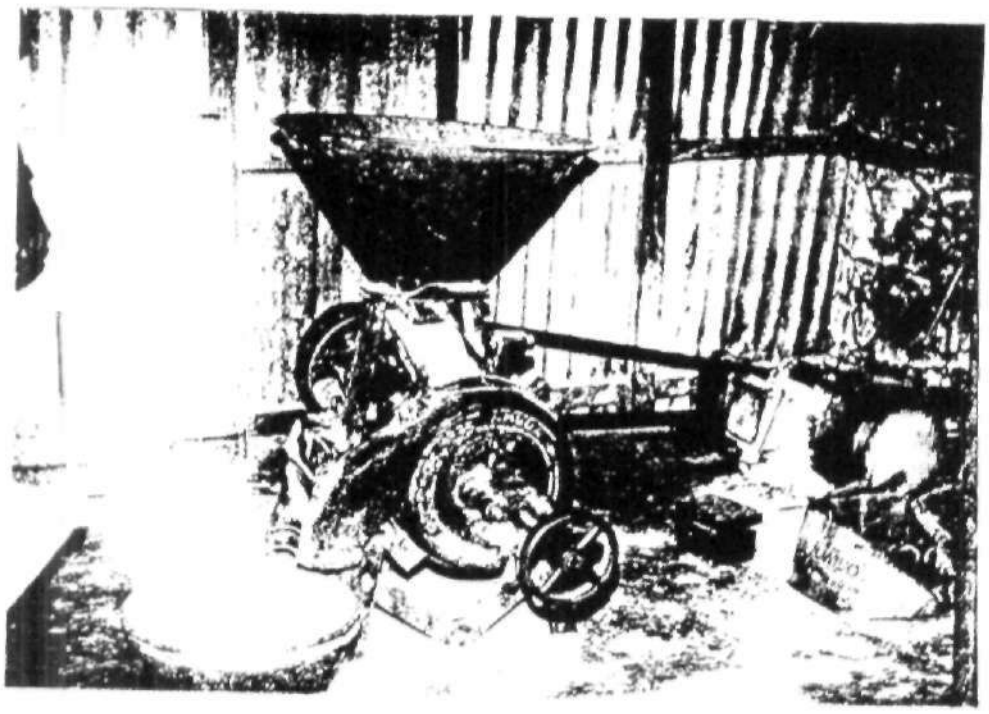


Plate 27: Motorized grinding mill

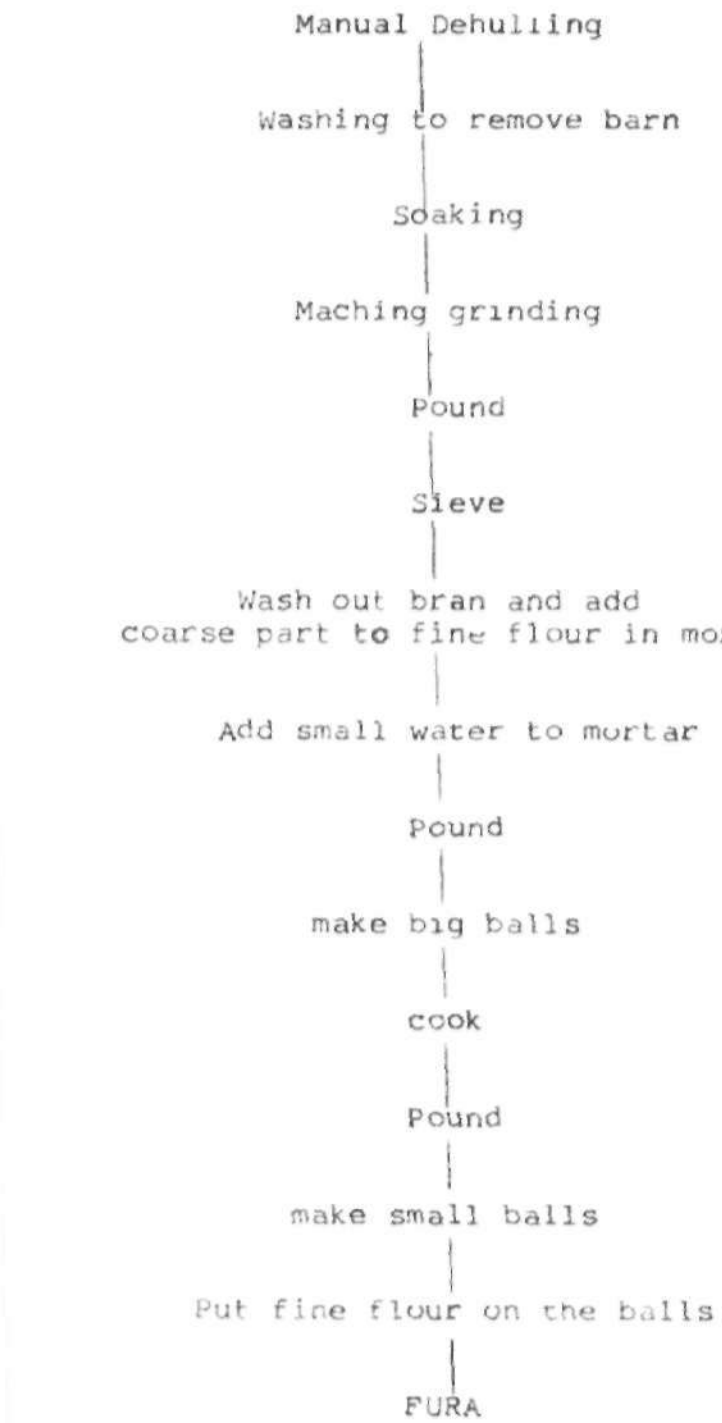


Fig. 4.10: Manual dehulling, machine grinding (System D)

Table 4.23: Average Time and Energy Requirements in Fura Making by System D

Activity	Volume = 2.5 kg				Volume = 5.0 kg			
	Time* requirement (mins)	Percentage of total	Human Energy* requirement (kJ)	Percentage of total	Time* requirement (mins)	percentage of total	Human Energy* requirement (kJ)	percentage of total
Manual denulling	17.4	14.6	83.4	32.1	31.9	18.4	137.5	31.5
Washing to remove bran	8.2	6.9	18.2	7.0	13.5	7.8	14.9	3.4
Soaking/Drying	9.6	8.0	0.0	0.0	29.8	17.2	0.0	0.0
Machine grinding	3.4	2.8	0.0	0.0	3.0	1.7	0.0	0.0
Pound	2.3	1.9	3.0	1.2	3.0	1.7	7.9	1.8
Sieve	11.7	9.8	14.1	5.4	14.4	8.3	21.1	4.8
Wash out bran and add coarse part to fine flour in mortar	2.7	2.3	4.2	1.6	3.0	1.7	6.5	1.5
Add small water to mortar	-	-	-	-	-	-	-	-
Pound	3.0	2.5	15.1	5.8	5.1	2.9	10.7	2.5
Make big balls	2.6	2.2	7.7	3.0	3.6	2.1	9.0	2.1
Place big balls in boiling water	2.1	1.8	1.4	0.5	1.2	0.7	5.3	1.2
Cook	26.6	22.3	34.9	13.4	32.5	18.8	108.0	24.7
Remove cooked balls into mortar	0.7	0.6	0.6	0.2	0.8	0.5	1.1	0.3
Pound	10.3	8.6	41.7	16.0	14.0	8.1	66.9	15.3
Make small balls	18.4	15.4	35.2	13.5	16.6	9.6	46.8	10.7
Put fine flour on the balls	0.5	0.4	0.7	0.3	0.6	0.3	1.0	0.2
Total		119.5		260.2		173.0		436.7

* Time and Human Energy data represent average for ten trials.

Table 4.24: Ranking for System D

Operations	Time ranking	Energy ranking	Combine ranking
Dehulling (Manual)	3	1	1
Washing	7	5	6
Drying	6	14	10
Grinding (machine)	8	14	11
Pound to release granules in the flour	12	10	11
Sieving	4	7	5
Wash out bran and add coarse part to fine flour in water	10	9	8
Pound to mix flour with coarse part	9	6	7
Make big balls	11	8	8
Place big balls in boiling water	13	11	13
Cooking	1	4	2
Remove cooked balls into mortar	14	13	14
Pound cooked fura	5	2	4
Form small balls	2	3	2
Put flour on the balls	15	12	14

Table 4.25: Comparison Between Systems C and D of Fura Making

Quantity	Time Comparison						Human Energy Comparison					
	Total Time (mins)			Grinding Time (mins)			Total Human Energy (kJ)			Grinding Energy (kJ)		
	Sys.C	Sys.D	% saving	Sys.C	Sys. D	% saving	Sys. C	Sys.D	% saving	Sys.C	Sys.D	% saving
2.5	224.9	124.1	44.8	59.5	3.4	94.3	503.2	260.2	48.3	220.2	0.0	100.0
5.0	331.0	173.0	47.7	100.4	3.0	97.0	777.8	436.7	31.2	351.6	0.0	100.0

Note that in System C, pounding ranks first, but is now ranking 11 due to adoption of motorized grinding. Saving in human energy expenditure was 100% (i.e. 351.6 kJ for 5.0 kg), while time saving was 97% (i.e. 97.4 mins). Detail of data is given in Table 4.25. A processor could do other income generating activities with part of the time, and could use the rest for leisure. One might observe that money or cost is attached to use of a motorized grinding unit. This cost is normally small (₦1.50/2.5 kg). When this cost is compared with cost of food that will give energy for manual pounding, it could be seen to be negligible.

4.15.2 System B

This method is represented in a line process chart in Fig.4.11. Data on time and energy requirements are found in Table 4.26. The difference between this method and System C is that a motorized dehuller (Plate 28), and a grinding unit are used instead of manual dehulling and manual pounding.



Plate 28: Motorized Dehuller

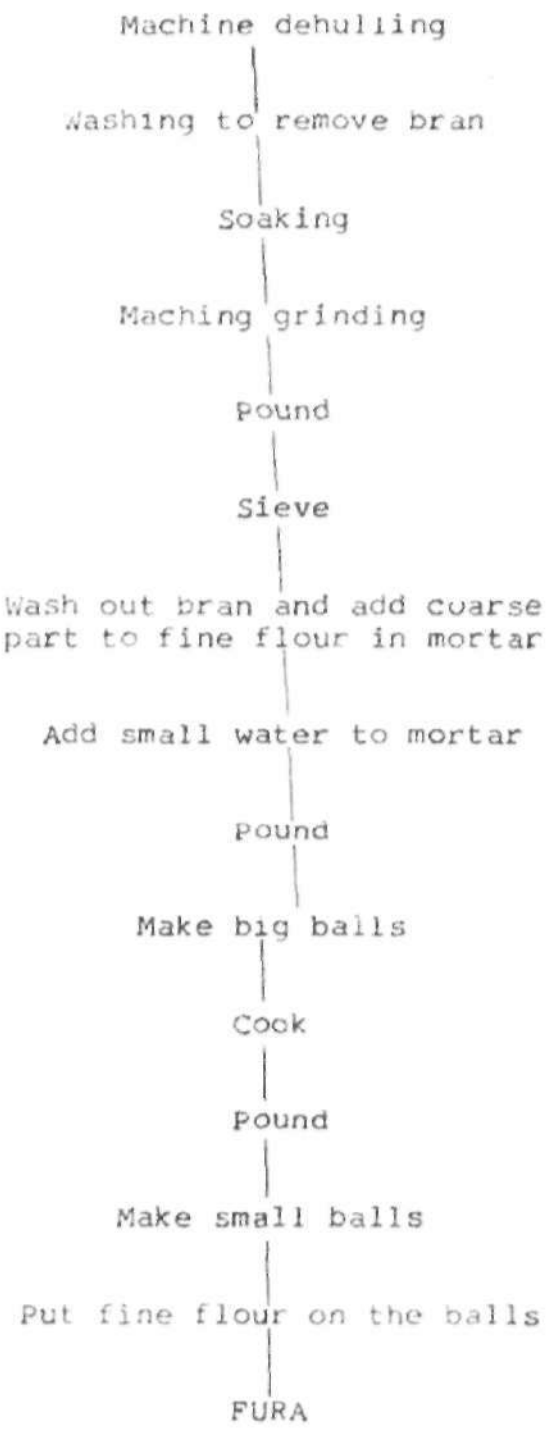


Fig. 4.11: Machine dehulling, machine grinding (System E)

Table 4.26: Time and Energy Requirement in Fura Making by System E

Activity	Volume = 2.5 kg				Volume = 5.0 kg			
	Time* requirement (mins)	Human Energy* percentage of total	requirement (kJ)	percentage of total	Time* requirement (mins)	Human Energy* percentage of total	requirement (mins)	percentage of total
Machine dehulling	5.5	5.4	0.0	0.0	7.3	5.0	0.0	0.0
Washing to remove bran	5.8	5.6	18.5	10.4	7.7	5.3	18.3	7.4
Soaking/Drying	21.6	21.0	0.0	0.0	23.9	16.5	0.0	0.0
Machine grinding	2.8	2.7	0.0	0.0	2.6	1.8	0.0	0.0
Pound	1.5	1.5	3.4	1.9	1.7	1.2	3.2	1.3
Sieve	5.0	4.9	10.3	5.8	19.1	13.2	35.6	2.3
Wash out bran and add coarse part to fine flour in mortar	2.9	2.8	5.0	2.8	2.8	1.9	8.4	3.4
Add small water to mortar	-	-	-	-	-	-	-	-
Pound	2.9	2.8	15.1	8.5	4.0	2.8	19.7	7.9
Make big balls	2.4	2.3	7.8	4.4	4.1	2.8	10.1	4.1
Place big balls in boiling water	0.4	0.4	1.6	0.9	0.8	0.6	1.8	0.7
Cook	20.1	20.3	30.1	20.2	33.7	23.3	34.4	13.9
Take the cooked balls into mortar	0.4	0.4	1.0	0.6	0.9	0.6	2.4	1.0
Pound	8.2	8.0	44.1	24.7	14.3	9.9	50.0	20.1
Make small balls	13.9	13.5	34.6	19.4	20.8	14.4	62.6	25.2
Put fine flour on the balls	0.4	0.4	1.0	0.6	1.0	0.7	1.7	0.7
TOTAL		102.8		178.5		144.7		248.2

* Time and Energy data represent average of ten trials.

Table 4.27: Ranking for System E

Operations	Time ranking	Energy ranking	Combine ranking
Machine dehulling	6	12	8
Washing to remove bran	5	4	4
Soaking/drying	2	12	7
Machine grinding	10	12	12
Pound to release granules in flour	12	9	11
Sieve	7	6	5
Wash out bran and add coarse part to fine flour in mortar	8	8	10
Pound to mix flour with cearse part	8	5	5
Make big balls	11	7	8
Place big balls in boiling water	13	10	13
Cook	1	2	1
Remove cooked balls into mortar	13	11	14
Pound cooked balls	4	1	2
Make small balls	3	3	3
Put fine flour on the balls	13	11	14

Table 4.28: Comparison Between Systems C and E

Quantity (kg)	Time Comparison: Total Time (mins) Sys.C	Sys.E	% saving	Dehulling and Pounding Time (mins) Sys.C	Sys.E	% saving	Human Energy Comparison: Total Human Energy (kJ) Sys.C	Sys.E	% saving	Dehulling and Pounding Energy (kJ) Sys.C	Sys.E	% saving
2.5	224.9	102.8	54.3	78.0	8.3	89.4	503.2	178.5	64.5	303.5	0.0	100.0
5.0	331.0	144.7	56.3	132.8	9.9	92.5	777.8	248.2	68.1	497.4	0.0	100.0

Ranking of the process is given in Table 4.27. Cooking ranks first, pounding of cooked balls ranks second and making small balls comes up third. Note that pounding which ranked first in System C now ranks twelveth and dehulling which ranked third in System C is now eighth.

Comparative performance (Table 4.28) shows a saving of 186.3 mins (56.3%) between Systems C and E (when processing 5.0 kg). Amount of energy saved was 529.6 kJ (68.1%).

Laboratory Analysis - To compare composition of products from the three systems, samples were subjected to laboratory analysis. Results obtained are presented in Table 4.28a below.

Table 4.28a: Composition of Fura Samples from Different Systems

System	% Protein	% Oil	% Ash	% Fibre	% CHO
C	8.44	1.49	0.75	0.47	88.85
D	8.43	1.51	0.70	0.47	88.89
E	8.40	1.51	0.70	0.49	88.90

From the results above, there is little difference between the samples. This shows that irrespective of system used, product is same.

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CHAPTER FIVE

SYSTEMS ANALYSIS OF TECHNOLOGICAL INTERVENTIONS

5.1 Description of Systems

The following describes the systems used in this study and codes used for analysis.

	Code	Description
1.	System A	Traditional butter extraction using a gourd.
2.	System B	Churning using improved churn.
3.	System C	Traditional Fura making
4.	System D	Fura making by manual dehulling, but machine grinding.
5.	System E	Fura making by machine dehulling, and machine grinding.
6.	System AC	Processing 'Fura da Nono' by traditional butter and fura making (combination of system A and C)
7.	System AD	Processing 'Fura da Nono' by System A and D
8.	System AE	Processing by Systems A and E
9.	System BC	Processing by Systems B and C
10.	System BD	Processing by Systems B and D
11.	System BE	Processing by Systems B and E

5.2 Analysis of Possible Systems

Different systems were considered in Sections 4.2 and 4.8 for milk churning and Sections4.9 and 4.15 for fura making. From all these possible interventions and traditional methods, various system combinations exist to make 'Fura da Nono' in an integral enterprise/industry. Assessment parameters for these options are tabulated in Table 5.1. These parameters include: Time, Energy and Cost. Considerations in cost calculations and for each system are given in Appendices XVIII and XIX respectively.

5.3 Time Comparison Between Systems

Detail time requirement for each system of operation for different levels of 'Fura' and 'Nono' are given in Table 5.1. Four bar charts are drawn to show what happens at different levels of production. Note that on Figs. 5.1 and 5.2, which are high levels of processing, there is distinct difference between the systems (i.e. between AC and BC, between AD and BD, and between AE and BE). However, looking at Figs. 5.3 and 5.4, the difference between these matching systems is small. As such at low milk processing levels, there is no appreciable time difference whether improved churn or the traditional process is used. Table 5.1 shows that significant difference occur from 5 litres milk processing level upwards.

Table 5.1 : Systems' Data (Time*, Energy+ and Cost×)

System	Fura (kg)	Nono (Units)	3	4	5	6	7	8	9	10
AC	2.5		243.6*	246.6	266.5	261.5	269.9	269.1	284.2	291.2
			(523.5)+	(540.1)	(551.1)	(556.5)	(565.2)	(575.9)	(588.4)	(603.7)
			[12.11]×	[12.34]	[12.58]	[12.70]	[12.89]	[13.13]	[13.45]	[13.52]
	5.0		340.7	352.7	372.6	367.6	376.0	375.2	390.3	397.3
			(804.1)	(814.7)	(825.7)	(831.1)	(839.8)	(850.5)	(856.0)	(868.3)
			[16.15]	[18.38]	[18.63]	[18.74]	[18.94]	[19.17]	[19.29]	[19.56]
BC	2.5		240.1	246.0	249.4	254.6	248.8	248.0	247.8	249.9
			(508.0)	(513.3)	(524.5)	(515.8)	(515.4)	(527.4)	(515.4)	(519.8)
			[11.93]	[12.04]	[12.29]	[12.10]	[12.09]	[12.35]	[12.09]	[12.18]
	5.0		346.2	352.1	355.5	350.7	354.9	354.1	353.9	356.0
			(782.6)	(787.9)	(799.1)	(790.4)	(790.0)	(802.0)	(790.0)	(794.5)
			[17.97]	[18.08]	[18.33]	[18.14]	[18.13]	[18.39]	[18.13]	[18.23]

Table 4.29 Cont'd.

		2.5	138.2 (286.5) [8.76]	141.2 (297.1) [9.00]	161.1 (308.1) [9.24]	156.1 (313.5) [9.36]	164.5 (322.2) [9.55]	163.7 (332.9) [9.78]	178.8 (338.4) [9.90]	185.8 (350.7) [10.18]
AD		5.0	194.7 (468.0) [14.65]	194.7 (473.6) [14.88]	214.6 (484.6) [15.12]	209.6 (490.0) [15.24]	218.0 (498.7) [15.43]	217.2 (509.4) [15.67]	232.3 (514.9) [15.79]	239.3 (527.2) [16.06]
		2.5	134.7 (265.0) [8.58]	140.6 (270.3) [8.70]	144.0 (281.5) [8.94]	139.2 (272.8) [8.75]	143.4 (272.4) [8.74]	142.6 (284.4) [9.01]	142.4 (272.4) [8.74]	144.5 (276.8) [8.84]
BD		5.0	188.2 (441.5) [14.46]	194.1 (446.8) [14.58]	197.5 (458.0) [14.83]	192.7 (449.3) [14.63]	196.9 (448.9) [14.63]	196.1 (460.9) [14.89]	195.9 (448.9) [14.63]	198.0 (453.3) [14.72]

Table 4.39 Cont'd.

AE	2.5	121.5	124.5	144.4	139.4	147.8	147.0	162.1	169.1
		(204.8)	(215.4)	(226.4)	(231.8)	(240.5)	(251.2)	(256.2)	(269.0)
		[8.69]	[8.92]	[9.16]	[9.28]	[9.47]	[9.71]	[9.85]	[10.10]
	5.0	163.4	166.4	186.3	181.3	189.7	188.9	204.0	211.0
		(274.5)	(285.1)	(296.1)	(301.5)	(310.2)	(320.9)	(326.4)	(338.7)
		[14.22]	[14.45]	[14.69]	[14.81]	[15.00]	[15.24]	[15.36]	[15.26]
BE	2.5	118.0	123.9	127.3	122.5	126.7	125.9	125.7	127.8
		(183.3)	(188.6)	(199.8)	(191.1)	(190.7)	(202.7)	(190.7)	(195.1)
		[8.50]	[8.62]	[8.87]	[8.67]	[8.67]	[8.93]	[8.67]	[8.76]
	5.0	159.9	165.8	169.2	164.4	168.6	167.8	167.6	169.7
		(253.0)	(258.3)	(269.5)	(260.8)	(260.4)	(272.4)	(260.4)	(264.8)
		[14.04]	[14.15]	[14.40]	[14.21]	[14.20]	[14.46]	[14.20]	[14.30]

• Time in mins.
* Energy in kJ
x Cost in Naira

System BE consistently required least time, while AC required most time.

The relationship between systems AE and BD changes: at high processing levels AE requires more time than BD; at low levels of milk processing, system AE is more time efficient.

Analysis of variance for time requirement shows that dirference between tne systems was very significant (Table 5.2). The table also shows that there is significant time difference between the different levels or fura processing considered. However, between different processing levels of Nono, time difference was not significant.

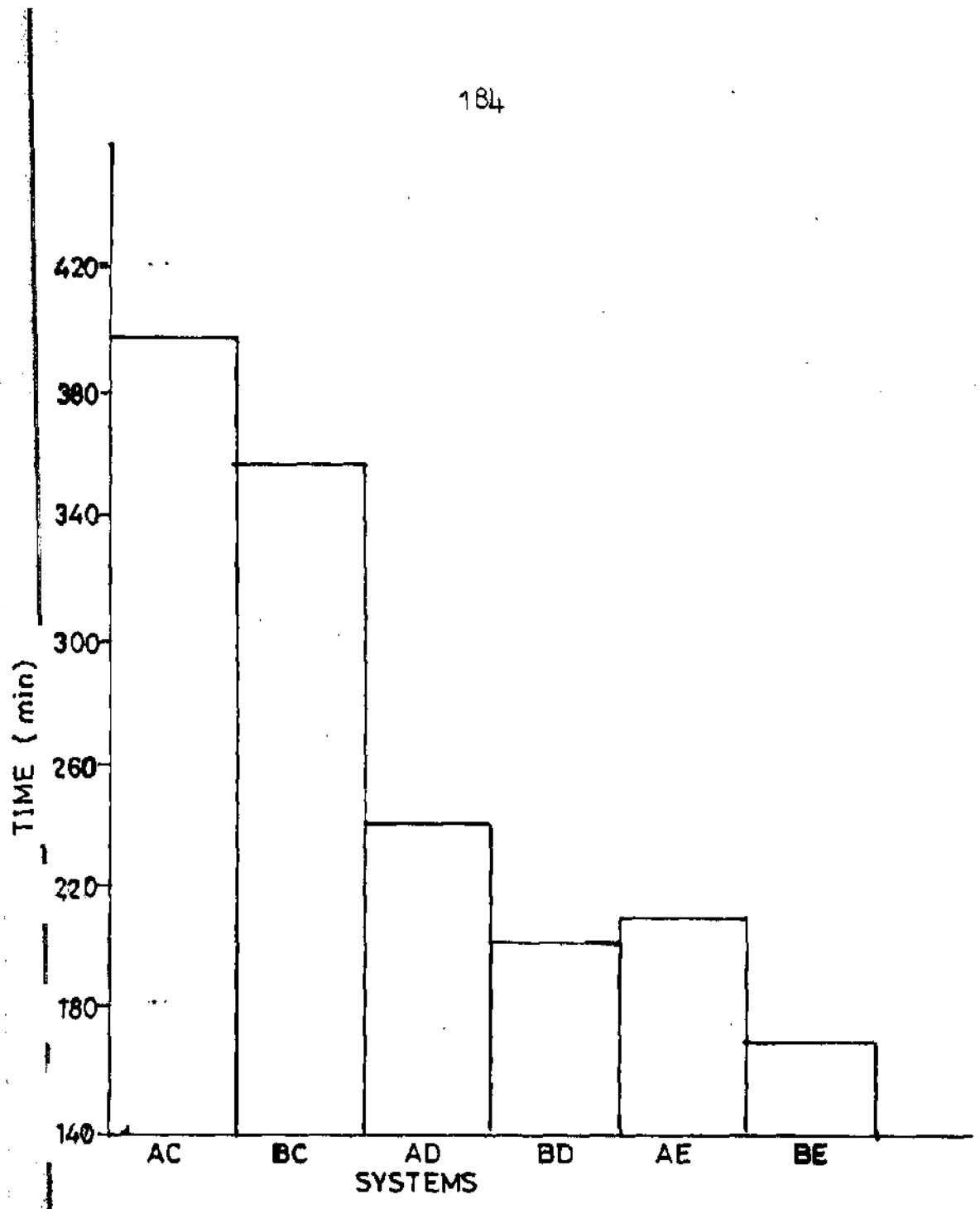


Fig. 5.1: Barchart for different systems processing 5.0 Kg millet and 10 litres milk.

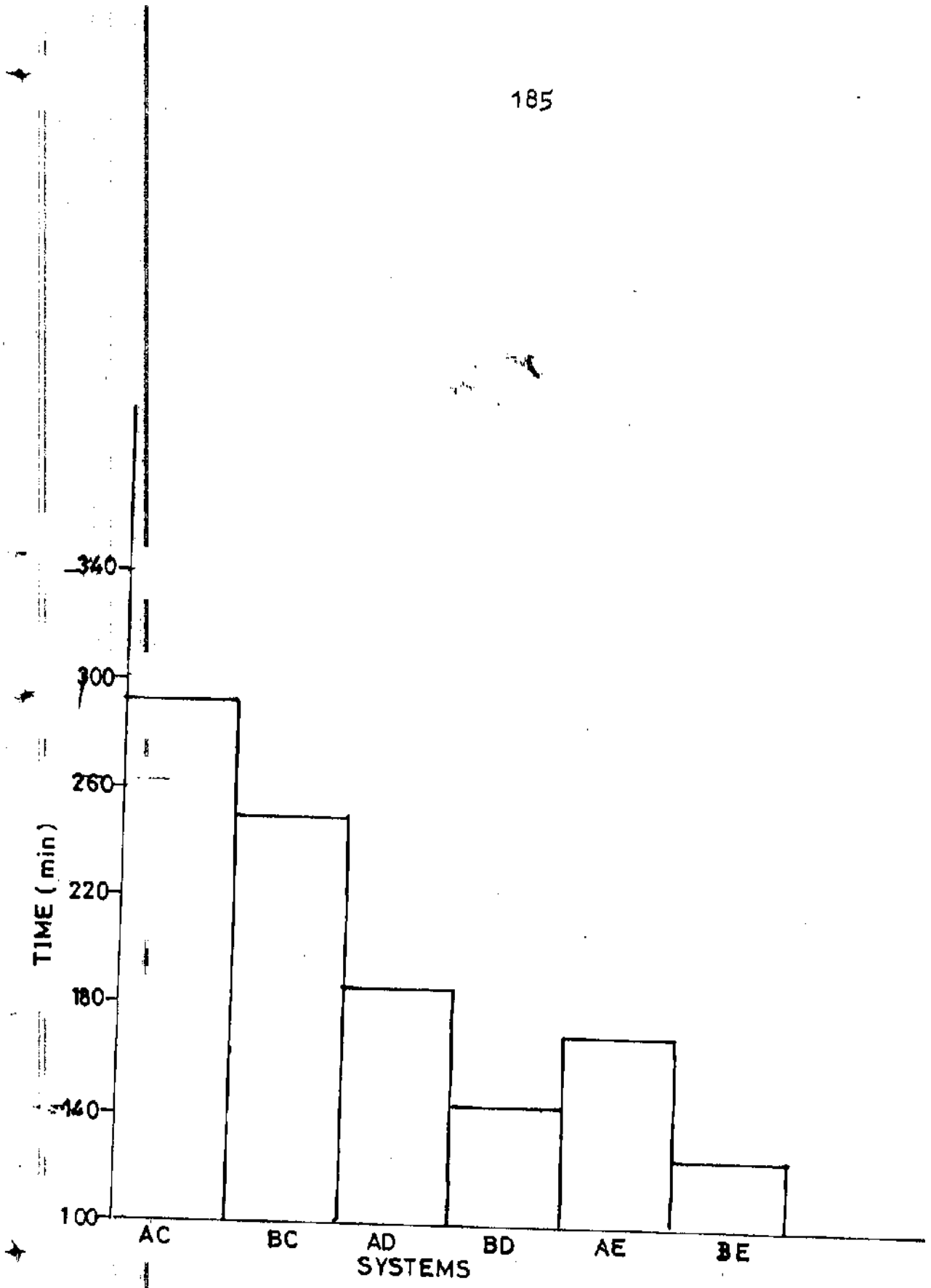


Fig 5.2 Barchart for different systems processing 2·5 Kg millet and 10 litres milk.

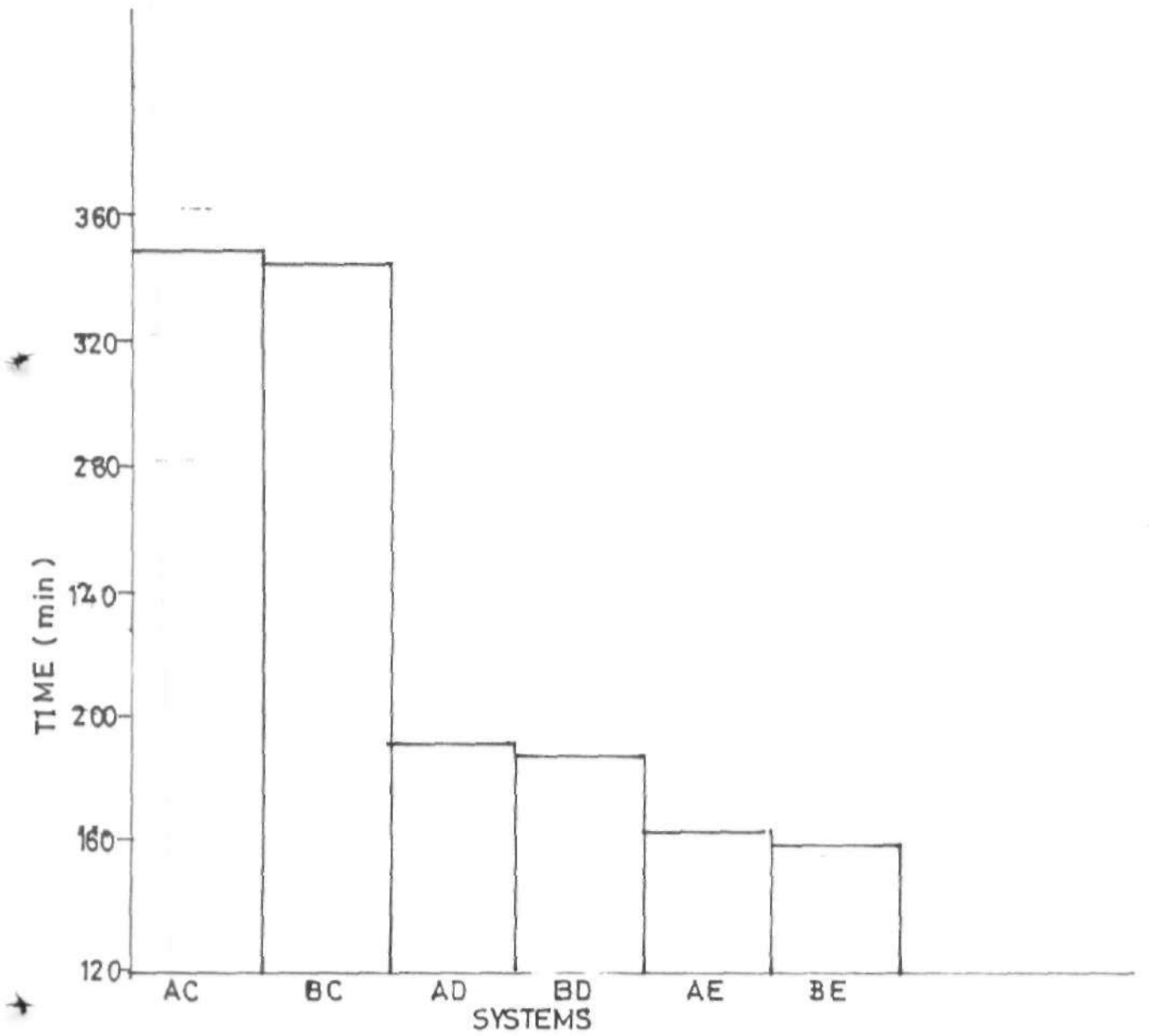


Fig. 5.3 Barchart for different systems processing 5.0 Kg millet and 3 litres milk.

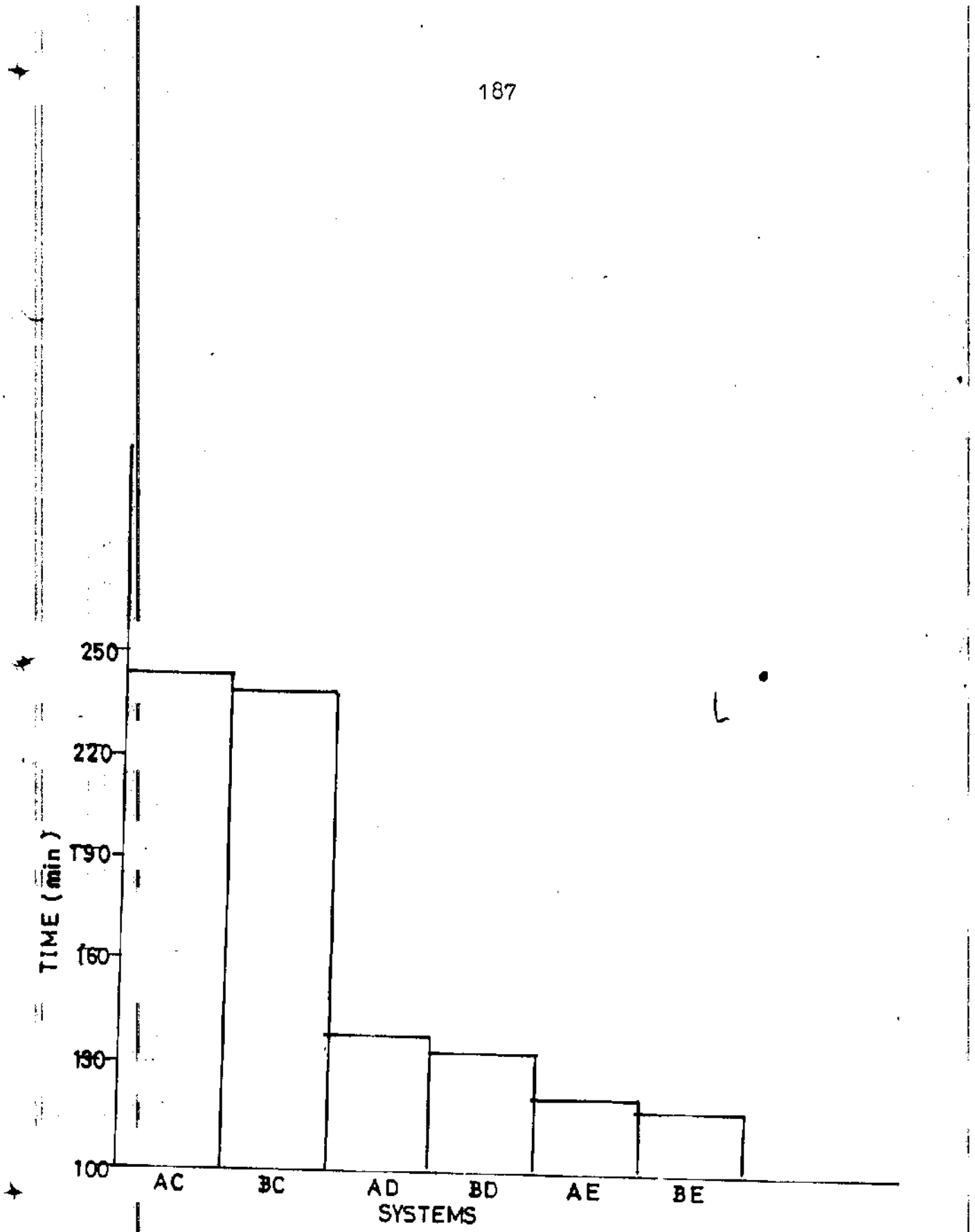


Fig. 5.4 Barchart for different systems processing 2·5 Kg millet and 3 litres milk

Table 5.2 : Analysis of Variance for Time Requirement

Source of Variation	DF	Sum of squares	Mean square	F	Significance of F
Fura	1	108272.7	108272.7	271.72	**
Nono	7	7587 .9	1084.0	2.72	*
System	5	453501.8	90680.4	227.57	**
Interaction	35	4173.6	119.2	0.29	
Residual	47	18727.9	398.5		
Total	94	483891.3	5147.8		
Grand Total	95	592163.9			

* Significant at 5% level

** Significant at both 5 and 1% levels

5.4. Human Energy Comparisons Between Systems

Detail energy requirement for each system of operation for different levels of 'Fura' and 'Nono' are given in Table 5.1. Figs. 5.5 to 5.8 show relationship between the systems at same processing levels. At all levels, sequence starting with system of lowest energy was BE, AE, BD, AD, BC, AC - consistently, system BE requires least energy and system AC requires the greatest human energy expenditure. Difference in energy requirement was greater between pairing systems (i.e. AC and BC, AD and BD, and AE and BE) at high levels of processing.

Analysis of variance for energy requirement (Table 5.3) shows that difference between the systems was significantly different. In addition energy requirement for different levels of Fura production were significantly different. For different levels of Nono, difference was not significant. This points to the fact that it is more efficient (energy wise) to process large volumes than small volumes.

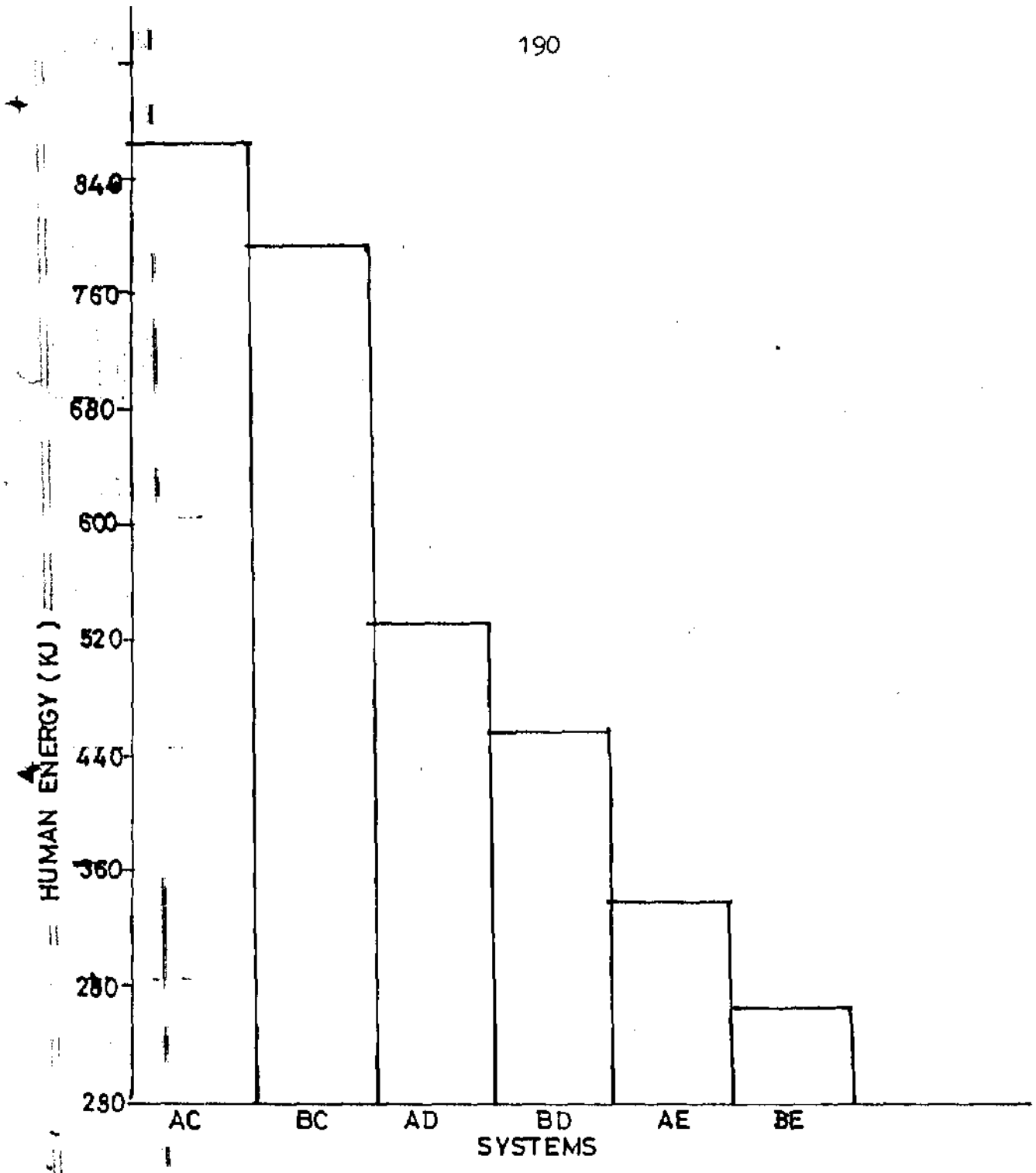


Fig. 5.5 Barchart for different systems processing 5.0 Kg millet and 10 litres milk.

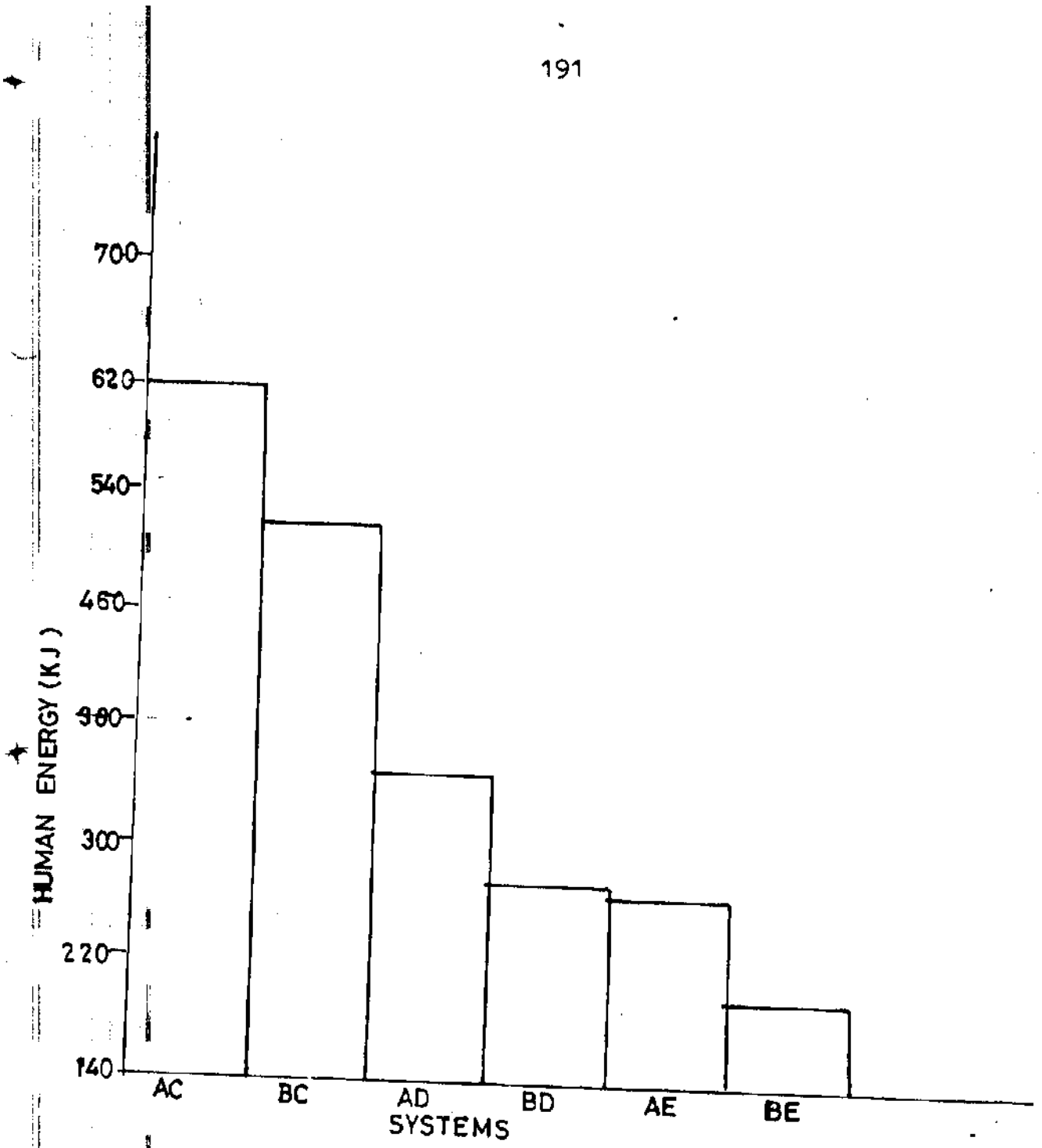


Fig. 5.6 Barchart for different systems processing 2·5 Kg. millet and 10 litres milk.

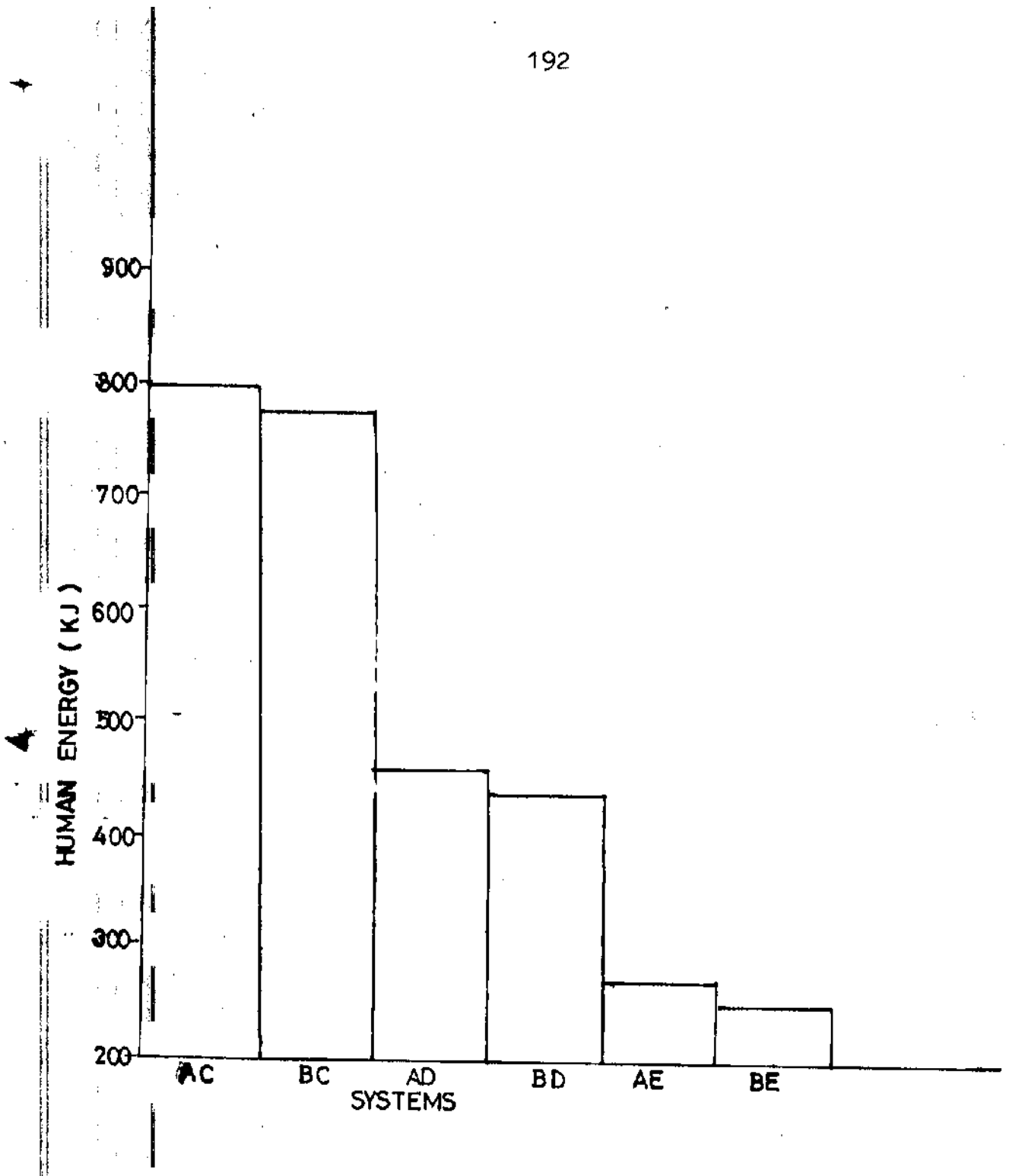


Fig. 5.7 Barchart for different systems processing 5.0 Kg millet and 3 litres milk.

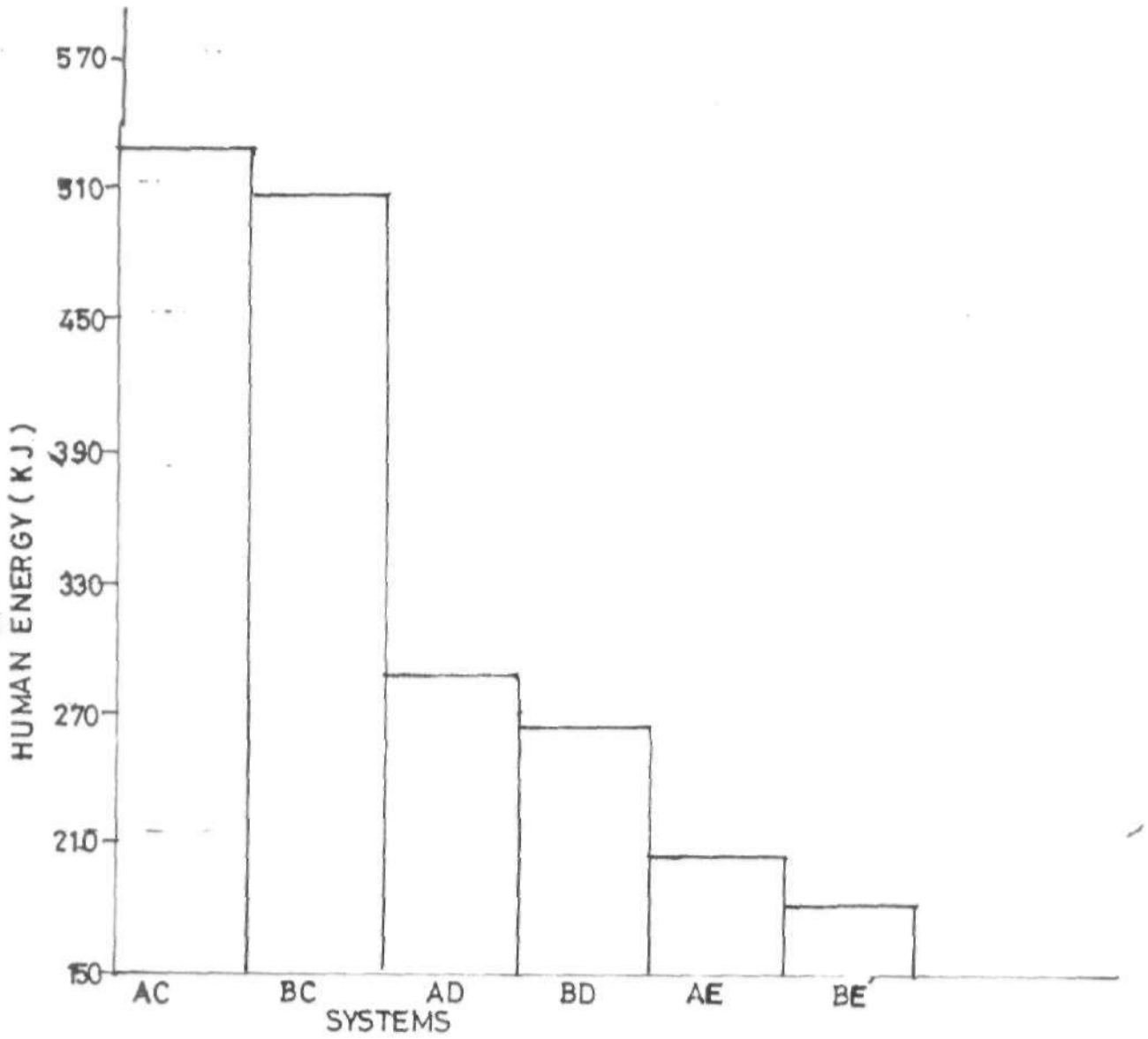


Fig. 5.8 Barchart for different systems processing 2·5 Kg millet and 3 litres milk.

Table 5.3 : Analysis of Variance for Energy Requirement

Source of variation	DF	Sum of squares	Mean square	F	Significance of F
Fura	1	723304	723304	202.29	**
Nono	7	13606	1944	0.54	
System	5	3097676	619535	173.27	**
Interaction	35	7639	218	0.06	
Residual	47	168047	3575		
Total	94	3286967	34968		
Grand Total	95	4010272			

* Significant at 5% level

** Significant at both 5 and 1% levels

5.5 Cost Comparison Between Systems

Detail total cost for each system of operation for different levels of 'Fura' and 'Nono' are given in Table 5.1 . Figs. 5.9 to 5.12 give bar charts to depict comparison between systems for same volumes of operation. It is shown repeatedly that system BE incurs least cost; similarly AC incurs highest cost. The difference between systems BE and BD is small. This shows that cost of dehulling by either manual or motorized methods is about same. Similarly cost difference between systems AD and AE is small, all pointing to cost of manual dehulling as being at par with that of motorized. Contrary to believe of a casual onlooker that not physically paying money when doing an operation manually makes the operation free - no operation is free whether to the owner or the labour or to somebody else.

Analysis of variance for cost shows that difference between systems was very significant (Table 5.4). The cost difference between various levels of Fura processing was also very significant. Sequence of variation, starting with system of least cost, is as follows: BE, BD, AE, AD, BC, and AC.

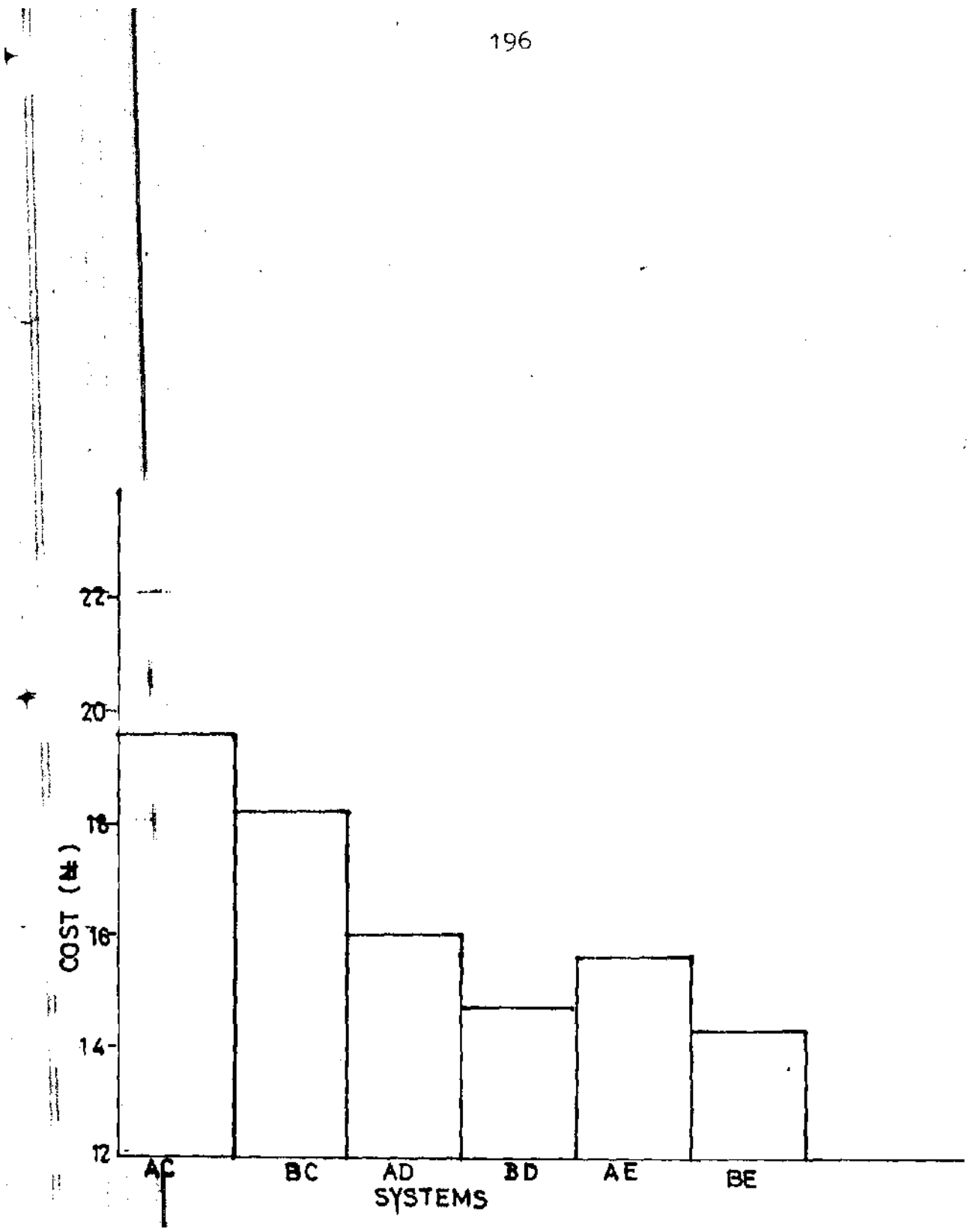


Fig 5.9 Barchart for different system processing 5.0Kg millet and 10 litres milk.

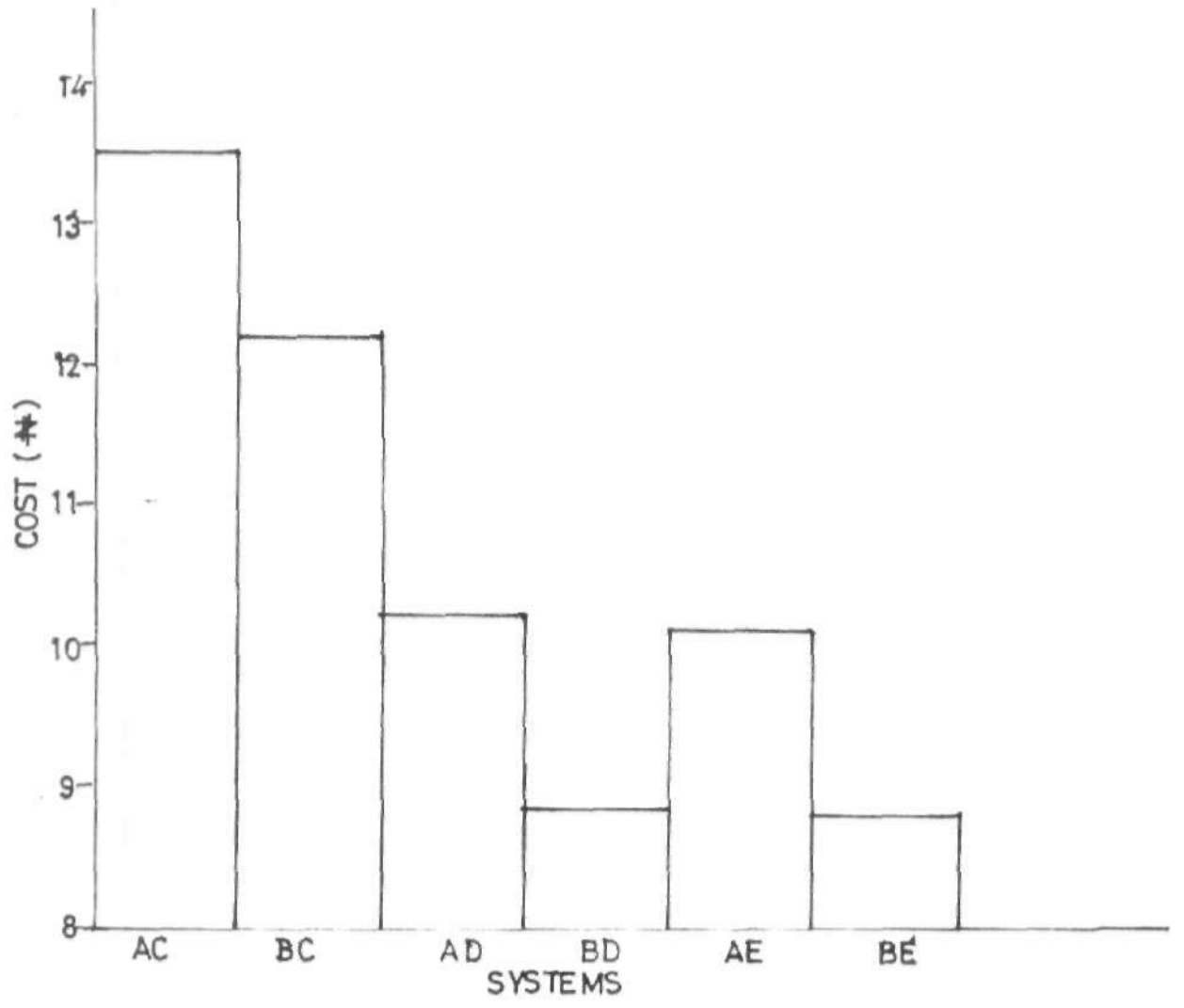


Fig.5.10 Barchart for different systems processing 2.5Kg millet and 10 litres milk.

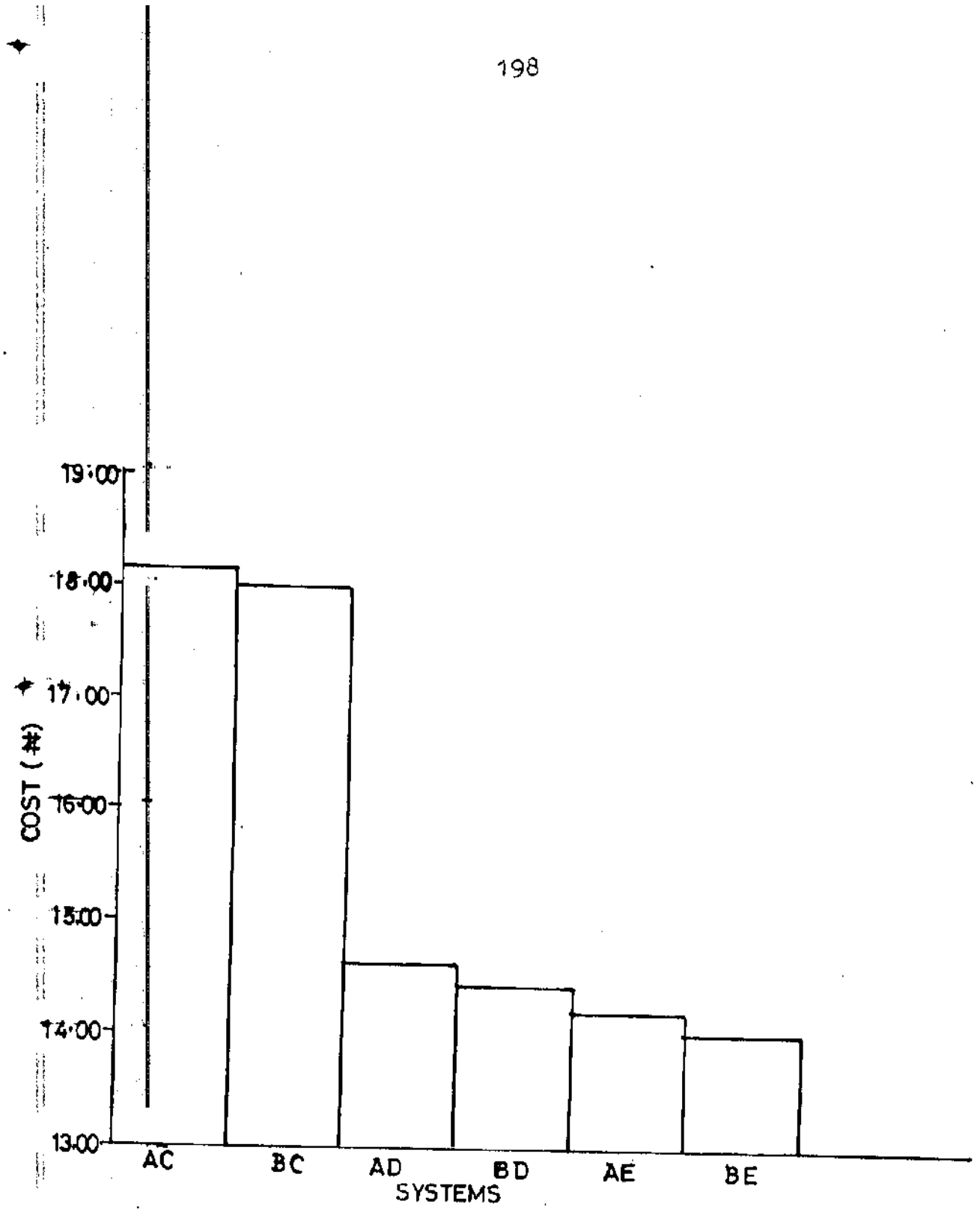


Fig.5.11 Barchart for different systems processing 5.0 millet and 3 litres milk.

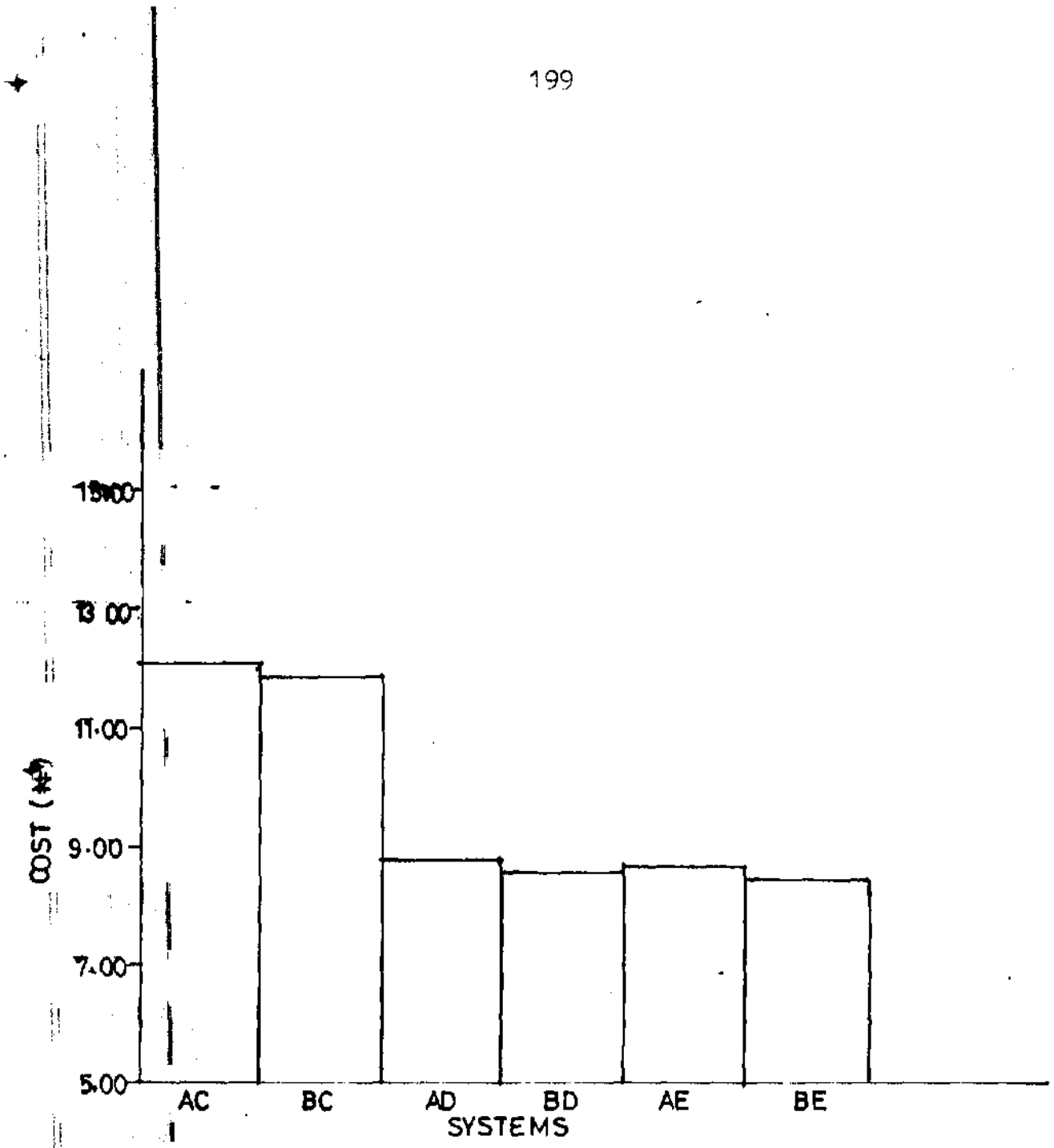


Fig. 5.12 Barchart for different systems processing 2·5 Kg millet and 3 litres milk.

Table 5.4 : Analysis of Variance for Costs

Source of variation	DF	Sum of squares	Mean square	F	Significance of F
Fura	1	801.10809	801.10809	14551.24	**
Nono	7	7.02362	1.00337	18.22	**
System	5	270.45145	54.09029	983.49	**
Inter-action	35	5.92734	0.16935	3.07	**
Residual	47	2.58755	0.05505		
Total	94	285.98996	3.04245		
Grand Total	95	1087.09802			

* Significant at 5% level

** Significant at both 5 and 1% levels

5.6 General Comparison of Systems

To have a single assessment of systems based on cost, time and energy, the systems were ranked as shown in Table 5.5. This ranking shows that system BE has the least time and energy requirements and the operation incurs least cost. Note that use of improved churner (System B) and System D (motorized grinding and manual dehulling) is better than traditional churning (System A) combined with System E (motorized grinding and dehulling) on the combined ranking table for high milk volumes only. The positions switch at low milk volumes. This points to the fact that system selection depends on volume processed. System AD (indigeneous milk and Fura processing) ranks 1, showing that it fairs least compared to other systems.

Table 5.5 : General Ranking of Systems

System	Time ranking at low milk volumes (<5 lits)	Time ranking at high volumes (≥5lits)	Energy ranking at low milk volumes (<5lits)	Energy ranking at high volumes (≥5lits)	Cost ranking at low milk volumes (<5lits)	Cost ranking at high volumes (≥5lits)	Combined ranking at low volumes	Combined ranking at high volumes
AC	(1)	1	(1)	1	(1)	1	1	1
BC	(2)	2	(2)	2	(2)	2	2	2
AD	(3)	3	(3)	3	(3)	3	3	3
BD	(4)	5	(4)	4	(4)	5	4	5
AE	(5)	4	(5)	5	(5)	4	5	4
BE	(6)	6	(6)	6	(6)	6	6	6

5.7 Cooking in Fura Making

Note that cooking ranked 4, 2 and 1 in System C, D and E respectively. There is scope for improvement in time usage and energy requirement pertaining to cooking. Time could be reduced by use of improved methods of cooking. For energy, note that high energy figures from cooking is not from physical activity - it is from exposure to heat. As such the energy is a reflection of heat stress, not exertion in cooking. This energy expenditure could be reduced by reducing exposure to heat while cooking. Experience tells how long it takes to cook a quantity of Fura balls. As such the processor can stay away until the Fura balls are cooked.

5.8 User Recommendation

1. Milk Processing

a) System A - For low volumes of milk processing (< 5 lits), the traditional churn is as good as the improved churn. To reduce capital investment, low volume processors should go for the traditional gourd.

b) System B - Recommended for those that produce more than 5 litres. It is from this volume that you get appreciable difference between the traditional and by use of churn. In addition, efficiency of butter extraction differs in favour of improved churn from 5 litres upwards.

2. Fura Processing

a) System C - This system is only recommended when there is no option. This is because compared to other systems, it faired lowest. Time, energy and cost was comparatively highest for this system.

b) System D - Note that grinding machines are more popular than dehulling machines. There are various places where you find a grinding machine, but a dehulling machine is not available. Under this situation this system is the best option.

c) System E - This is the best method for fura making. The system consistently used low energy, less time and minimal cost.

3. Milk and Fura Combination

a) System AC - For all parameters of assessment, this system faired least. As such it should only be used by those without access to other systems. Note that at low milk processing volumes, there is no much difference between AC and BC for all assessment parameters.

b) System BC - This system is better than AC only at high level of milk churning. A user could use any or the two methods at low milk levels.

c) Systems AD and BD - There is a sharp difference between these two systems and the two previously considered (i.e. AC and BC), leading to not less than 30% saving in cost, time and energy. In a situation where system BE is not feasible, these are the best systems recommended.

d) Systems AE and BE - At low milk volume, it makes little difference to use either AE or BE (e.g. time difference is about 2%). At high volumes of milk processing, it is better to use system BD than AE. System BE proved to be the best system for all production levels and for all assessment parameters.

For all systems, there is advantage in processing at high levels of fura and nono. At such levels, there is greater efficiency in use of time, energy and expenditure. For example, under System BD, time required to process 5.0 kg of millet and 10 litres of milk is 198 minutes, time required to process 2.5 kg and 3 litres is 134.7 minutes. Requirements for 5.0 kg are not double that of 2.5 kg

With these options in systems, there is a need to educate processors on appropriateness of a system in a given situation and what benefits they could obtain from correct selection.

CHAPTER SIX

SUMMARY AND CONCLUSION

Some selected traditional processing systems used in milk processing and millet processing into fura were studied to find their detailed operations. Surveys were undertaken in areas where milk and Fura making is very common and the areas included Kaduna, Kano, Katsina, Sokoto and Kebbi States. The intricacies of the processes and variations in methodology were obtained and quantified. The traditional processes were carefully analysed to identify the relative drudgery and time involvement at various stages of processing. These set the priorities where technical intervention or change in work postures will ease the process. The prime focus was, however, to retain the traditional concept so that acceptability was maximised. In particular the following was accomplished:

1. Milk Processing

a) Surveys - Salient findings are:

i) Women are responsible for milk processing; when this plus their house chores are considered, their time demands exceed 16 hrs/day.

ii) The average daily off-take of milk per woman is 0.2 lits. in dry season and 4-6 litres in rainy season. Volume of milk processed per day ranges between 2-10 litres throughout the year.

iii) Some identified constraints in their activities include: lack of simple improved tools and tedious nature of processing tasks.

b) Laboratory Studies

i) Time studies for different milk volumes (as above) showed that 17.5 minutes is total time required to churn 2 litres, and 65.5 minutes is required to extract butter from 10 litres.

ii) Energy studies showed that churning 2 litres required 16.2 kJ, while churning 10 litres required 90.5 kJ.

iii) Ranking of component tasks in churning showed that agitation ranked first for both time and energy. Thus, agitation process was considered an element for intervention.

iv) Biomechanical studies were done simulating the traditional churning operation and it showed that agitation is proportional to angles between the arms and the trunk, height of lifting gourd and muscle force applied. A relationship was developed between churning time and energy expenditure.

v) From anthropometric studies of prospective users, *recommended diameter for gourd neck* should be 6.17 cm; and recommended values for neck height should be 21.12 cm.

c) Interventions

i) The existing churning process could be improved by adopting better biomechanical postures. For example, butter yield was increased by 18.3% and time saved was 46.2% when height of lifting gourd was increased by 40 cm.

ii) Appropriate selection of gourd will help achieve compatability between tool and operator for enhancement of performance.

iii) An agitator was developed to replace the traditional gourd. After development, this agitator was put with collaborating users at Kano, Kaduna, Niger and Plateau States; their suggestions were subsequently incorporated in series of modifications made. Comparative tests between the agitator versus traditional showed an average saving of 84.4% in time use and 349.4% in energy requirement. Laboratory evaluation at different volumes gave varying extraction efficiency for the existing and the agitator. For example,

efficiency when churning 10 litres was 62.44% for the existing method and 69.25% for the agitator. At low volumes i.e. 3 litres, efficiency for both churns was 67.14%

2. Fura Processing

a) Surveys

As in milk, fura survey were done to establish meticulously the existing intricacies.

Salients findings from the survey are:

i) Variations exist between places surveyed; certain good practices could be disseminated for adoption. Note, however, that certain variations are due to certain practices peculiar to places.

ii) Most processes in fura making have a regime which is determined by certain parameters which fura makers can gauge by observation and/or feeling, e.g. correct moisture content to start dehulling and appearance that shows completion of dehulling.

iii) Volume of millet processed into fura range from ½ - 3 tiyas, with most processors falling within 1 - 2 tiya. Each processor has a reason for the quantity she produces. Some are limited by market, others by ability to produce.

iv) Tools used for fura making are common household utensils. These include mortar, pestle, sieve, calabash, flat tray, local wood stove, pot and small bowls.

v) Fura making is profitable at all levels of production (i.e. from 1-3 tiyas)*. The more produced, the greater the profits. Constraint militating against high production is the time and drudgery involved.

b) Laboratory Studies

i) Detailed time and energy studies on traditional fura making showed that the component activities ranked as follows: manual grinding using mortar and pestle ranked first, cooking fura balls ranked second, and manual dehulling ranked third. Manual grinding and dehulling were selected for intervention.

* a tiya is approximately 2.5 kg

ii) Biomechanical studies on pounding shows that speed and efficiency of pounding is positively affected by weight of pestle, muscle force applied, angles between arms and between arm and body trunk.

iii) Anthropometric analysis using data of users shows the need to select appropriate pestle as it represents the interface between the operator and the work. Recommended dimensions of pestle diameter is 6.17 cm and recommended value for height of pestle is 103.8 cm.

c) Interventions

i) The study found that there is scope in improving existing process of pounding by exploiting the relationship between Kinesiology and pounding. Training could help optimize motor and force application to achieve desired output with less time and drudgery.

ii) Selection of appropriate tools would help achieve compatability for efficient performance in pounding. Awareness on importance of selecting a pestle that has a diameter of 6.2 cm and height of 103.8 cm is desired.

iii) Existing technologies for dehulling and grinding were tested. System D refers to process of fura making in which grinding mills are used to eliminate manual dehulling. System E refers to fura making process in which a motorized grinding mill and dehulling machines are used to eliminate both manual dehulling and pounding. Comparative studies with the existing method showed that 46.3% time and 39.8% energy is saved when system D is used. Similarly, 55.3% time and 66.3% energy is saved when System E is used instead of the existing method.

3. Integral Milk and Fura Processing

Relative performance of possible systems were also attempted and these involved basically the following:

a) Processing by existing churning process and existing method of making fura (System AC).

b) Processing by existing churning process and use of motorized grinder in fura making (System AD).

c) Processing by existing churning process and use of both dehulling machines and grinding machines in fura making (System AE).

d) Processing by improved agitator and existing method of fura making (System BC).

e) Use of improved agitator and a grinding mill (System BD).

f) Use of improved agitator, grinding mill and dehulling machine (System BE).

Results showed that a system need be chosen in line with several parameters e.g. volume processed, availability or access to prime movers, etc. The study, as an example, established the guideline that can be used to choose a particular system for maximum output, minimum energy and maximum profit.

6.1 Suggestions for Future Work

1. The two processes studied have possibilities of new product lines. This should be explored in future work. For example, fura could be cubed, packaged and preservative added.
2. Tools should be fabricated in accordance with anthropometric findings and be evaluated for time and energy requirements.
3. Effort should be made to develop simple devices to improve on other component tasks of milk and fura processing. However, it is important that these devices should be simple in operation and cheap for the processors to afford, and also retain maximum of traditional concepts.
4. Grinding by use of a motorized mill was the greatest single intervention achieved. However, considering the problems associated with grinding, which include non-availability, lack of electricity, long distance to a mill, it is reccmmended that a manual grinder be developed. This would form a readily available substitute to motorized grinder.

REFERENCES

Abrams, C.F. and C.W. Suggs, 1969. Chain Saw vibration Isolation and Transmission through the Human arm. Transactions of ASAE 12(4): 423-425.

Adeyokunnu, O.T., 1981: Women and Agriculture in Nigeria. Research series for African Training. Rockefeller Foundation.

Adeoti, J.S. and R.N. Kaul, 1991. Development and Testing of a Hand pushed water carrier. A report on research findings under the IAR-Ford Foundation project on Technology for Women.

Akerblom, B., 1954: Chairs and sitting proceedings (Vol. II) of the symposium on Human Factors in Equipment Design. Edited by W.F. Floyd and A.T. Welford. The Ergonomics Research Society. Reprint Edition 1977. Arno Press Inc. New York.

Ali, M.A., 1986. Comparative Ergonomic Studies of Male and Female operators on selected Farm Tasks. M.Sc. Thesis (unpublished).

Ali, M.A., R.N. Kaul and T.K. Atala, 1991. Milk processing and other activities among Fulani Women: A survey of Zaria area. A report of Ford Foundation/I.A.R. project.

Ali, M.A., and R.N. Kaul, 1993: Fulanis at Falgore (Kano State): A conceptual lesson for settlement of Fulanis and scope of technological intervention. A report on research findings under the IAR-Ford Foundation project in Technology for Women.

Ali, M.A., and R.N. Kaul, 1993: Development of an improved milk churner. A report of research findings under the IAR-Ford Foundation project on Technology for Women.

Ali, M.A., 1993: Intricacies of indigeneous Technologies: Case of 'Fura' making. Paper presented at Regional Workshop on role of women in Agriculture with focus on Farm Tools and related Technologies in Commonwealth Africa from November 8 to 13, 93.

Azarya, V., 1978. Aristocrats facing change: The Fulbe in Guinea, Nigeria and Cameroon. University of Chicago press.

Barham, J.N., 1978: Mechanical Kinesiology. C.V. Mosby Company. Saint Louis.

Barnes, R.M. Motion and Time Study design and measurement of work. Seventh Edition. John Wiley and Sons, 1980.

Bedford, T., 1954. Thermal Factors in the environment which influence fatigue. Proceedings (Vol. I) of the Symposium on fatigue. Edited by W.F. Floyd and A.T. Welford. Arno press.

Bovill, E.W., 1933. Caravans of the old Sahara. Harmonds - Worth. Penguin.

Bundy, D.S. and T.E. Hazan, 1975: Dust levels in swine confinement systems associated with different feeding methods. Trans ASAE 18(1): 137-139.

Burfisher, E.M. and N.R. Horenstein, 1983: Sex roles in the Nigerian Tiv Household and the different impacts of development projects. New York population council. New York.

Chakravorty, S., 1981: Times International. January 26th, 1981.

Chen, Y.R., B.K. Huang and C.W. Suggs, 1971: Noise control by Acoustic Interference. Trans. ASAE 14(3): 424-427.

Christensen, H.E., 1954: Physiological valuation of work in Nykroppa Iron Works. Proceedings (Vol.I) of the symposium on fatigue. Edited by W.F. Floyd and A.T. Welford. The Ergonomics Research Society. Reprint Edition 1977. Arno press Inc. New York.

Christensen, H.E., 1976: Man at work - studies on the application of physiology to working conditions in a subtropical country. ILO, Geneva.

Clements, E.M.B., 1954. Body measurements of the working population. Proceedings (Vol.II) of the symposium of human factors in equipment design. Edited by W.F. Floyd and A.T. Welford. Arno press Inc., New York.

Consolazio, C.F., L.O. Matough, R.A. Nelson, J.B. Torres and G.J. Isaac, 1963. Environmental temperature and energy expenditures. J. Applied physiology 18(1): 65-68.

Curfs, H.P.F., 1974. Small tractor: Problems and prospects. Paper presented at annual meeting of Agric. Engineers, Zaria.

Datta, S.R. and N.L. Ramanathan, 1969: Energy expenditure in work predicted from Heartrate and Pulmonary ventilation. J. Applied physiology 26(3): 297-302.

Davies, E., 1922. The air-cooling plant at the Merro Velno Mine. Trans. Instn. Min. Engrs., London.

Dey, J., 1981: "Gambian Women: Unequal partners in rice development projects?" London.

Diener, R.G., F.H. Buelow and G.E. Mase, 1965: Visco elastic analysis of the behaviour and properties of cherry bark and wood under static and dynamic loading. Trans. ASAE 2(3): 323-331.

Dupire, M. 1963. The position of women in a pastoral society (The Fulani WoDaabe, nomads of the Niger) In Paulme, D. (ed.), Women of tropical Africa, Berkeley, University of Californice press pp 47-92.

Easther, B., 1970: Women's role in Economic Development. St. Martins press. New York.

Farmer, E., R. St. C. Brooke and E. G. Chambers, 1923: A comparison of different shift systems in the glass trade. Rep. Industry. Fatigue Res. Bd. London 24.

Food and Agricultural Organization of the United Nations, 1979: Review and analysis of the Agrarian Reform and Rural Development in the Developing countries since mid 1960s. WCARRD/Inf. 3 p. 87.

FAO, 1975. International Scheme for coordination of dairy development: Nigeria. Rome: FAO.

Ford, A.B. and K.H. Herman, 1959: Estimation of Energy Expenditure from pulmonary ventilation. J. Applied Physiology 14(6): 891-893.

Frantz, C., 1975. Pastoral Societies, stratification and national integration in Africa. Research report No. 30. Uppsala: Scandinavian Institute of African Studies.

Fricke, W. 1979: Cattle husbandry in Nigeria: a study of its ecological conditions and socio-geographical differentiations Heidelberger Geographischer Arbeiten 52. Heidelberg: Geographisches Institut der Universitat Heidelberg.

Gupta, P.K. and B.S. Pathak, 1981: Heartrate Response to Human Back vibration. Journal of Agric. Eng. Indian Society of Agric. Eng. Indian Society of Agric. Eng. 18(1): 83-88.

Haggard, H.W. and L.A. Greenberg, 1977: Diet and physical efficiency. Arno. press. New York.
Haselgrove, N.M. and K.A. Scallon, 1981. The How and Why of Cookery. Published by Collins Educational 8 Grafton Street, London.

Henderson, A. and T. Howard, 1985: Women ending Hunger. A shift in the wind. A hunger project newspaper number 21, April 1985 p. 3.

Hill, P. 1970. Cattle ownership on the Accra plains with special reference to the Fulani herdsmen. In: Hill, p., studies in rural capitalism in West Africa, CUP, pp. 53-79.

Hopen, C.E., 1958. The pastoral Fulbe Family in Gwandu. London. IAI/OUP.

Huang, B.K. and G.W. Suggs, 1967: Vibration Studies of Tractor Operators. Trans ASAE 10(4): 478-482.

Huang, B.K. and C.W. Suggs, 1968: Tractor noise and operator performance. Trans. ASAE 2(1): 1-5.

ICRISAT, 1992. Utilization of sorghum and Millets. Edited by M.I. Gomez, L.R. House, L.W. Rooney, and D.A.V. Dendy. ICRISAT, Patancheru, Andhra Pradest India.

ILCA, 1988. Annual Report. International Livestock Centre for Africa. P.O. Box 5689, Addis Ababa, Ethiopia.

ILCA, 1989. Annual Report. International Livestock Centre for Africa. P.O. Box 5689, Addis Ababa, Ethiopia.

Ireland, H.J. and A.J. Orenstein, 1921: A contribution to the study of the influence of mine atmospheric conditions on fatigue. Journal of African Instn. Engrs. 19, P. 126.

Janelid, I. 1975: The role of women in Nigerian Agriculture. FAO, Rome.

Jette, M.J., L.M. Windland and L.I. Okelly, 1969: An inexpensive motor-driven treadmill for exercising small laboratory animals. J. Appl. Physiology 26(6): 863-864.

Johnston, H.A.S., 1967. The Fulani empire of Sokoto. London OUP.

Karpovick, P.V. and W.E. Sinning, 1971: Physiology of Muscular Activity. W.B. Saunders Company. Philadelphia.

Kittredge, R.J. and N. Smith, 1968: Direct measurement of muscle work output with Bio-potentials Trans. ASAE. 2(4): 500-501.

Knapp, L.W. 1966: Man-Machine relationship in tractor accidents. Trans. ASAE 9(2): 178-179.

Le-Blanc, J.A., 1957: Use of heartrate as an index of work output. J. Appl. physiology 10(2): 275-280.

Magel, J.R., D.M. William and M.G. Roger, 1969: Telemetered heartrate response to selected competitive swimming events. J. Applied physiology 26(6): 764-770.

Manby, T.C.D., 1963-64: Comfort and safety on tractors. National Institute of Agricultural Engineering Annual report.

Mascarenhas, O., 1984: Rural women under rapid industrialization in Tanzania. Working paper 6 Dares Salaam.

Mascarenhas, O., 1985: Confronting the male bias in research prioties. Cares FAO review on Agriculture Aid Development. 18(3): May - June, 1985.

Matthews, J., 1968: Measurements of Environmental Noise in Agriculture. J. Agric. Eng. Res. 12(2): 157-167.

Matthews, J. and A.A. Knight. 1971: Ergonomics in Agricultural Equipment Design. National Institute of Agricultural Engineering, Silsoe.

Miller, W.F., Johnson, R.L. and Nancy W., 1959: Relationships between fast vital capacity and various timed expiratory capacities. J. Appl. Physiology 14(2): 157-163.

Morant, G.M., 1954: Body size and work spaces. Proceedings (Vol.II) of the symposium on human factors in equipment design. Edited by W.F. Floyd and A.T. Welford. Arno. press Inc.

More house, L.E. and Miller, A.T., 1959: Physiology of exercise. The C.V. Mosby Company, S.T. Louis. Third Edition.

Muchema, O., 1977: "Women, subsistence farming, and extension services in the tribal lands of Rhodesia". Unpublished Thesis. Cornell University.

Muller, H.G., 1970. Traditional Cereal processing in Nigeria and Ghana. Ghana Journal of Agric. Science 3, 187-195 (1970) Accra. Ghana Universities press.

Murrell, K.F.H., 1954: Equipment layout. Proceedings (Vol.II) of the symposium on human factors in equipment design. Edited by W.F. Floyd and A.T. Welford. Arno Press Inc.

Naluman Si S. and R.N. Kaul, 1992. Studies on the traditional system of groundnut oil extraction and possible improvements. A report on research findings under the IAR-Ford Foundation project on Technology for Women.

Newland, K., 1980: Women, men, and the division of labour. Ibid P.21.

Nwasike, C.C. and Aba, D.A. (1986). Situation of sorghum and millet production in Nigeria. Avenues for improvement. Presented at NAFPP Workshop, Ibadan.

Nwuba, E.I.U., 1981: Human energy demand of selected agricultural hand tools. Unpublished M. Eng. Thesis. Department of Agricultural Engineering, Ahmadu Bello University, Zaria.

Nwuba, E.I.U. and R.N. Kaul, 1985: Ergonomic studies on improvement of shadoof irrigation in Northern Nigeria. Paper presented 9th Annual Conf. NSAE, Owerri.

Nwuba, E.I.U., and R.N. Kaul, 1986: The Effect of working posture on the Nigerian Hoe Farmer. J. Agric. Eng. Research. 33:179-185.

Okaiyeto, P.O. 1980. An overview of the main Socio-economic contributions of the settled pastoral Fulani women in Zaria area of Kaduna state in Nigeria. AAASA/Ford Foundation Workshop on Agriculture and Rural Development in Africa, Lome, 1-5 June 1980.

Okeyo, A.P., 1980: The Joluo Equation: Land Reform-Lower status for women in CERES 75:40-41.

Olatunji, O., O.A. Koleoso, and A.B. Oniwinde, 1992. Recent experience on the milling of sorghum, millet and maize for making non-wheat bread, case and sausage in Nigeria. Pages 83-88 in utilization of sorghum and millets. Edited by Gomez, M.I., House, L.R., Rooney, L.W., and Dendy, D.A.V. Patancheru.

O'Mahony, F. and Bekele, E. 1985. Traditional butter making in Ethiopia and possible improvements. ILCA Bulletin 22:9-14.

Patel, A.U., and Q.B.O. Anthonio, 1973: "Farmers wives in agricultural development: Nigerian Case". Paper presented at the 15th International Congress of Agricultural Economics. Brazil.

Perten, H., 1983. Practical experience in processing and use of millet and sorghum in Senegal and Sudan. Cereal Foods World 1983 28(11) P. 680-684.

Philips, G.G. 1954: The metabolic cost of common West African Agricultural Activities. J. Tropical Med. and Hygiene. 56:12-20.

Putt, S.N.H., Shaw, A.P.M., Matthewman, R.W., Bourn, D.M., Underwood, M., James, A.D., Hallam, M.J. and Ellis, P.R. 1980. The social and economic implications of trypanosomiasis control: a study of its impact on livestock production and rural development in Northern Nigeria. Veterinary Epidemiology and Economics Research Unit study No. 35 Univ. of Reading.

Raay, H.G.T. Van. 1974. Fulani pastoralists and cattle. OCC. Paper No. 44 The Hague: Institute of social studies.

Roebuck, J.A., K.H.E. Kroemer and W.G. Thomson, 1975: Engineering anthropometry methods. John Wiley and Sons, Inc.

Rosegger, R., and S. Rosegger, 1960: Health Effects of tractor driving. J. Agric. Eng. Res. 5(2): 241-275.

Ryland, D.W. and P.K. Turnquist, 1970: Effect of cab, sound-proofing, and exhaust-control methods on tractor noise at operator's site. Trans. ASAE 13(1): 148-150.

Sawyer, L.R. 1985: Women and potatoes in Developing country Food systems: The CIP experience. Report on a seminar on Women and Agricultural Technology: Relevance for research (Vol.II). The Rock feller Foundation.

Schertz, C.E., 1967: Human energy expenditure for picking oranges. J. Agric. Eng. Res. 12(4): 281-284.

Simmons, E.B. 1975. The Small Scale Food processing industry in Northern Nigeria. Food Research Institute Studies 14(2): 147-161.

Singh, H. and R.N. Kaul, 1972: Human Energy Requirements of Selected Farm Operations. Journal of Agricultural Engineering Vol IX(3). Published by Indian Society of Agricultural Engineers.

Singh, H. and R.N. Kaul, 1973: Some studies on vibration of knapsack sprayer effecting operator comfort. Journal of Agric. Engineering Vol. XI(7).

Sjoflot, L., 1980: Big mirrors to improve tractor driver's posture and quality of work. J. Agric. Eng. Res. 25(1): 47-55.

Stangl, G.A., J.G. Porter field and R.L. Lowery, 1973: Tractor exhaust noise evaluation technique. Trans. ASAE 16(4): 601-605.

St. Croix, F.W. de. 1944. The Fulani of Northern Nigeria: Some general notes. Lagos: Government printer.

Stenning, D.J. 1959. Savannah nomads: a study of the Wodaabe pastoral Fulani of Western Bornu province, Northern Region, Nigeria. London: IAI/OUP.

Suggs, C.W. and W.E. Splinter, 1958: Time and Energy Analysis of Agricultural Tasks. Trans ASAE 1(1): 50-52.

Suggs, C.W. and W.E. Splinter, 1961: Some physiological responses of man to workload and environment. J. Appl. Physiology 16(3): 413-420.

Sutton, D.H., 1974: A study of human energy expenditure in the Winnowing Process. Unpublished M.Sc. thesis. University of Reading.

The Tanzanian Agricultural Policy, 1981: Dares Salaam.

Tiffen, M. 1976. The enterprising peasant: Economic development in Gombe Emirate, North Eastern State, Nigeria 1900-1968. Overseas Research Publication No. 21. London: HMSO.

Vernon, H.M. 1919: The influence of hours of work and of ventilation on output in Tinplate manufacture. Industr. Fatigue Res. London. No. 1.

Vos, H.W. 1966: Human effort in the staking of Bales on a moving wagon. J. Agric. Eng. Res. 11(4): 238-242.

Vos, H.W. 1973: Physical workload in different body postures, while working near to, or below ground level. Ergonomics 16(6): 817-828.

Wagami, S.Y. 1983: Selected Ergonomics Studies of commonly used manually operated farm tools. Unpublished M.Sc. Thesis. Department of Agricultural Engineering, Ahmadu Bello University, Zaria.

Waters-Bayer, A., 1988: Dairying by settled Fulani Agropastoralists in Central Nigeria. The Role of Women and Implications for Dairy Development. Farming systems and Resource Economics in the Tropics. Vol. 4.

Wingate - Hill, R.A. 1970: Treadmill for Exercise Studies with farm animals. J. Agric. Eng. Res. 15(4): 393-394.

Woodson, W.E. and C.W. Donald, 1964: Human engineering guide for equipment designers. Second edition. University of Californica Press. Berkeley, Los Angeles.

Wyndham, C.H., N.B. Strydomand J.S. Maritz, J.F. Morrison, J. Peter and Z.U. Potgieter, 1959: Maximum oxygen intake and Maximum heart rate during streneous work. J. Appl. Physiol. 14(6): 927-936.

Appendix I: QUESTIONAIRE ON FULANI TOOL/ACTIVITIES

Note : This questionnaire should be answered by a woman.

1. Name
2. Location
3. Educational background.
   a) No education Yes.... No.....
   b) Koranic education Yes.... No.....
   c) Western education Yes.... No.....
   d) Any other education (specify)
4. Source of training for milk processing .....
5. Specify number of female in the family (total)
   No of wives .....
   No of daughters.....
6. Since how long have you been in this location (if moving, where to)?
7. From where did you come to this location?
8. What are the duties of a fulani woman within the family set-up (tick appropriate and add any not listed)

   Firewood collection
   Cooking
   Child bearing and, care water fetching
   Washing
   Marketing milk produce
   Processing, etc others

9. How are responsibilities shared within a family with more than one female.
   a) Do you work together
   b) Do you assign jobs
   c) If not above, which arrangements?
10. What is your time - distribution within a day (i.e What she does by the hour (for each hour throughout the day).
11. What is the contribution of the man and his male children as regards the role of the women in the house.
12. Briefly describe all your activities pertaining to rearing and processing of milk products.
13. What tools do you use for milking. If there are no tools, how do you milk the cows?
14. When milking, how do you ensure that the cow stays in one place? Do you sit on stool or squat on your legs.
15. What quantity of milk do you obtain during dry season?
16. What quantity of milk do you obtain during rainy season?
17. List any factor that affects quantity of milk during dry season.
18. List factors that affect quantity of milk during rainy season.
19. Observe and describe the different processes of conversion into secondary products.

Appendix II: Energy Expenditure in Traditional Churning

		2 Litres				3 Litres				4 Litres				5 Litres			
		DH. R.	Dur.	Av. W.R.	EN.	DH. R.*	Dur.	Av. W.R.	En.	DH. R.	Dur.	Av. W.R.	EN.	DH. R.	Dur.	Av. W.R.	EN.
1.	Pouring milk into gourd	0	1.6	0	0.0	6	2.6	0.6	1.6	9	2.0	0.9	1.8	6	2.4	0.6	1.4
2.	Rinsing container & putting into gourd	7	0.5	0.7	0.4	6	2.0	0.6	1.2	15	0.4	1.5	0.6	7	2.0	0.7	1.4
3.	Churning	11	12.0	1.1	13.2	13	12.0	1.3	15.6	27	9.3	2.7	25.1	13	25.4	1.3	33.0
4.	Pouring out into container	8	0.1	0.8	0.1	10	1.6	1.0	1.6	22	0.7	2.2	1.5	10	3.0	1.0	3.0
5.	Rinsing gourd and putting into container	7	0.9	0.7	0.6	10	1.7	1.0	1.7	18	0.6	1.8	1.1	10	1.5	1.0	1.5
6.	Stirring	6	0.7	0.6	0.4	2	1.0	0.2	0.2	9	0.7	0.9	0.6	6	1.5	0.6	0.9
7.	Removing butter into container	8	0.8	0.8	0.6	10	2.6	1.0	2.6	13	3.0	1.3	3.9	10	4.5	1.0	4.5
8.	Washing & Kneading	10	0.9	1.0	0.9	9	2.0	0.9	1.8	15	1.5	1.5	2.3	10	2.2	1.0	2.2
	TOTAL ENERGY				16.2kJ				26.3kJ				36.9kJ				47.9kJ

Appendix II (Contd.): Energy Expenditure in Traditional Churning

		6 Litres			7 Litres			8 Litres			9 Litres			10 Litres		
	Activity	Av. W.R.	Dur.	EN	Av. W.R.	Dur.	EN	Av. W.R.	Dur.	EN.	Av. W.R.	Dur.	EN.	Av. W.R.	Dur.	EN
1.	Pouring milk into gourd	0.9	3.6	3.2	1.3	2.7	3.5	0.9	4.0	3.6	0.9	5.6	5.0	0.6	6.4	3.8
2.	Rinsing container & putting into gourd	2.0	1.2	2.4	1.1	1.7	1.9	0.6	2.0	1.2	1.6	2.3	3.7	0.7	2.3	1.6
3.	Churning	1.6	20.0	32.0	1.5	26.3	39.5	1.9	26.0	49.4	1.3	35.0	45.5	1.5	41.0	61.5
4.	Pouring out into container	1.3	2.4	3.1	1.1	2.7	3.0	0.9	3.2	2.9	1.4	3.5	4.9	0.8	4.0	3.2
5.	Rinsing gourd and putting into container	2.4	1.4	3.4	1.9	1.5	2.9	1.5	1.5	2.3	2.6	2.0	5.2	1.4	2.0	2.8
6.	Stirring	0.3	1.4	0.4	0.5	1.6	0.8	0.7	1.7	1.2	0.3	2.3	0.7	1.6	2.4	3.8
7.	Removing butter into container	2.1	2.5	5.3	1.4	4.6	6.4	4.3	1.8	7.7	3.9	2.0	7.8	4.2	2.0	8.4
8.	Washing & Kneading	1.4	2.5	3.5	1.6	2.5	4.0	1.7	2.7	4.4	1.8	3.0	5.4	1.6	3.4	5.4
	TOTAL ENERGY			53.3 kJ			62.0 kJ			72.7 kJ			78.2 kJ			90.5 kJ

Appendix IV: Energy requirement using Calabash Churn

	Activity	Volume (lits)	Energy requirement for different values in kJ 3	4	5	6	7	8	9	10
1.	Setting Calabash Unit		0.7	0.5	0.8	0.7	0.7	1.2	0.8	0.8
2.	Churning		4.4	7.5	13.5	7.5	7.5	15.0	7.5	10.0
3.	Stirring		0.2	0.5	1.3	0.2	1.0	0.5	1.5	1.5
4.	Extract out butter with Calabash spoon		0.1	0.7	2.6	0.9	2.0	1.3	2.4	2.8
5.	Wash and Knead		0.4	0.9	2.1	0.8	1.0	0.7	1.5	1.5
	TOTAL ENERGY		5.8	10.1	20.3	10.1	12.2	18.7	13.7	16.6

APPENDIX V: FURA SURVEY

INTRODUCTION

This survey is aimed at understanding the present practices and variations between locations of high 'Fura' consumption. This would allow an overview of Fura situation across areas where it is produced most and consumed in great quantity. The survey was undertaken to find out among others the following:

a) Historical perspective of Fura from different locations.
b) Methods adopted in different places and constraints there in
c) Scope of production and technological intervention possible.

Work Programme

a) To get a historical account of Fura making (an old man/woman or a historian to give an account of history of Fura).

b) To know the different methods and their constraints
   i) Sequence of events
   ii) Time requirements
   iii) Certain processes that help to enhance some characteristics favoured by consumers.

c) Use Diagrams attached to get vital dimensions of mortar and pestle.

d) As many pictures as possible (of each event) e.g. pounding, sieving, cooking, interview session, Sellers moving to market, Sellers in market, etc.

e) Photocopy any available document on Fura.

f) Bring back samples of Fura. Wherever you lodge put the samples in fridge.

QUESTIONS

1) What are the major Crops grown in these areas?

2) What other food products are made from millet? What is the ratio? i.e. Which one is made most followed by, etc.

3) Are there differences between millets in these areas?
What millet is preferred for Fura making?

4) Do people prefer making Fura at home or buy from hawkers. How is the ratio of those that make at home and those who buy?

5) How is Fura drink made - Is it mixed with water or milk or both? What other additives are added?

6) What is the relationship between Fura makers and Fulani? Do they sell together or you buy Fura, then look for Fulani to buy milk? How much is a ball of Fura? Or there are for different prices.

7) Why is Fura made in round balls? Why not rectangular or cubicle, etc.

8) Why is Fura made? Any historical reason why it is made?

9) What quantity of millet is processed per woman per day?

10) What are the expectation of consumers in Fura e.g. taste, appearance, etc.

11) When making large quantity Fura, do you adopt a different method?

12) How is Fura stored in different places?

For example if you want to keep for a week? Or one month? Or just two days?

13) What tools are used for Fura making? List them.

14) What reasonings do you have when choosing mortar and pestle?

15) Any other thing that you might observe. Be on the alert to observe any methods, doing/practice, any new tool, etc.

Appendix VI: Time requirement in Fura making (System C) for 2.5 kg

		Time in minutes									
	Description	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1.	Dehulling	16.8	21.1	17.0	17.0	18.8	20.3	19.1	21.0	16.9	17.0
2.	Packing from mortar into a container	0.8	1.0	0.9	1.0	1.0	0.9	0.8	0.8	0.8	0.9
3.	Winnowing	3.3	4.0	4.0	4.0	3.5	3.8	4.0	3.3	3.4	4.0
4.	Washing	8.7	14.8	10.7	10.5	10.0	9.5	9.5	8.0	8.5	8.7
5.	Drying	23.6	27.8	29.8	30.0	27.6	26.1	23.5	22.6	22.0	27.0
6.	Pounding (milling manually)	21.7	23.5	24.4	22.6	20.8	21.3	23.1	20.3	24.5	23.5
7.	Sieve	7.5	4.4	9.1	6.0	6.0	6.7	5.5	6.0	5.5	9.1
8.	Pound	24.9	10.7	18.5	17.8	16.6	20.8	14.3	19.8	11.7	10.7
9.	Sieve	8.3	4.2	8.3	6.3	6.5	7.4	5.3	6.3	5.2	8.3
10.	Pound	10.5	9.5	11.0	10.0	9.0	9.7	9.8	8.8	10.5	9.5
11.	Sieve	5.3	2.0	5.6	3.3	3.6	4.5	2.7	3.9	3.0	5.6
12.	Pound	4.1	-	4.0	4.1	3.0	3.6	4.0	3.0	4.0	4.0
13.	Sieve	2.5	6.0	4.0	4.3	5.0	3.9	5.2	4.0	7.0	6.0
14.	Pound	7.3	-	6.8	7.0	6.7	7.0	6.0	6.0	7.1	6.8
15.	Sieve	3.3	-	4.0	3.0	4.4	3.9	4.2	3.0	3.4	5.0
16.	Pound	-	-	-	-	-	-	-	-	-	-
17.	Sieve	2.1	2.5	-	-	-	-	-	-	-	3.0
18.	Wash out bran	3.0	3.0	3.0	3.0	3.0	3.1	3.0	3.1	3.1	3.0

[illegible]

Appendix VI (Cont'd)

19.	Add 18 plus fine flour into mortar	0.1	0.3	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2
20.	Pound	3.0	2.5	3.0	3.2	3.2	2.8	2.5	2.7	2.7	2.8
21.	Form big balls	2.3	2.6	3.0	3.0	3.0	2.3	2.6	2.3	4.0	2.3
22.	Place big balls in boiling water	2.2	2.0	2.1	2.1	2.0	2.3	2.0	2.0	2.2	2.1
23.	Cook	24.5	30.6	30.5	30.9	31.5	32.0	32.0	32.0	29.0	32.5
24.	Remove cooled balls into mortar	0.5	0.7	0.5	0.6	0.6	0.6	0.8	0.7	0.7	0.5
25.	Pound	4.0	9.1	11.0	9.3	10.4	10.5	10.4	9.5	9.3	10.5
26.	Form small balls	15.3	21.7	22.7	20.3	21.5	23.7	24.5	24.6	22.8	15.0
27.	Spread fine flour onto the balls	0.3	0.4	0.5	0.6	0.3	0.3	0.3	0.4	0.6	0.7
	TOTAL TIME	3 hrs 25.9	3 hrs 24.4	3 hrs 54.5	3 hrs 40.0	3 hrs 38.2	3 hrs 47.1	3 hrs 35.3	3 hrs 34.3	3 hrs 28.1	3 hrs 38.7

Appendix VII: Time requirement in Fura making (System C) for 5.0 kg

	Description	Time in minutes									
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1.	Dehulling	31.6	32.8	32.0	33.6	34.5	33.3	31.0	31.0	35.0	29.2
2.	Packing from mortar into a container	1.5	1.5	1.0	0.8	1.3	1.6	1.7	0.9	0.9	1.3
3.	Winnowing	4.5	5.0	4.8	4.0	5.0	5.1	5.3	4.3	4.9	4.0
4.	Washing	8.5	5.0	6.3	8.0	7.8	8.8	8.5	9.0	9.2	5.5
5.	Drying	28.0	30.0	33.0	30.0	29.0	30.0	30.0	29.0	29.8	32.6
6.	Pounding (milling manually)	35.0	32.2	31.9	40.0	32.5	32.9	38.0	33.8	36.5	30.0
7.	Sieve	14.7	15.4	15.9	18.0	14.9	14.9	16.4	14.8	15.6	15.0
8.	Pound	23.8	22.6	22.9	26.0	22.3	21.9	24.9	23.1	24.4	20.7
9.	Sieve	7.6	9.6	10.3	9.0	8.8	9.1	6.3	8.2	7.0	10.0
10.	Pound	16.8	14.5	14.1	19.0	14.0	13.3	17.9	15.4	17.4	11.2
11.	Sieve	6.5	9.4	11.9	7.7	6.8	10.2	7.1	13.3	6.8	7.0
12.	Pound	13.9	14.6	15.2	15.2	14.0	14.1	19.1	14.0	16.5	14.1
13.	Sieve	6.0	8.7	7.7	8.0	9.6	6.5	7.0	7.8	6.5	5.1
14.	Pound	12.2	12.4	12.9	13.1	11.8	11.7	12.7	12.0	12.5	11.3
15.	Sieve	2.9	2.8	2.5	4.0	3.0	3.0	4.0	3.0	3.5	3.0
16.	Pound	-	-	-	-	-	-	-	-	-	-
17.	Sieve	-	-	-	-	-	-	-	-	-	-
18.	Wash out **bian**	2.7	3.0	3.0	3.2	3.4	3.1	2.9	2.8	2.7	2.8

Appendix VII (Cont'd)

19.	Add 18 plus fine flour into mortar	0.9	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.8
20.	Pound	5.7	5.5	6.0	6.0	5.0	4.8	4.9	4.4	5.2	5.7
21.	Form big balls	2.7	3.0	3.3	3.9	3.0	2.8	2.8	3.0	3.0	3.2
22.	Place big balls in boiling water	1.8	1.6	1.6	1.6	1.7	1.6	1.6	1.7	1.8	1.8
23.	Cook	45.0	50.5	46.8	38.4	50.5	49.2	39.9	45.0	46.0	50.0
24.	Remove cooked balls into mortar	1.0	0.9	1.0	1.1	1.0	1.0	1.0	1.2	0.9	1.3
25.	Pound	20.7	20.1	18.9	19.9	18.4	18.4	19.4	19.6	18.2	20.2
26.	Form small balls	23.0	19.9	20.9	20.9	21.8	20.4	23.0	20.0	22.0	25.0
27.	Spread fine flour onto the balls	1.0	0.8	0.9	0.9	1.0	0.9	0.8	1.0	1.0	0.8
	TOTAL TIME	5 hrs 18m	5 hrs 22.7m	5 hrs 25.7m	5 hrs 33.1m	5 hrs 22.0m	5 hrs 19.5m	5 hrs 27.1m	5 hrs 19.2m	5 hrs 28.2m	5 hrs 11.6m

Appendix VIII: Energy requirement in Fura making (manual dehulling, manual grinding) for 2.5 kg

	Description	Energy in kJ E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling (manual)	73.6	48.0	78.6	80.3	86.7	90.3	90.9	76.7	104.6	103.3	83.3
2.	Packing from a mortar into a container	8.5	8.3	8.9	9.0	9.2	9.3	9.6	8.9	8.8	9.5	9.0
3.	Winnowing	3.5	3.5	4.0	3.8	4.2	3.6	3.5	3.6	3.7	3.6	3.7
4.	Washing	18.7	15.5	15.9	16.0	16.3	17.8	16.7	16.9	17.2	17.0	16.8
5.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.	Pounding (milling manually)	82.2	81.2	90.5	96.3	94.1	95.0	89.9	93.8	91.4	95.6	91.0
7.	Sieve	4.7	.6	6.1	4.9	4.8	5.5	8.5	5.2	5.0	5.7	5.9
8.	Pound	41.9	47.0	49.9	50.6	80.4	58.6	58.9	66.7	67.3	59.7	58.1
9.	Sieve	13.2	6.0	4.9	5.0	5.2	5.0	5.1	4.8	3.8	6.0	5.9
10.	Pound	33.3	33.5	34.3	34.8	35.2	35.0	31.7	34.4	33.8	37.0	34.3
11.	Sieve	2.6	2.5	3.3	3.5	3.9	3.4	4.1	4.5	3.8	4.4	3.6
12.	Pound	13.6	14.6	12.8	12.4	13.8	13.8	15.2	10.1	13.3	13.4	13.3
13.	Sieve	5.9	4.5	4.3	4.8	4.2	4.1	4.2	3.2	3.8	4.0	4.3
14.	Pound	18.0	19.0	19.9	25.6	24.2	26.3	28.1	23.2	22.8	27.9	23.5
15.	Sieve	3.9	3.4	2.8	2.8	2.8	3.0	3.1	3.0	3.2	3.0	3.1
16.	Wash out bran	2.5	1.0	3.0	3.8	3.2	3.8	3.8	2.9	3.0	3.0	3.0

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Appendix VIII: (Cont'd)

17.	Add 16 plus fine flour into mortar	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
18.	Pound	10.2	7.6	4.2	4.9	3.8	5.6	5.6	4.8	4.6	4.7	5.6
19.	Form big balls	5.6	6.0	6.0	6.0	6.1	6.2	6.4	6.4	6.1	7.2	6.2
20.	Place big balls in boiling water	3.1	4.1	3.3	3.4	3.3	3.2	3.2	3.0	3.1	2.3	3.2
21.	Cook	48.0	30.0	50.2	48.4	49.3	50.1	52.5	54.5	56.2	49.7	48.9
22.	Remove c cooked balls into mortar	0.5	0.4	0.4	0.4	0.6	0.4	0.4	0.4	0.4	1.1	0.5
23.	Pound	33.6	19.6	30.4	32.3	33.0	32.8	35.1	32.0	32.0	35.5	32.0
24.	Form small balls	55.4	48.0	46.2	46.4	44.8	47.1	48.3	44.4	43.4	42.0	46.6
25.	Spread fine flour onto the balls	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.2	0.4
	TOTAL ENERGY											503.2

Appendix IX: Energy requirement in Fura making (manual dehulling, manual grinding) for 5.0 kg

	Description	Energy in kJ E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling	104.0	150.6	136.0	157.8	133.7	149.3	160.2	144.1	165.7	156.6	145.8
2.	Packing from mortar into a container	1.4	1.0	1.1	1.5	1.3	1.7	1.3	1.4	1.6	1.7	1.4
3.	Winnowing	4.8	4.5	4.6	4.7	4.8	4.7	4.7	4.6	4.7	4.9	4.7
4.	Washing & putting in a Calebash	15.8	13.6	10.2	13.5	13.0	12.8	12.9	13.2	13.1	12.9	13.1
5.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.	Pounding (milling manually)	87.8	123.6	130.3	145.3	120.7	119.2	120.6	120.4	118.7	114.4	120.1
7.	Sieve	20.0	13.2	13.8	12.9	14.0	14.0	12.6	12.0	13.8	13.7	14.0
8.	Pound	81.0	88.7	73.6	80.2	81.3	90.2	80.3	79.1	81.0	80.6	81.6
9.	Sieve	8.2	7.0	7.3	8.0	7.7	7.6	7.6	7.5	7.8	8.3	7.7
10.	Pound	58.6	60.6	50.6	53.1	54.6	50.8	49.8	50.7	53.8	56.4	53.9
11.	Sieve	8.0	8.3	7.8	7.5	7.6	7.7	7.6	7.3	8.2	8.0	7.8
12.	Pound	53.2	50.6	55.5	53.0	53.0	51.1	52.6	52.8	52.9	54.3	52.9
13.	Sieve	6.7	8.3	6.8	6.5	6.7	6.7	6.6	6.6	6.0	5.1	6.6
14.	Pound	40.0	44.6	45.3	48.6	43.2	40.3	41.1	40.3	44.6	43.0	43.1
15.	Sieve	3.0	2.8	2.8	2.8	3.0	2.9	3.0	2.7	2.7	3.3	2.9

Appendix IX (Cont'd)

16.	Wash out bran	0.9	3.2	3.0	3.0	4.3	3.8	3.1	2.9	3.0	2.8	3.0
17.	Add 16 plus fine flour into mortar	7.4	9.8	10.4	10.6	11.0	9.5	9.6	9.8	8.5	10.4	9.7
18.	Pound	7.4	12.6	10.8	10.9	8.2	11.6	11.7	11.0	10.5	11.3	10.6
19.	Form big balls	5.1	7.1	8.0	6.9	7.0	8.2	7.2	7.0	8.6	5.9	7.1
20.	Place big balls in boiling water	1.1	3.1	3.2	2.4	2.5	2.9	2.9	3.2	2.6	2.1	2.6
21.	Cook	36.0	30.0	69.6	90.4	100.2	80.1	82.8	75.6	88.9	84.4	73.8
22.	Remove cooked balls into mortar	0.5	0.9	1.2	1.3	0.9	0.9	1.0	0.9	0.8	0.6	0.9
23.	Pound	28.0	66.0	66.3	67.6	65.9	76.7	80.3	78.3	65.7	65.2	66.0
24.	Form small balls	40.0	47.0	48.0	53.4	49.9	47.8	48.0	48.0	47.6	47.3	47.7
25.	Spread fine flour onto the balls	0.5	0.7	0.6	0.8	0.8	0.9	0.8	0.8	0.9	1.2	0.8
	TOTAL ENERGY											777.8

Appendix X: Time requirement in Fura making (System D) for 2.5 kg

Description	Time in minutes T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	Av.
Dehulling	16.0	16.0	16.0	30.0	18.0	19.5	18.3	12.0	12.1	16.1	15.1	17.4
Washing & putting in calabash	7.0	9.0	9.0	10.0	10.0	9.5	9.0	3.5	7.4	8.0	N.A.	8.2
Drying	8.4	18.0	20.0	30.0	22.0	20.5	18.0	17.7	17.7	22.0	21.6	9.6
Milling (by machine)	3.0	3.0	3.0	3.0	7.0	3.0	2.4	3.1	3.1	3.0	2.1	3.4
Pound	1.0	5.0	1.3	11.15	0.58	0.7	1.0	1.0	1.0	0.75	N.A.	2.3
Sieve	7.0	17.3	10.0	10.38	8.0	4.5	16.0	15.5	15.6	13.03	12.8	11.7
$Pound_2$	0.5	0.3	1.0	0.45	0.0	0.8	0.0	0.0	0.0	0.0	2.7	0.3
$Sieve_2$	15.0	11.0	6.2	4.21	0.0	6.5	0.0	0.0	0.0	0.0	9.0	4.3
Wash out bran from sifted course part	2.5	2.5	2.5	2.5	2.4	2.4	2.5	2.5	2.4	2.4	N.A.	2.5
Put course part from 9 and fine flour into mortar	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	N.A.	0.2

Appendix X (Cont'd.)

11.	Pound	3.0	5.3	3.2	3.16	2.83	2.0	2.5	2.7	2.7	2.8	3.0	3.0
12.	Form big balls	1.0	4.0	2.0	4.0	2.0	1.5	2.0	3.0	3.0	3.0		2.6
13.	Place big in boiling water	2.0	2.1	2.0	2.2	2.0	2.0	2.3	2.0	2.1	2.1		2.1
14.	Cook	22.0	28.0	28.4	29.4	19.0	19.0	30.0	30.0	30.0	30.0		26.6
15.	Remove cooked balls into mortar	0.6	0.6	0.5	0.6	0.5	0.5	0.9	0.7	0.9	0.9		0.7
16.	Pound	13.0	11.0	15.1	8.2	9.3	5.5	10.4	10.5	10.4	9.5		10.3
17.	Form small balls	20.0	21.0	18.5	20.0	7.5	7.0	22.0	22.8	22.9	22.0		18.4
18.	Spread fine flour on the balls	1.0	0.5	0.6	0.3	0.3	0.3	0.4	0.6	0.7	0.7		0.5
	TOTAL TIME	2 hrs 3.1m	2 hrs 34.7m	2 hrs 19.5m	2 hrs 49.6	2 hrs 51.6m	2 hrs 45.4m	2 hrs 17.9m	2 hrs 7.8m	2 hrs 12.2	2 hrs 16.5		2 hrs 4.1 mins

Appendix XI: Time requirement in Fura making (System D) for 5.0 kg

	Description	Time in minutes T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	Av.
1.	Dehulling	30.8	30.0	31.7	32.5	31.3	32.0	32.0	36.0	30.2	30.2	31.9
2.	Washing & putting in Calabash	13.3	10.0	14.2	15.0	13.8	12.8	11.7	16.0	14.8	14.8	13.5
3.	Drying	30.0	30.0	30.0	30.0	30.0	28.0	30.0	25.0	30.0	35.0	29.8
4.	Milling (by machine)	2.8	3.0	3.2	3.5	3.0	3.0	3.0	3.0	2.9	3.0	3.0
5.	Pound	2.7	3.0	3.1	3.5	2.9	2.8	2.8	2.7	3.0	3.1	3.0
6.	Sieve	13.0	11.8	14.0	15.0	13.5	13.8	14.0	18.2	16.0	15.0	14.4
7.	Pound	-	-	-	-	-	-	-	-	-	-	-
8.	Sieve	-	-	-	-	-	-	-	-	-	-	-
9.	Wash out bran from sifted course part	1.9	2.5	2.7	3.5	2.3	2.0	2.0	2.0	2.5	2.0	2.3
10.	Put course part from 9 and fine flour into mortar	0.7	0.5	0.9	1.0	0.8	0.7	0.6	0.7	0.8	0.7	0.7
11.	Pound	4.9	3.9	5.5	6.0	5.2	4.4	4.9	4.8	5.0	6.0	5.1
12.	Form big balls	2.7	3.0	3.3	3.9	3.0	2.8	4.0	3.8	4.2	3.0	3.6

Appendix XI (Cont'd)

13. Place big balls in boiling water	0.5	1.0	1.0	1.5	0.8	0.8	1.6	2.0	0.9	0.8	1.2
14. Cook	30.0	29.4	30.0	30.0	29.0	30.0	30.0	29.0	30.0	28.0	32.5
15. Remove cooked balls into mortar	0.6	0.7	0.8	1.0	0.7	0.7	0.7	0.9	0.6	1.0	0.8
16. Pound	12.9	15.1	13.9	14.9	13.4	13.4	13.0	14.6	13.2	15.2	14.0
17. Form small balls	14.9	15.9	15.9	16.8	15.4	18.0	15.0	17.0	20.0	17.4	16.6
18. Spread fine flour on the balls	0.5	0.6	0.6	0.7	0.6	0.5	0.5	0.6	0.5	0.6	0.6
TOTAL TIME	2 hrs 42.2	2 hrs 40.4	2 hrs 50.8	2 hrs 58.8	2 hrs 45.7	2 hrs 45.7	2 hrs 45.8	2 hrs 56.3	2 hrs 54.6	2 hrs 57.1	2 hrs 53mins

Appendix XII: Energy requirement in making Fura (Manual dehulling, machine grinding) for 2.5 kg

	Description	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling (manual)	87.9	78.6	84.4	80.3	86.7	76.7	85.1	80.6	83.3	90.0	83.4
2.	Washing & putting in Calabash	18.7	17.8	18.7	18.0	18.3	17.9	17.5	18.7	18.1	17.9	18.2
3.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.	Milling(by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	Pound	3.1	3.0	3.1	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0
6.	Sieve	13.9	14.1	14.5	13.2	13.7	14.2	14.5	14.5	14.8	13.9	14.1
7.	Pound	-	-	-	-	-	-	-	-	-	-	-
8.	Sieve	-	-	-	-	-	-	-	-	-	-	-
9.	Wash out bran from sifted course part	2.2	3.0	3.0	3.0	3.1	3.0	3.0	3.0	3.1	3.0	2.9
10.	Put course part from 9 & fine flour into mortar	0.7	1.0	0.9	1.2	1.3	1.0	1.3	1.2	1.0	1.0	1.3
11.	Pound	13.6	15.1	15.3	16.0	15.0	15.3	15.0	15.2	15.2	15.3	15.1

Appendix XII (Cont'd)

12. Form big balls	7.2	8.0	8.0	7.8	7.9	8.0	7.1	7.4	7.6	7.9	7.7
13. Place big balls in boiling water	0.5	1.0	1.0	1.3	1.5	1.6	1.8	1.8	1.6	1.8	1.4
14. Cook	32.0	38.2	32.2	33.4	35.1	30.8	34.6	35.1	38.5	38.6	34.9
15. Remove cooked balls into mortar	0.4	0.5	0.3	0.7	0.7	0.6	0.8	0.8	0.8	0.7	0.6
16. Pound	45.0	40.6	46.5	40.5	41.1	41.7	39.4	39.8	40.9	41.6	41.7
17. Form small balls	32.7	34.7	38.7	34.6	35.0	34.5	34.2	34.0	35.1	38.6	35.2
18. Spread fine flour on the balls	1.2	0.8	1.0	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.7

260.2

Appendix XIII: Energy requirement in making Fura (Manual dehulling, machine grinding) for 5.0 kg

	Description	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling (manual)	60.4	146.3	140.4	156.6	149.1	133.7	157.8	136.0	150.6	144.1	137.5
2.	Washing & putting in Calabash	18.7	15.8	19.0	13.5	12.9	13.2	14.0	13.6	13.1	15.2	14.9
3.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.	Milling (by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	Pound	8.0	7.8	8.0	8.0	7.9	7.8	8.0	8.0	7.9	7.8	7.9
6.	Sieve	20.8	20.4	21.0	21.3	21.1	20.3	21.6	23.2	20.9	20.4	21.1
7.	Pound	-	-	-	-	-	-	-	-	-	-	-
8.	Sieve	-	-	-	-	-	-	-	-	-	-	-
9.	Wash out bran from sifted course part	3.2	3.8	4.0	4.0	4.0	4.0	3.8	3.8	4.0	4.0	3.9
10.	Put course part from 9 and fine flour into mortar	2.2	2.5	2.2	2.6	2.6	2.8	2.8	2.7	2.6	2.5	2.6
11.	Pound	10.2	10.6	9.8	11.0	9.9	11.2	10.8	11.3	11.5	10.8	10.7

Appendix XIII (Cont'd.)

12. Form big balls	8.9	9.0	9.0	8.8	8.9	9.0	9.1	9.0	8.9	9.0	9.0
13. Place big balls in boiling water	6.6	5.0	5.6	5.1	4.8	4.8	5.4	5.5	5.3	4.9	5.3
14. Cook	114.0	112.2	100.7	109.3	113.6	103.6	108.3	111.1	112.2	95.3	108.0
15. Remove cooked balls into mortar	1.2	1.3	1.1	1.3	1.1	1.0	1.0	1.0	1.2	1.1	1.1
16. Pound	51.2	65.2	66.0	65.7	78.3	76.7	65.9	67.6	66.3	66.0	66.9
17. Form small balls	43.0	47.3	45.3	47.6	48.0	47.8	49.9	43.4	48.0	47.3	46.8
18. Spread fine flour on the balls	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

436.7

Appendix XIV: Time requirement in Fura making (System E) for 2.5 kg

	Description	Time in minutes T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	Av.
1.	Dehulling (by machine)	5.9	6.0	5.8	4.0	4.5	5.9	5.8	4.8	5.9	6.0	5.5
2.	Washing & putting in Calabash	5.2	5.0	5.1	7.2	6.5	6.7	7.0	5.2	5.2	5.2	5.8
3.	Drying	18.0	20.0	17.0	17.0	19.0	25.0	28.2	30.0	19.5	22.0	21.6
4.	Milling (by machine)	2.7	2.4	3.0	3.1	3.0	2.8	2.7	2.7	2.7	3.0	2.8
5.	Pound	1.7	1.5	1.3	1.5	1.5	1.5	1.6	1.5	1.4	1.5	1.5
6.	Sieve	5.0	4.5	4.3	4.8	6.0	4.9	5.3	5.6	4.5	4.7	5.0
7.	Wash out bran from sifted course part	1.5	2.0	1.5	2.0	2.0	2.0	1.8	1.6	1.5	1.5	1.7
8.	Put course part from 7 and fine flour into mortar	1.6	1.3	1.0	0.8	0.8	1.0	1.5	1.6	1.2	1.3	1.2
9.	Pound	2.9	3.0	2.8	3.0	3.0	3.2	3.0	3.0	2.8	2.7	2.9

Appendix XIV (Cont'd.)

10. Form big balls	1.9	2.0	2.0	4.0	3.8	2.0	2.2	2.0	1.9	1.9	2.4
11. Place big balls in boiling water	0.3	0.4	0.3	0.5	0.4	0.3	0.3	0.5	0.3	0.3	0.4
12. Cook	30.0	30.0	28.6	28.5	25.8	28.4	30.0	30.0	30.0	30.0	29.1
13. Remove cooked balls into mortar	0.3	0.5	0.3	0.2	0.3	0.4	0.3	0.4	0.4	0.5	0.4
14. Pound	7.8	9.1	9.3	7.9	7.8	8.0	8.3	8.2	6.5	9.5	8.2
15. Form small balls	11.8	15.6	13.4	17.6	12.6	12.0	15.4	15.0	13.1	12.8	13.9
16. Spread fine flour on the balls	0.3	0.5	0.4	0.3	0.3	0.3	0.4	0.5	0.3	0.3	0.4
	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr	1 hr
	36.9	43.8	36.1	42.4	37.3	44.4	53.8	52.6	37.2	43.2	42.8mins

Appendix XV: **Time requirement** in Fura making (System E) **for** 5.0 kg

	Description	Time in minutes							
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	Av.
1.	Dehulling (by machine)	8.0	6.9	7.0	7.5	7.0	7.8	7.0	7.3
2.	Washing and putting in Calabash	8.0	8.8	5.5	8.4	7.2	8.2	8.0	7.7
3.	Drying	20.0	31.0	18.2	30.0	19.2	30.0	18.7	23.9
4.	Milling (by machine)	4.0	1.6	3.0	3.0	2.3	2.3	2.0	2.6
5.	Pound	2.0	1.7	1.2	1.9	1.5	1.8	1.6	1.7
6.	Sieve	15.2	21.8	17.6	18.5	19.7	20.2	20.8	19.1
7.	Wash out bran from sifted course part	2.0	2.1	2.1	2.1	2.0	2.1	2.1	2.1
8.	Put course part from 7 and fine flour into mortar	0.9	0.7	0.6	0.8	0.7	0.8	0.7	0.7
9.	Pound	3.2	4.6	3.3	3.9	4.0	4.3	4.4	4.0
10.	Form big balls	8.2	2.7	2.2	5.5	2.5	4.1	3.4	4.1
11.	Place big balls **in boiling water**	0.9	0.9	0.4	0.9	0.7	0.9	0.9	0.8
12.	Cook	30.0	37.0	30.7	33.5	33.9	35.0	36.0	33.7
13.	Remove cooked **balls into mortar**	1.0	0.9	0.9	1.0	0.9	0.9	0.9	0.9

Appendix XV (Cont'd.)

14. Pound	14.2	15.8	10.7	15.0	13.3	15.4	15.6	14.4
15. Form small balls	16.5	23.0	20.6	19.8	21.8	21.4	22.2	20.8
16. Spread fine flour on the balls	1.0	0.9	1.0	1.0	1.0	1.0	0.9	1.0
TOTAL TIME	2 hrs 15.1	2 hrs 40.4	2 hrs 5.0	2 hrs 25.3	2 hrs 17.7	2 hrs 36.2	2 hrs 25.2	2 hrs 24.7 mins

Appendix XVI: Energy requirement for making Fura (Machine dehulling, machine grinding) for 2.5 kg

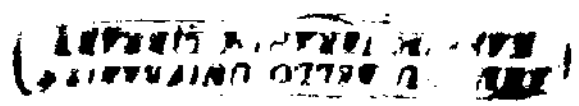
	Description	Energy in kJ										
		E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling (by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.	Washing & putting in Calabash	15.2	15.8	17.6	19.7	20.0	18.8	19.6	19.1	18.9	19.8	18.5
3.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.	Milling (by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	Pound	3.3	3.0	2.8	3.5	2.8	3.6	3.7	3.6	3.5	3.8	3.4
6.	Sieve	6.0	11.3	12.6	5.8	13.3	12.8	10.3	10.5	10.1	10.5	10.3
7.	Wash out bran from sifted course part	2.1	3.0	3.0	3.2	3.1	3.0	3.0	3.0	3.2	3.0	3.0
8.	Put course part from 7 and fine flour into mortar	2.2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
9.	Pound	14.4	16.0	13.6	15.3	15.2	15.2	15.0	15.3	15.0	16.0	15.1

Appendix XVI (Cont'd.)

10. Form big balls	8.0	8.0	7.8	7.9	7.6	7.4	7.1	8.0	7.8	7.9	7.8
11. Place big in boiling water	1.6	1.6	1.5	1.5	1.6	1.6	1.5	1.6	1.5	1.5	1.6
12. Cook	31.6	29.7	30.6	36.1	39.0	40.3	33.6	30.5	39.8	49.8	36.1
13. Remove cooked balls into mortar	1.6	0.9	0.8	1.0	1.1	1.0	1.0	0.9	0.8	1.0	1.0
14. Pound	42.9	39.7	40.5	44.9	45.0	46.0	43.6	48.7	44.6	44.9	44.1
15. Form small balls	32.2	37.1	34.5	34.3	35.0	38.3	32.9	33.6	33.1	34.8	34.6
16. Spread fine flour on the balls	1.2	1.2	1.0	1.5	0.9	0.9	1.0	1.1	0.8	0.8	1.0
											178.5

Appendix **XVII**: Energy requirement for making Fura (machine dehulling, machine grinding) for 5.0 kg

	Description	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	Av.
1.	Dehulling (by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.	Washing & putting in Calabash	12.1	18.6	19.3	18.5	18.9	18.6	19.0	19.2	18.7	20.3	18.3
3.	Drying	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.	Milling (by machine)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.	Pound	1.9	3.0	3.8	2.0	2.6	3.6	3.8	3.8	3.7	3.8	3.2
6.	Sieve	35.2	35.1	34.8	35.7	36.0	36.3	36.4	35.2	35.8	35.8	35.6
7.	Wash out bran from sifted course part	5.9	6.0	6.2	5.8	6.0	5.9	5.8	5.9	6.0	5.9	5.9
8.	Put course part from 7 and fine flour into mortar	1.5	2.0	2.5	2.6	2.6	2.8	2.8	2.7	2.6	2.6	2.5
9.	Pound	15.6	18.3	20.5	21.2	20.6	20.4	19.9	19.8	18.9	21.3	19.7



Appendix XVII (Cont'd.)

10.	Form big balls	6.1	9.6	10.3	10.8	10.1	9.9	11.2	11.1	11.3	10.6	10.1
11.	Place big balls in boiling water	1.7	1.9	1.8	1.8	1.9	1.8	1.9	1.8	1.8	1.8	1.8
12.	Cook	36.9	30.6	32.4	32.6	37.5	37.1	36.8	30.9	31.7	37.0	34.4
13.	Remove cooked balls into mortar	2.4	2.5	2.4	2.5	2.4	2.4	2.4	2.5	2.4	2.4	2.4
14.	Pound	50.2	50.8	51.3	49.6	48.9	50.1	50.0	50.6	49.3	49.6	50.0
15.	Form small balls	66.0	60.9	60.8	62.2	63.1	60.8	66.3	59.6	59.9	66.1	62.6
16.	Spread fine flour onto the balls	1.7	1.6	1.7	1.7	2.0	1.8	1.7	1.7	1.8	1.7	1.7
	TOTAL ENERGY											248.2

Appendx XVIII: Costs involved in different systems (Considerations)

System	Costs
AC	Capital- Capital cost of using a gourd, and capital cost of using mortar and pestle. Operating cost- Cost of energy used in possessing gourd and pestle and other operations.
AD	Capital - Capital cost of using a gourd, and capital cost of using a mortar and pestle for dehurlling. Operating cost- Cost of energy used in operation plus money paid to millers for grinding:
AE	Capital - Capital cost of using a gourd. Operating cost- Cost of energy used in operation plus money paid to millers for grinding and dehulling.
BC	Capital - Capital cost of using an improved churn, and cost of using a morter and pestle. Operating Cost- Cost of energy used in operation.
BD	Capital- Capital cost of an improved churn, and cost of moter and pestle used for dehulling. Operating cost- Cost of energy used in operation and cost paid to millers for grinding.

BE — Capital- Capital cost of an improved churn.
Operating cost- Cost of energy used in operation and cost paid to millers for grinding and dehulling.

APPENDIX XIX: Cost Calculations

1 To calculate cost of energy, maize was used as source of food energy being a staple diet in this area.
100g of maize contain:

Carbohydrate	71.0 x 16	= 1136.0
Protein	10.0 x 17	= 170.0
Fat	4.5 x 37	= 166.5
	Total Energy	= 1472.5KJ

Tuwo, populs food from maize contains about 90% moisture.

300gm Tuwo costs about ₦10.00

" 1gm will cost $\frac{1000}{300}$ = ₦ 3. 3k

1472.5KJ is got from 1000gm Tuwo

1KJ " " " $\frac{1000}{1472.5}$ = 0.679g

" Cost of 1KJ = 0.679 x 3.3 = 2.2k

2 Mortar and pestle - A unit costs ₦450.00. Life span is estimated at 10 years. Average use per week is 3 days.

" cost per day = $\frac{45000}{53x3x10}$ = 28k

3. Gourd - A unit cost ₦150.00 Estimated life span is 4 years. Average use per week is 4 days.

" cost/day = $\frac{15000}{53x4x4}$ = 18k

4. Improved Churn - A unit costs ₦1,000.00. Life span is estimated at 10 years. Average use per week is 4 days.

" Cost/day = $\frac{10000}{53x4x10}$ = 47k

5. Cost to millers - At present, cost to dehull a tiya is ₦2.00, similarly cost of grinding a tiya is ₦2.00.