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The contribution of fermented foods to food security in Ghana

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Declaration

I hereby declare that this thesis entitled: The contribution of fermented foods to food security in Ghana is my own work and all the sources have been quoted and acknowledged by means of complete references.

In Prague, 26/04/2017.

…….

Kingsley Buaben Obeng

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Abstract

The objective of this diploma thesis was to investigate the contribution of fermented food products to food security in Ghana particularly in Tolibre, Chiana, Paga Zenga and Paga Kaakum communities. With the use of questionaries and preference ranking exercise, a mixed method approach such as individual (face to face) interview method, household sampling and focus groups was used for collection of qualitative and quantitative data to obtain pertinent information in these study communities. The data were collected from August to September 2015. In total, there were 125 participants in all four communities with a total of twelve fermented plant food products documented with all produced from cereals and legumes. According to the individual method, the most consumed fermented plant food product was *Tuozaafi* and the least was *Masa* across all communities. In PRE, *Tuozaafi* was also the most consumed FPF, while *Koko* was the least consumed FPF across all communities. *Dawadawa* was the only documented wild fermented food product that was used for culinary purposes. The storage and processing techniques that was used in preparation of these fermented plant food products were documented accordingly. On a more general note, these fermented plant food products were found to form a vital part of the people's daily cuisines with correspondingly high rates in frequency of consumption, thus providing a high depency for food availability, assess and stability. Therefore, the significance of fermented plant food products cannot be underestimated as they have long formed a vital part of the daily cuisines of the local people in these communities.

Key words: Fermentation, foods, preference ranking exercise, fermented plant foods, plants, food security, local communities, poverty.

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List of the abbreviations

CFSVA - Comprehensive Food Security and Vulnerability Analysis

FAO - Food and Agricultural Organisation

FDA - Food and Drug Administration

FFPs - Fermented food Products

FPF - Fermented Plant Food

FPFs - Fermented Plant Foods

GOG - Government of Ghana

GSS - Ghana Statistical Service

HH - Household

LAB - Lactic Acid Bacteria

MDG - Millenium Development Goal

MDGs - Millenium Development Goals

MTEF - Medium Term Economic Framework

PoABTFF - Panel on the Applications of Biotechnology to Traditional Fermented Foods

PRE - Preference ranking exercise

PREs - Preference ranking exercises

PTT - Profiles Task Team

UNICEF - United Nation’s Children’s Fund

USDA - The United States Department of Agriculture

WFP- World food programme

1 INTRODUCTION

Fermentation is an old and economical method of producing and conserving food (Chavan and Kadam, 1989). Several studies have shown that fermented foods and beverages do not only represent a significant part of daily cuisines, but more interestingly, local communities still perceive them to be a crucial part of their culture or traditions, with several practices which are deeply inculcated into the local societies and their history (Soukand et al., 2015). According to (Pieroni et al., 2016), globally, fermented foods increase storability of foods ensuring that food remains available for consumption throughout the year. According to (Badmost et al., 2014), in Africa, fermented foods have been found to improve nutritional quality, enhance socio-economic value, antibiotic properties, reduce hunger, enhance food detoxification and cheese coagulation. The role that fermented foods play in the fight against food insecurity in Ghana, especially in rural communities cannot be under emphasized. Quave and Pieroni (2015) once elaborated that the availability of fermented foods contributes to food security and sovereignty. These fermented foods are mostly easy to produce and inexpensive to obtain in terms of affordability and availability.

Food insecurity has been a global threat to food crisis to the world's human population since the beginning of the 19th Century (FAO, 1996). The United States Department of Agriculture (USDA) defined food insecurity as the "consistent access to adequate food is limited by a lack of money and other resources at times during the year". Simply, it is a lack of food access based on financial and other material resources to attain food. According to (FAO et al., 2014) about 805 million people globally, were chronically undernourished during the period 2012-2014, most of the victims are women and children. Thirty-nine countries in the world (twenty-five in Africa, eleven in Asia and the middle east, two in Latin America, one in Europe) were experiencing serious food insecurity emergencies and require critical food aids for dealing with such state of food insecurity (FAO, 2006). The FAO has estimated that food availability has been on the low in most parts of conflict stricken and deprived areas of the developing world. Africa has been a breadbasket for food in the world with over 60% of the world's largest arable land size, yet

it still has the highest record of being the most food insecure continent of the world. About 1.2 million people representing 5 percent of the population in Ghana are food insecure with about 175,000 of this population in the Upper West region followed by Upper East with 126,000 and Northern region with 152,000. In the rural areas of Upper West, Upper East and Northern regions, over hundreds of thousands of people are vulnerable of becoming food insecure in the nearest future (Biederlack and Rivers, 2009).

According to (Ilaboya et al., 2012), improvement of science and technology, increasing agricultural production, improving market access, capacity building, development of gender specific programs, adequate storage facilities, rural off farm opportunities and good governance will provide very good solutions to fighting food insecurity in the world. Also, according to Oyewole and Isah (2012), fermented foods are capable of fighting food insecurity. However, in recent times, there has not been much related research carried out in Ghana pertaining to fermented plant foods (FPFs) and how they contribute to food security (CFSVA, 2009).

Therefore, this study aims to document and characterize all types of fermented plant products and their importance in the daily diet of the people living in rural communities in the northern Ghana. Subsequently, this will be used to assess the contribution of fermented plant food products to food security in these communities in Ghana.

1.1 Overview and History of Fermentation

Fermentation of food began by accident than by consciousness. It has been in use since prehistoric times to preserve foods. For over thousands of years, fermentation have been made without understanding its microbial mechanisms. Fruit fermentation is a natural process and and is known to exist before beginning of human history (Chojnacka, 2011). The first fermentations included the production of beer which begun in Babylonia (Battock and Azam-Alli, 1998; Chojnacka, 2011). Soy sauce begun in Japan and China, fermented milk beverages began in the Balkans and Central Asia. Table 1 shows a summary of the history of fermentation products (Chojnacka, 2011).

Before the first world war, the only large-scale product from fermentation was ethanol. During the first world war, acetone-butanol fermentation was commercially established.

Acetone was used in production of explosives. Shortly after the war, there was a sharp increase in the market of fermentation. Before the second world war, fermentation had been a method of food production (Chojnacka, 2011). Between 1941 and 1946, the market for industrial fermented products (like antibiotics) had been established (Chojnacka, 2011). This is illustrated in the Table 1 below:

Table 1. Summary of the history of fermentation products (Source: Chojnacka, 2011).

Time	**Fermentation Product**	**Place**
Antiquity	Bread, vinegar, soya sauce, wine and beer	
7000 B.C	Beer and wine	Assyria, Caucasia, Mesopotamia, Sumer
6000 B.C	Wine making	Georgia
5000 B.C	Wine Jars	Zagros Mountains, Iran
5000 B.C	Fermented beverags	Babylon
3000 B.C	Beer and fermented milk products	Babylon
2600 B.C	Bread	Egypt
1000 B.C	Soy sauce and miso	China
600 B.C	Cheese	Asia
500 B.C	Preservation of fish and meat	
100 B.C	Bread	Ancient Rome
Modern Days		
1700's	Vinegar – from fruit Pomace	
1750's	Gallic acid	
1800's	Yeast induce fermentation	Erxleben, Germany
1850's	- Bacteria produce lactic acid which conserves food - Pasteurization – heat treatment to prevent unwanted fermentation - Yeast + grape juice = Wine: beginning of the science of food fermentation	Louis Pasteur France
End of 1800's	Composting	

Chojnacka (2011) explained that Fermentation will continue to be with us far into the future as they are the source of alcoholic foods or beverages, vinegar; yogurts, pickled vegetables, sausages, cheeses, vegetable protein amino acid / peptide sauces and pastes with meat-like flavors, leavened and sour-dough breads.

1.1.1 Traditional fermented food products (FFPs) in Africa

As already been explained above, fermentation has been a traditional way of preserving food since prehistoric times. The table below displays some FPFs with their main products from which they are made from in Africa.

Table 2. Some traditional FFPs and their main products (Source: Benkerroum, 2012).

FPFs	**Main product**
Leben or lben	Fermented milk
Zebda beldia/zebda baladi/zebda beldi	Raw butter
Shmen	Rancid butter
Raib	Curdled Raw milk
Laben zeer	Milk
Jben	Milk
Smen	Milk
Mish cheese	Milk
Zabadi	Milk
Klila	Milk
Gueddid	Meat product
Pastirma	Meat
Khlii	Meat
Mkila	Meat
Merguez	Meat
Sujuk	Meat
Bubanita / Boubanita	Meat
Tehal / tehane	Meat
Pickled green Olive	Vegetable
Pickled lemon	Vegetable
Dry figs	Vegetable
Black ripe Olives	Vegetable

1.1.2 Food Fermentation in West Africa

As already said earlier in the previous section, the history of fermentation is traced down to over 7000 years ago. Odunfa (1998) asserted that the absence of writing culture in West Africa during the middle ages makes the origin of fermentation difficult to trace. In 1392, Ibn Batuta, a medieval Morrocan traveller reported that the natives of *Walata* in Sudan were consuming Porridge produced from millet and sour milk. Mansa Sulaiman, the king of Mali served Ibn with a gourd with sour milk (Badmos et al., 2014). The governor of *Walata* was also reported to serve his esteemed dignitaries with "Dankno" – a beverage made from honey and sour milk (Odunfa 1988; Badmos et al., 2014). West African countries are known for their varieties of FFPs consumption.

1.1.3 Tradtional FPFs consumed in West Africa

Ogi

A traditional FPF that is made by soaking maize, millet or sorghum in water for one, tow or three days, accompanied by wet milling, wet-sieving and fermentation for 2 to 3 days. *Ogi* is commonly made from Maize (and if made from sorghum, it's called "ogi baba" in the Yoruba language of Nigeria). It is also known as "Akamu" in the northern Nigeria, "*Koko*" in Ghana. The preparation (solid) of ogi is called *Kenkey* in the akan dialect of Ghana, "mawe" in benin republic and *agidi* in the western parts of Nigeria (Badmos et al., 2014).

Fufu

This is a meal obtained from slurry (or paste) after excoriating, slicing, soaking, fermenting, grading and cooking cassava (*Manihot spp*). The pulp is crushed by hand, sieved and the starch content is cooked into thick slurry called Fufu (Badmos et al., 2014).

Masa

Masa is a fermented puff mixture made from rice, millet, maize or sorghum. *Masa* is quite similar in shape to *Idli* and *Dosa* with taste (Badmos et al., 2014).

Gari

Gari is the flake obtained after excoriating, washing, grating and fermenting cassava. The pulp is crushed, filtered and toasted till dryness. The flakes can be soaked and drank in the

afternoon as beverage, or mixed with hot water to form a hard meal called *Eba* (Badmos et al., 2014).

Dawadawa

Dawadawa is made from washing, cooking and fermentation of African locust bean seeds (Onyenekwe et al., 2012). The fermented seeds are then made to form balls and wrapped in pawpaw or banana leaves (Badmos et al., 2014).

1.1.4 Overview of fermentation

The term "fermentation" originates from a Latin word *fermentum* (which means, to ferment) (Chojnacka, 2011). It (fermentation) is defined as the slow process of organic substances induced by micro-organisms, or by complex nitrogenous substances (or matter) of plants or animal origination. Fermentation exists in yeast, bacteria and in oxygen-starved muscle cells in the case of lactic acid fermentation (Battock and Azam-Ali,1998). Fermentation was conventionally a process which enabled to preserve food and is been used for many centuries. However, recently, the main purpose of fermentation is not just to preserve but to produce a wide variety of fermented products with unique taste, flavour and texture (Chojnacka, 2011). Fermentation conditions (microorganisms, substrates, temperature, fermentation time etc.) and chemical engineering enables production of many types of dairy (cheese, fermented milk), vegetable (pickles, sauerkraut, olives), fermented meat products, alcoholic beverages (wines, beers, ciders), vinegars, breads as well as oils.

The processes of Fermentation is biochemical and it involves lactic acid fermentation to produce products such as organic acids, alcohols, aldehydes and ketones. Examples of microorganisms involved in fermentation are *Lactococcus, Lactobacillus, Leuconostoc, Streptococcus, Penicillium, Enterococcus* and *Saccharomyces*. FFPs are food substances invaded by edible microorganisms whose enzymes (amylases, lipases or proteases) hydrolyze the polysaccharides, proteins and lipids to non-poisonous products with flavours, aromas and pleasant textures that are attractive to the consumer, usually humans (Steinkraus, 2002). Local FFPs are vital in providing food availability, employment opportunities, market improvement and poverty alleviation. Advantages of locally FFPs include enhancement of organoleptic and preservative properties, provision of high

nutritional quality, detoxification and antibiotics. Meanwhile, they add to food spoilage and health defects. Some factors affecting production of locally fermented foods are temperature, water activity, oxygen availability, hydrogen ion concentration (pH) and substrate used for food fermentation procedure (Chojnacka, 2011).

1.1.5 Factors influencing the development of fermented foods

As fermentation has already been explained to be a metabolic process, it occurs with impact of the following factors:

Temperature

Various bacteria have different levels of tolerance to temperatures (Lee et al., 2011). While most bacteria have an ideal temperature of between 20^{o} to 30^{o}C, there exists some thermophites which prefer higher temperatures between 50 – 55^{o}C and those which prefer colder temperatures of about 18-22^{o}C (Oyewole and Isah, 2012). A group (genus) of gram positive bacteria which initiate fermentation called “Leuconostoc” do have an optiumu temperatures of 18-22^{o}C (Oyewole and Isah, 2012). Lactobacillus spp. are favoured by temperatures above 22C (FDA 2011; Oyewole and Isah, 2012).

Salt concentration

Lactic Acid bacteria tolerate very high salt concentrations. The ability to permit salt gives them an advantage over other less tolerant bacteria species. This allows the lactic acid fermenters to begin metabolism, that produces acids to inhibit the growth of non-desirable organisms. “Leuconostoc” is a bacterium that tolerates high salt concentrations and for this reason it’s able to initiate majority of Lactic Acid fermentations (FDA, 2011).

Water Activity

Generally, bacterias require a quite an amount of water to survive (Oyewole and Isah, 2012). Bacteria require water to break down the food that they use for growth and energy. It allows food to enter into the cells. Water is needed for many chemical reactions necessary for life and development (Fraser, 2012).

Oxygen Availability

Some fermentative bacterias are anaerobes meaning they live in the asence of oxygen while others require oxygen for their metabolic activities (aerobes) (Battock and Azam-Ali, 1998)

Some lactobacilli are micro-aerophyllic that is they grow in the presence of reduced amounts of atmospheric oxygen. Usually, the volume of oxygen present determines the type and amount of biological product obtained, energy produced and the amount of substrate used (Oyewole and Isah, 2012).

Hydrogen Ion concentration (pH)

Bacterias live within an optimum pH of about 7.0. Some bacteria tolerates acid and are able to survive at lower pH values. Common acid tolerating bacteria are Lactobacillus and Streptococcus species. They play a part in the fermentation of dairy and vegetable products (FDA, 2011).

Nutrients

All bactieria require some sources of nutrients for their metabolism (Egbere, 2008). Fermentative bacteria needs carbohydrate – either simple sugars such as glucose and fructose or complex carbohydrates such as starch. The requirements of energy by of micro-organisms are very high. Reducing the number of substrates available can control their growth (FDA, 2011).

1.1.6 Microorganisms involved in fermented food production

Microorganisms are living creatures that are microscopic in size and are heterogeneous organisms that can be in form of plant or animal such as algae, fungi (yeasts or moulds), and bacteria (Battock and Azam-Ali, 1998). The production of microorganisms in food is greatly influenced by the inherent (intrinsic factors) and environmental characteristics of the food (Onyenekwe et al., 2012). In general, microorganisms increase rapidly in moist, nutritional, neutral pH and warm oxygen environment (Nester et al, 2007). The more popular organisms responsible for fermentation of foods are acid-forming bacteria such as genera lactic acid bacteria (LAB) such as Lactobacillus, Leuconostoc, Lactococcus, Streptococcus, Enterococcus, Aerococcus and Pediococcus (Chelule et al., 2010; Agarry et al., 2010) alsoc called (obligate fermenters), flavour / aromatic compound microorganisms and Propionibacterium species (Bukola and Abiodun, 2008). The yeasts are mostly of the species Saccharomyces, Candida, Kluyeromyces and Debaryomyces (Omemu et al., 2007). Moulds have been used mainly in milk and cheese fermentation (William and Dennis,

2011) and they include Penicillium, Geotrichium, Mucor and Rhizopus species (Chelule et al., 2010). Of more importance are the lactic acid bacteria (LAB). LAB are a group of gram positive bacteria, non-respiring, non-spore forming rods or cocci, the genera Lactobacillus, Pediococcus, Leuconostoc and Streptococcus are the main species that play a key role in safety and acceptability of the products of carbohydrates in tropical climate (Nwachukwu et al., 2010). Most pathogenic microorganisms found in food cannot live in the low pH, hence, Lactic acid fermentation of food has been found to reduce the risk of having pathogenic microorganisms grow in the food (Abdel et al., 2009). Alkali fermentation cause the hydrolysis of protein to amino acids and peptides to release ammonia which increases the alkalinity by the Bacillus species such as Bacillus subtilis, B. licheniformis and B. pumilius (Enujiugha et al., 2008; Chelule et al., 2010). These bacteria are not harmful to the consumers and have enzymes such as proteases, lipases and amylases that hydrolyze food complexes into simple nontoxic products with desirable textures, aroma that makes them appetizing for consumption (Nwachukwu et al., 2010). Microorganisms used in industrial fermentations include:

Bacteria: Acetobacter, Lactococcus, Streptococcus, Leuconostoc, Pediococcus, Lactobacillus, Propionibacterium, Brevibacterium, Bacillus, Micrococcus, Staphylococcus.

Yeast: Saccharomyces, Candida, Torulopsis and Hansenula

Mold: Aspergillus, Penicillium, Mucor, Rhizopus , Monascus and Actinomucor

LAB are naturally present in milk, fruit juice, plant products, intestine, and mucosa. In fermentation products, antimicrobial effect of their acids is used. Lactic acid bacteria are divided into three groups: Homolactic (*Streptococcus spp.*, *Pediococcus spp.*), Heterolactic (*Leuconostoc spp.),* Facultative (*Lactobacillus spp*.). *Lactobacilli* are stronger acid producers than *Streptococci.*

1.1.7 Fermentation processes

Fermented foods are produced world-wide using various manufacturing techniques, raw materials and microorganisms. However, there are four main types of fermentation processes: alcoholic fermentation, lactic acid fermentation, acetic acid and alkali fermentations (Chojnacka, 2011).

Alcohol fermentation produces ethanol and yeasts (wines and beers). Lactic acid fermentation (fermented milks and cereals) is majorly carried out by LAB. The second group of bacteria in food fermentations are the acetic acid producers from the acetobacter species (McKay and Baldwin, 1990).

1.1.8 Effects of Food fermentation

As explained, fermentation is the controlled action of microorganisms to alter the texture of food, to preserve (by the production of acids and alcohols) and to produce characteristic aromas and flavors.

Changes produced by fermentation of foods are represented in Table 3 below:

Table 3. Changes produced by fermentation of food (Source: Batty and Folkman, 1983).

Change	Description
Texture	Food becomes softened by complex changes in proteins and carbohydrates
Nutritional Value	Microorganisms improve digestibility by hydrolysis of polymeric compounds, mostly polysaccharides and proteins.
Enrichment with	Protein, essential fatty acids, essential amino acids.
Flavour	Sugars are fermented into acids, reducing sweetness and increase acidity, in some cases bitterness is reduced by enzymatic activity.
Aroma	The production of volatile compounds, fatty acids, amines, aldehydes, ketones and esters.
Colour	Proteolytic activity, degradation of chlorophyll and enzymatic browning may produce brown pigments

1.2 Classification of Food Fermentations

According to Steinkraus (2002), food fermentations can be classified into various different ways:

By categories – These are alcoholic beverages caused by yeasts; vinegars by Acetobacter; milks fermented by lactobacilli; pickles fermented by lactobacilli; fish or meat fermented by lactobacilli; and, (6) plant proteins which are fermented by moulds with or without lactobacilli and yeasts;

By classes – For example, in beverages; cereal products; dairy products; fish products; fruit and vegetable products; leguminous products; or meat products

By commodity – This is represented in fermented starchy roots (usually, cassava based); fermented cereals; fermented legumes, beverages (alcoholic and non-alcoholic); fermented vegetable proteins; and fermented animal protein (Steinkraus, 2002).

Dirar (1993) states that in Sudan, they traditionally classify their foods, not based on commodity or microorganisms but based on a functional basis as following**:** *Kissar* (staples - porridges and breads such as *Aceda* and *Kissra*). *Milha*t (from sauces and relishes for staples)**.** *Marayiss* (includes 30 types of opaque beer, date wines, clear beer and meads and other alcoholic drinks) and *Akil munasabat* (for special occasions) (Steinkraus, 2002). Meanwhile, Steinkraus (1995) classified fermentation according to the eight following categories.

1. Fermentations producing vegetable protein meat substitutes in legume/cereal mixtures. Examples include *ontjom* and *tempe*. **2.** High salt/savory meat-flavored/amino acid/peptide sauce and paste fermentations. Examples are Chinese soya sauce, Japanese *miso* and *shoyu* Indonesian *kecap,* Malaysian *kicap, kanjang, "inyu",* Philippine *taosi*, Korean *doenjang/kochujang*, Indonesian *tauco*, Vietnamese *mam* and *nuocmam*, Malaysian *belachan,* Philippine *patis* and *budu,* fish pastes*:* Philippine *bagoong, Vietnamese,* Cambodian *prahoc,* Indonesian *trassi and* Korean *jeotkal*. These are predominately Oriental fermentations but the use of these products is becoming established in developed countries like the United States. **3.** Lactic acid fermentations. Examples of vegetable lactic acid fermentations are: sauerkraut, pickled cucumber, olives in the Western world; Egyptian pickled vegetables in the middle East; Indian pickled vegetables and Korean *kim*-

chi, Thai *pak-sian-dong*, Chinese *hum-choy*. Lactic acid fermented milks include yogurts in the Western world, Middle-East yogurts, Russian *kefir*, *liban* (Iraq), Indian *dahi*, *laban zeer*, Egyptian *laban rayab*, Malaysian *tairu*. Lactic acid fermented cheeses in the Western world and Chinese *sufu/tofu-ru*. Lactic acid fermented yogurt or wheat mixtures: Egyptian *kishk*, Turkish *tarhanas, trahanas* of greece,. Lactic acid fermented cereals and tubers (cassava): Ghanian *Kenkey*, Nigerian *gari*; Mexican *pozol*, boiled rice/raw shrimp/raw fish mixtures: Philippine *balao balao*, *burong dalag*; lactic fermented/leavened breads: sourdough breads in the Western world; Indian idli, dhokla, khaman, Sri-lankan hoppers; Sudanese *kisra*, Ethiopian *enjera* and Philippine *puto*; Western fermented sausages and Thai *nham* (fermented fresh pork). **4.** Alcoholic fermentations. Examples are grape wines, *pulque* in mexico, honey wines, South American Indian *chicha* and beers in the Western World; wines and Egyptian *bouza* in the Middle East; Palm and Jackfruit wines in India, Indian rice, beer, Indian *madhu* and *ruhi*; in Africa, Ethiopian *tej*, Kenyan *muratina*, palm wines, Kenyan *urwaga*, *Kaffir/bantu* beers, *Pito*, Ethiopian *talla*, Kenyan *busaa*, Zambian maize beer; in the Far East, sugar cane wines, palm wines, Japanese sake, Indonesian tape, Malaysian *tapuy*, Chinese *lao-chao*, Thai rice wine, Indonesian *brem*, *tapuy in Phillipine*.

5. Acetic acid/vinegar fermentations. Some of them are apple cider and wine vinegars in the West; palm wine vinegars in Africa and the Far East, coconut water vinegar in the Philippines; tea fungus/ *Kombucha* in Europe, Indonesia, Japan and recently in the United States. **6.** Alkaline fermentations. They include Nigerian *Dawadawa*, Ivory Coast *soumbara*, African *iru*, *ogiri*, Indian *kenima*, *natto* in Japan, Thai *thua-nao*. **7.** Leavened breads. Examples are Western yeast and sourdough breads; Middle East breads. **8.** Flat unleavened breads.

The above classes of fermented foods are found around the world. The differences between the various classifications are not always distinct. *Tempe* as in class 1 involves a lactic acid fermentation during soaking of the soyabeans. Yeast (alcoholic) or lactobacilli (lactic acid) interactions are rather frequentfor example in dough breads, in primitive beers and wines and in Chinese soy sauce/Japanese *shoyu* / *miso* fermentations (Steinkraus, 1995). The classification has been found useful by Steinkraus as it also relates well to safety factors found in fermented foods. Fermented foods used to be originally household and expanded

to cottage industry as consumer demands increased but they have now been industrialized (Steinkaus, 1995).

1.3 Industrial Fermentation

Fermented products from foods do have applications in the general industry. The use of Industrial fermentation is applied in the manufacture of some industrial chemicals, such as acetic acid, citric acid, and ethanol (Steinkraus, 1995). The term Industrial fermentation could either be aerobic or anaerobic. Industrial fermentation describes the process that uses a chemical change induced by a living organism or enzyme, particularly bacteria, yeast, moulds or fungi which produce a specified product. It could also be defined as the intentional use of fermentation by microorganisms such as bacteria and fungi to produce useful products for human usage (Chisti, 1999).

1.4 Wild plants for fermentation purposes

According to Soukand et al. (2015), wild plants are a major important source of fermented foods The most common parts used are berries, fruits and dry parts of the leaves. They are commonly used in producing fermented beverages or herbal teas. The beverages are prepared by fermenting fresh wild berries and fruits to produce non-alcoholic or very low alcoholic gassy fruit beverages. The leaves are mostly used in fermented beverages or in herbal teas (Pieroni et al., 2016). The fermented beverages are considered healthy and are used for treating diseases. The herbal teas are often drunk as daily recreational beverages and panaeas for general health (Pieroni et al., 2016).

1.5 Food security

According to (Priya et al. 2014), the World Food Summit defined food security as “a situation that occurs when people at all times have physical and economic access to sufficient, safe and nutritious food that meets the dietary requirements for a healthy and active life”. Food security is a function of availability, affordability, stability of supply, quality and safety of food. In other words, food must be adequate in both quality and quantity to enable humans to lead an active and healthy life (Priya et al., 2014).

1.5.1 Dimensions of Food security

There are three dimensions of food security. They are food availability, food access and food utilization.

Food availability refers to the availability of food in sufficient amounts with the right quality that is supplied through all forms of domestic production, food aids or imports (FAO, 2006). Food access describes the ability of an individual to regularly acquire food in adequate amount. This could be through its own production, barter, gifts, food aid, purchases or borrowing. Food utilization involves the use of food to which they have access to the full capacity of the individual's ability to absorb and metabolize the nutrients absorbed (Biederlack and Rivers, 2009).

1.5.2 Food security situation in Ghana

The Comprehensive Food Security and Vulnerability Analysis (CFSVA) is the first detailed nationwide food security survey in Ghana. It provides a detailed summary of food insecurity in Ghana. It informs World food programme (WFP) and its partners about the present and future of food security, health and nutritional interventions. The CFSVA group included government partners (Ghana Statistical Service - GSS, Ministry of Agriculture, Ministry of Health/Nutrition Unit), UN agencies (World health Organisation - WHO, United Nation's Children's Fund - UNICEF) and NGOs (CARE, Plan International). The CFSVSA noted six factors causing food insecurity in Ghana. They are as follows:

Poverty

Food insecurity has been found to be closely linked to poverty. The CFSVA reiterated that 45% of the food insecure households and 35% of those at risk were from the poorest part of the population. The poorest households have the highest share of income spent on food, with little left for health and education (Biedarlack and Rivers, 2009).

Traditional agricultural practices and lack of access to services

The majority of smallholder farmers and agriculturists apply traditional inefficient agricultural practices that are entirely dependent on rain for cultivation (Biederlack and Rivers, 2009). They lack access to markets for the commercialization of their products. They also had insufficient access to credit facilities and alternative job opportunities

especially during the lean seasons. Although farming households have their buffer to be their own production for food consumption, the fundamental source of food remains the market, thus causing the poorest among them highly vulnerable to price and market inflations.

High food prices

The impact of the increase in food price is strongly felt among the urban poor who spend about 67% of their income on food. To about eighty percent of Ghana's population, open markets are their main sources of food. Staple food prices reaches their peak and do remain at an unusually high level despite a very good harvest. For example, inflation adjusted wholesale prices of 100 kg of maize to increase by 57% between 2007 and 2008 and 41% compared to the five-year average.

Lack of education

The analysis discovered that half of the food insecure households and 45% of those at risk were headed by adults who never received any education in their lifetime. The more education a household head had, the lower the probability of the household being food insecure.

Hazards

Adverse weather conditions such as floods and droughts are relatively pervasive throughout Ghana. They lead to poor soil quality and crop failures, which lead to food insecurity. Their impact is most devastating in the rural Northern Savannah zone where over 67% of the population is poor and ten percent of households living in this zone are fatally food insecure.

Malnutrition

While poverty is a strong predictor of malnutrition among children below five years of age, the CFSVA found certain additional underlying factors. They include diarrheal disease (arising from untimely introduction of complementary foods, poor water and sanitation), fever (high versus low malaria risk areas, insecticide treated bed-net usage) and poor food consumption.

1.5.3 CFSVA Malnutrition levels and health

Biederlack and Rivers (2009) explained that at national level, 22% of children between 0 and 59 months were stunted, 7% were wasted and 12% were underweight. Forty-one percent of children were sick in the two weeks preceding the survey. Patterns in malnutrition and vulnerability to poor health outcomes largely mirror the food security findings. Malnutrition was most severe in the northern areas, with stunting prevalence highest in Northern (30%) and wasting prevalence highest in Upper West (12%) and Upper East (11%). Vulnerability to poor health outcomes (diarrhoea, fever or cough) was most prevalent in Northern and Upper East Regions. Inaccessibility of health care resulted in increased vulnerability in Brong Ahafo and Eastern Regions. This is expressed in the Figure 1 and Table 4 below:

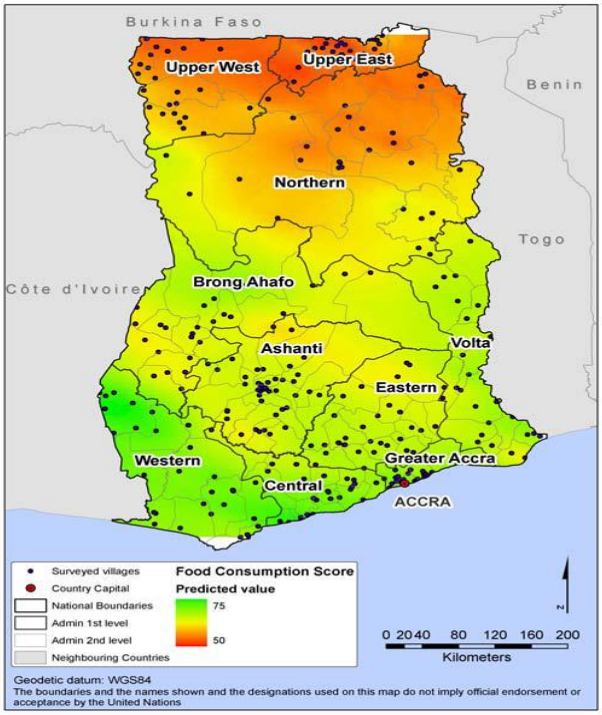

Figure 4. Geographical distribution of Food Insecurity in Ghana **(**Source: Biederlack and Rivers, 2009)

Table 4. Regional statistical distribution of Food Insecurity in Ghana (Source: Biederlack and Rivers, 2009).

Regions	Food Insecure		Vulnerable to food insecurity	
	No. of people	% population	No. of people	% population
Western Rural	12,000	1%	93,000	6%
Central Rural	39,000	3%	56,000	5%
Greater Accra Rural	7,000	1%	14,000	3%
Volta Rural	44,000	3%	88,000	7%
Eastern Rural	58,000	4%	116,000	8%
Ashanti Rural	162,000	7%	218,000	10%
Brong Ahafo Rural	47,000	3%	152,000	11%
Northern Rural	152,000	10%	275,000	17%
Upper East Rural	126,000	15%	163,000	20%
Upper West Rural	175,000	34%	69,000	13%
Urban (Accra)	69,000	2%	158,000	4%
Urban (Other)	297,000	4%	572,000	8%
Total	200,000	5%	2,007,000	9%

2 AIM OF THE THESIS

The aim of this thesis was to document and characterize all types of fermented plant products and their importance in the daily diet of the people living in rural communities in the Northern Ghana.

3 METHODS AND MATERIALS

3.1 Study Area

Ghana is a country located along the Gulf of Guinea in West Africa. It is bordered by Cote d'Ivoire to the West, Burkina Faso to the North and Togo to the East (Figure 2). Ghana has a total land area of 238,533 km^2 with 10 administrative regions and 170 districts (Tamakloe, 2015). The research was carried out in four communities, namely Tolibre, Paga Chiana, Paga Zenga and Paga Kaakum. Tolibre is located in the Lawra district whilst Paga Chiana, Paga Zenga and Paga Kaakum are located in the Kassena Nankana West district.

Lawra district is located in the Upper West region of Ghana while Kassena Nankana West district is located in the Upper East region.

The Lawra District is located on the northwestern corner of the Upper West Region with Lawra being the district capital (MOFEP, 2014). The district has an altitude of about 260 m a.s.l. According to Köppen–Geiger climate classification, its climate is classified as Tropical savannah. It is characterized by two main seasons, a rainy season from April to September and a dry season from November to March (Figure 4). It has an average annual temperature of 28°C (Rivas-Martinez 2017) with an average annual rainfall of 1,094 mm. About 73% of dwellers in this region are small scale farmers who work on their own agriculatural lands. The most cultivated food crops grown are grains (millet, sorghum and maize), roots and tuber crops (yams) and legumes (groundnuts and beans). These farmers are mostly living below the poverty line (GSS, 2013c).

Tolibre is one of 157 communities of the Lawra district (MTEF, 2012) (represented in Figure 3). It is located on coodinates 10°35' 0" N, 2°53' 0" W. It has an average temperature of 30.6 °C.

Figure 5. Map showing the location of Ghana in West Africa and the northern region (in the circle).

Figure 6. Map of northern Ghana showing the location of target districts.

Kassena Nankana West district is located in the Upper East region of Ghana (Figure 3) with Paga being the district capital (GSS, 2013b). It is one of nine districts in the Upper East region. It has an altitude of about 202 m a.s.l. The district is located in the Guinea Savannah belt, typically Sahelian (hot and dry) with a mean annual temperature and rainfall of 28.3^{o}C and 1,300 mm, respectively (Millogo, 2014). The Climate is classified as Tropical savannah by the Köppen–Geiger climate classification. It is characterized by two main seasons, a rainy season from May to September and a dry season from October to April (Figure 4). As at 2010, Kassena Nankana West had a population of about 70,667 (GSS, 2013b). Paga Zenga (10°58'0'' N and 1°4'60''W) is a populous community in the district with its population amounting to about 3,190 inhabitants. It is located at an average elevation of about 224 m a.s.l... Paga Chiana is located specifically on coordinates 10°59'32'' N, 1°6'48'' W (Maplandia, 2015). Paga Kaakum is located adjacent to Paga Zenga. In this district, 70.5% of the total population are farmers with most of them being land owners. The most cultivated food crops are Millet, Groundnuts, Rice, Maize, Beans, Soyabeans, Sorghum, Okro, Pepper and Onion (GSS, 2010b).

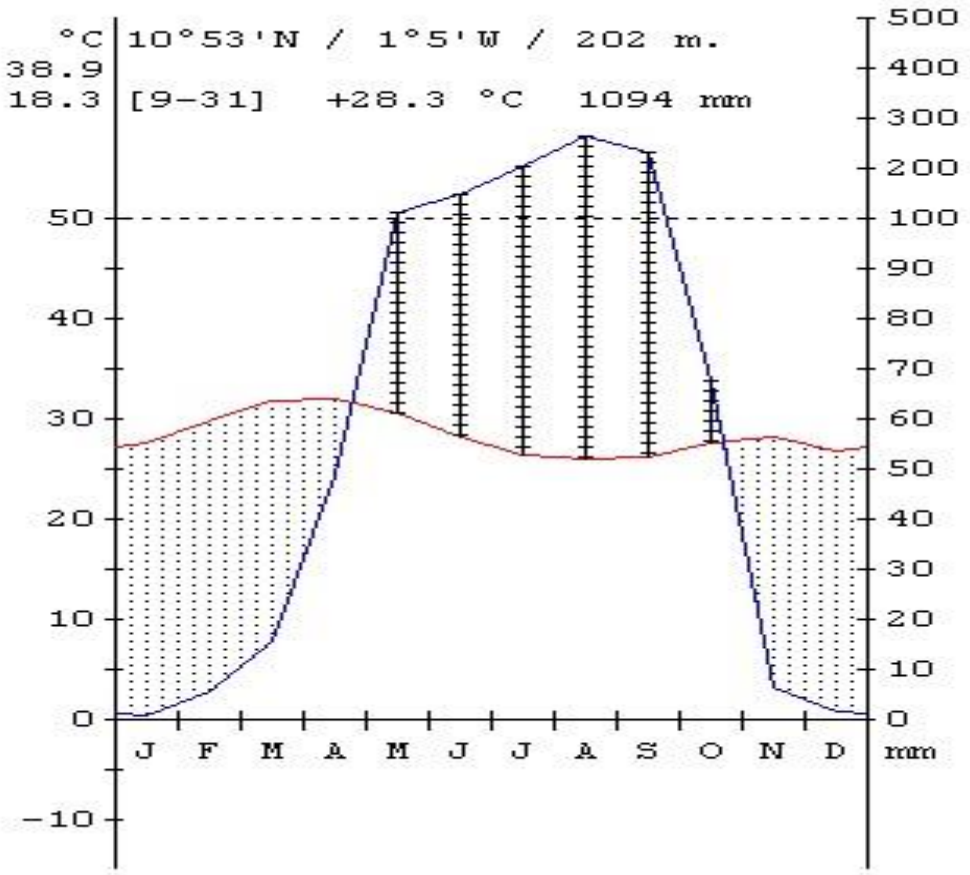

Figure 7. Climate diagram of Lawra and Kassena Nankana West District obtained from the Navrongo weather station (Source: Rivas-Martinez 2017).

3.2 Households' sampling

A total of 125 participants (men, women and children) were interviewed during the survey period from August to September. The number of household members among the households interviewed varied between 3 and 12. In Tolibre, the 53 participants were from different HH with varying number of HH members. They made a total of 465 HH members. In Paga Chiana, the 12 participants also were from different HH with a total of 83 HH members. Paga Zenga had 32 participants with 197 HH members. In Paga Kaakum the 23 participants also had a total of 168 HH members. These figures were obtained as participants were meant to answer questions pertaining to the number of HH members in their families during interviews. Each household is usually a common family. Majority of

the interviewees across all communities were between 30 and 55 years old, and were mostly engaged in various daily activities in agriculture. The younger group covered interviewees between 15 and 30 years of age. This group of interviewees included farmers, traders and students.

Tolibre community

The total number of respondents which were interviewed during the survey was 58, from which 53 of them being farmers, 2 being traders, 2 being *Pito* brewers (or producers) and 1 being an au pair (also called baby sitter).

Paga Chiana community

In Paga Chiana community, in total 12 respondents (2 men and 10 women) were interviewed during the survey. Five of the participants were farmers, 4 students, 1 being both a trader and farmer and 1 worked as *Pito* trader.

Paga Zenga community

A total of 32 participants (13 males and 19 females) were interviewed in Paga Zenga community. From the 32 participants 7were students, 22 farmers, 1 agro-chemical processor, 1 trader and 1 an artisan.

Paga Kaakum community

In Paga Kaakum, 23 participants were interviewed with 7 males and 16 females. Sixteen of the total 23 were farmers, 2 students, 4 traders, and one 1 unemployed.

3.3 Data collection

The study was conducted during the period of August to September 2015. In co-operation with local extension workers, we targeted communities that had co-operative leaders and their people were most ready to provide us with pertinent information required for the survey. Extension workers informed the community leaders several weeks before the conduction of the survey. We spent about 1 week conducting survey in each community thus the total duration of the field research was 1 month. Prior to beginning of the research, initial meeting was held with the extension workers to introduce them the method of

community entry, research aims, and data collection methods. Subsequently during community entry in every community, an initially community meeting was held to familiarise the participants with aims of the survey, and we explained what type of data we will collect, how the data will be collected, and the preliminary prepared informed consent was presented (Appendix 1). All participants in the study were from "Dagaarti" (in Tolibre community) and "Kassen" (in P. Zenga, P. Chiana and P. Kaakum communities) ethnic groups. The languages spoken are "Dagaari" and "Kassen" respectively. "English" or "Twi" (the native Ghanaian language) was also used as some interviewees were able to understand them. Therefore, interviewees were free to choose the language in which they wish to communicate. A local bilingual assistant (usually extension worker or a community leader) accompanied the investigator for translation.

Participatory Research Approaches (PRAs)

The PRAs were employed to involve every interviewee to openly share their ideas in regard to the relevant issues regarding fermented foods, and the research generally (Rademacher-Schulz et al., 2012). The main aim of the PRA is to make sure that the local people were able to express and analyse the realities of their lives and their living conditions.

For example during the Preference ranking exercise, the main aim of the Focus groups was to obtain group based information, for example during the PRE (Hennink and Monique, 2007). Participants were organised into groups of minimum, four (4) and maximum, twelve (12) members depending on the population per community. The groups were asked pertinent questions regarding fermented foods and their rankings.

3.3.1 Individual (face to face interviews)

During the individual interviews, demographic data including name, gender, age, occupation, ethnicity, religion and number of household members were collected. Subsequently, the preference ranking exercises (PREs) (conducted in groups) consisted of four to ten participants per group. For both cultivated and wild plants used, interviewees were asked questions about the local name and part of the plant, the availability of the plant all year round, what is done with the plant after harvest, which type of processing is used, a

description of how processing of the particular plant is performed (step by step), how long the FPF can be usually stored with no signs of spoilage. Paticipants also answered questions on if the plant product produced through fermentation is good for their healths. A sample of the questionnaire is attached in Appendix 7.

After completion of each interview the respondent was asked to show the reported plants and products on site. Thus, we have visited the local household settings, farms, local factories and the natural habitats to observe various practices associated with fermented plant products.

Specimens of plants and products were collected and authenticated taxonomically by local ethnobotanist, Dr. Kwagan Agyare at the University of Ghana, Legon, Accra. Duplicates of specimens were shipped to the Faculty of Tropical AgriSciences of the Czech University of Life Sciences Prague for deposition at the Department of Crop Sciences and Agroforestry.

3.3.2 Preference ranking

The preference ranking is a scale that was measured as a result of the interviewee's preference of the various FPF based on certain criteria. The evaluation of food products was done in groups for all four communities. The exercise was used to draw a table that ranked FPFs from the most consumed or preferred to the least consumed. The criteria for evaluation FPF preference were based on several attributes, namely Perception on taste, Perception on nutritive value, Socio-cultural value, Perception on health beneficial value and monetary value. The consumed FPF were listed out and participants were allowed to grade or allocate scores to each food product ranging from one (1 = least preferred) to five (5 = the most preferred). A total was calculated from the scores and the food products were ranked based on the highest total scores obtained.

Taste

Rating for taste was done by how sweet, sour or bitter the final food product is. All FPFs had variety of tastes based on different plant products from which they were made from, degree of fermentation applied to their processing and so on.

Nutritive value

Interviewees were asked to evaluate the individual food products based on their perceptions on nutritional benefits obtained through consumption of FPF.

Socio cultural value

Socio cultural value is the part that explains the social integrity that various food products do have among the people in the societies. Some foods are culturally regarded in the local setting of the society to have some social integrity allocated with the culture of the people and these food products are regarded as ideal for consumption in the society. In most societies, respondents explained that their ancestors have approved some foods for consumption and they regard it as beneficial for their generation, culture and tradition.

Health beneficial value

Health beneficial values of various food products explain the health benefits gained from various food products after their consumption. Respondents were able to rank various food products by the relative degree of health benefits to the body. According to many of the respondents, they mentioned that the products were able to provide energy, blood and vitamins.

Commercial Value

As poverty is one of the main causes of food insecurity, the PRE was dedicated to asking participants directly about monetary gains or income generation from the sale of FPFs.

3.4 Data analysis

After the data collection, raw ethno-botanical data were fed into the Microsoft excel version 16.0. The data were related to types of fermented foods consumed, amount of people / household consuming fermented foods, occupation details, preference ranking of foods, frequency of consumption, age range in correlation with the types of foods preferred, wild plant foods and processing and storage methods used were used for analysis of the data. This raw data was then quantified and translated into meaningful information that was used to prepare tables and figures to provide appropriate details on issues that accompany fermentation and food security in the studied areas.

The Average frequency of citation (or consumption) per week (AFC) was obtained arithmetically as **AFC = TFC / N_i**, where TFC referes to the Total frequency of consumption /week and N_i is a Total number of interviewees in the particular community. The Total frequency of consumption of FPF was calculated with the aid of simple arithmetic. In case of FPF consumption frequency was once per week mentioned by an individual, it was indicated as total frequency of 1 for whole week, if the frequency was daily, it was indicated with total frequency of 7 on a weekly basis. Likewise, when the food was consumed twice a day everyday, it was indicated as 14 (2*7 days), etc. Results drawn from the data analysis was consequently used in making discussions and conclusions about how well fermented foods have contributed generally to enhancing food security in the communities studied.

4 RESULTS

4.1 The fermented plant foods consumed in northern Ghana

The results across all communities show that a total of twelve FPFs were documented. Among the total documented FPFs, nine of them (*Tuozaafi, Banku, Furufuru, Kenkey, Koko, Fuura, Pito, Guliyan* and *Masa*) were from cereal sources while the other three FPFs were from leguminous sources (*Dawadawa, Koose, Tubaani*). The pattern of FPFs consumed were similar across all communities with only very little differences. This similarity is represented in the overlapping venn diagram (Figure 5). *Masa* was only consumed in both Paga Zenga and Tolibre, *Banku, Tuozaafi, Koose* and *Tubaani* were consumed in all four communities, *Furufuru* and *Dawadawa* were only consumed in Tolibre and Paga Kaakum, *Koose* was only consumed in Tolibre, Paga Zenga and Paga Kaakum, *Koko* was only consumed in Paga Kaakum and Paga Chiana, *Kenkey* was consumed in Paga Chiana, Paga Zenga and Paga Kaakum, *Fuura* was only consumed in Paga Zenga and *Guliyan* was only consumed in Paga Chaina. This was obtained through the individual method.

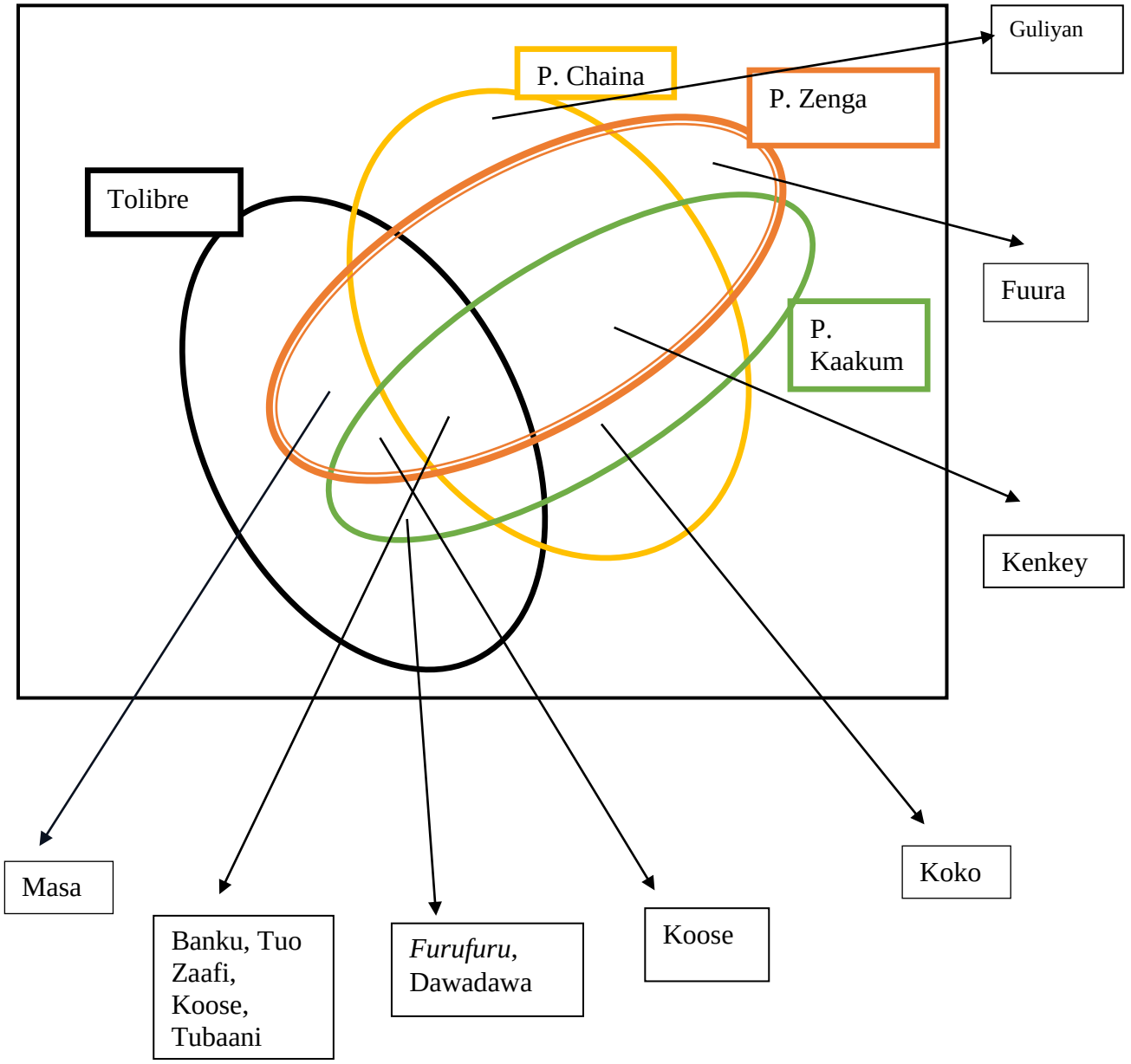

Figure 5. Overlapping Venn diagram showing similarities in FPFs across all communities

The consumption pattern of FPF across all four coummunities obtained by the individual method is shown in table 5 below. It shows specifically the list of FPFs consumed according to every community, number of citation (or consumption), number of respondents, percentage of consumption of every particular FPF consumed in every community, total average across communities and average frequency of citation.

Table 5. Consumption pattern of FPF accross communities obtained by the individual method.

FPF local name	Lawra Dist.		Kassena Nankana West Dist.						Total average across communities (%)
	Tolibre		Paga Chiana		Paga Zenga		Paga Kaakum		
	NC (N=58)	%	NC (N=12)	%	NC (N=32)	%	NC (N=23)	%	
tuozaafi	54	93	11	92	30	94	23	100	94.75
banku	3	5	6	50	19	59	17	74	47.00
fuura	-	-	-	-	1	3	2	9	3.00
furufuru	2	3	-	-	-	-	4	17	5.00
pito	4	7	-	-	1	3	2	9	4.75
dawadawa	13	22	-	-	-	-	2	9	7.75
kenkey	3	5	1	8	3	9	3	13	8.75
koose	-	-	-	-	-	-	3	13	3.25
koko	1	2	1	8	2	6	3	13	7.25
tubaani	2	3	4	33	3	9	1	4	12.25
masa	2	3	-	-	1	3	-	-	1.50
AFC	6.8 / week		6.4 / week		5.3 / week		4.0 / week		

NC: No. of citations; N: No. of respondents in the particular community; FPF: Fermented plant foods; AFC: Average frequency of citation

Tolibre community

The following were fermented foods consumed by the people in Tolibre community, i.e. *Dawadawa, Banku, Tuozaafi, Furufuru, Koose, Masa, Pito and Tubaani* (Table 5). Generally, most of the foods consumed were from cereals, i.e. *Banku, Tuozaafi, Furufuru, Masa and Pito in contrary to Dawadawa, Koose and Tubaani* which were from legumes. According to individual method summarized in the Tables 5 the *Tuozaafi* was the most consumed FPF with *Koko* been the least consumed in Tolibre. In contrary, in PRE, the *Banku* was found to be the most cosumed while the *Dawadawa* was the least consumed FPF as summarized in the Tables 6.

From the table 5 above *Tuozaafi* was the most consumed fermented plant food (FPF) in Tolibre. 54 respondents consume *Tuozaafi*, 13 respondents consumed *Dawadawa* with *Pito* being consumed by 4, *Banku* and *Kenkey* follow with 3 respondents each, with *Furufuru*, *Masa* and *Tubaani* being consumed by 2 respondents each. *Koko* was the least consumed with ony 1 respondent preferring it. The decreasing order of preference is represented below:

- *Tuozaafi*
- *Dawadawa*
- *Pito*
- *Banku*
- *Kenkey*
- *Furufuru*
- *Masa*
- *Tubaani*
- *Koko*

Table 6. The consumed FPFs by the preference ranking exercise in Tolibre

FPF local name	Attributes					Score	Rank
	Taste	Nutritive value	Socio-cultural value	Health beneficial value	Commercial value		
Dawadawa	5	5	5	5	5	25	8
Banku	**31**	**30**	**32**	**30**	**28**	**149**	**1**
Tuozaafi	**29**	**28**	**27**	**24**	**28**	**138**	**2**
Furufuru	9	9	9	8	7	42	7
Koose	13	13	11	12	11	59	5
Masa	20	16	16	17	16	88	4
Pito	20	19	19	19	20	97	3
Tubaani	10	10	9	9	10	48	6

The group preference ranking table above details out the most preferred FPF among the interviewees during the survey. *Banku* was the most preferred with a total score of 149. This was followed by *Tuozaafi* with a total score of 138. *Pito* was the third most preferred FPF by the people with a total score of 97, with *Masa* being the fourth most preferred with 88 as score. The fifth most preferred was the *Koose* with a total score of 59. The sixth most preferred during the survey was *Tubaani* with a total score of 48. The seventh preferred FPF was *Furufuru* with a total score of 42. *Dawadawa* was the eighth and least preferred FPF during the survey with a total score of 25

Paga Chiana community

In Paga Chiana community, the following fermented foods were consumed by the people i.e. *Tuozaafi*, *Banku*, *Koko*, *Tubaani*, *Kenkey*, *Guliyan* and *Pito*. Just like Tolibre, FPFs consumed in this society were mainly from cereals ie *Tuozaafi, Banku*, *Koko* and *Kenkey* except *Tubaani* which is leguminous. According to the two methods used (individual and group PRE), the *Tuozaafi*, *Pito*, *Tubaani* and *Banku* were the most consumed in the individual method while *Koko* was the least consumed with only one respondent preferring it during the individual method. Koko had 22 as scores during the PRE. In contrary, *Tuozaafi* was the most consumed in the group preference ranking while *Koko* and *Kenkey* were the least consumed. This information is represented in the table 5 and table 7.The decreasing order of preference (from Table 5) is represented below:

- *Tuozaafi*
- *Banku*
- *Tubaani*
- *Koko*
- *Kenkey*

Table 7. The consumed FPFs by the preference ranking exercise in Paga Chiana

FPF local name	Attributes					Score	Rank
	Taste	Nutritive value	Socio-cultural value	Health beneficial value	Commercial value		
Tuozaafi	**5**	**5**	**5**	**5**	**5**	**25**	**1**
Pito	**5**	**5**	**5**	**5**	**5**	**25**	**1**
Tubaani	**5**	**5**	**5**	**5**	**5**	**25**	**1**
Banku	**5**	**5**	**5**	**5**	**5**	**25**	**1**
Kenkey	**5**	**5**	**5**	**4**	**5**	**24**	**2**
Guliyan	5	5	5	5	3	23	3
Koko	4	4	5	4	5	22	4

According to the preference ranking table for Chiana, it is noted that *Tuozaafi, Pito, Tubaani* and *Banku* had the highest ranking with a score of 25. The second most preferred was *Kenkey* with a total score of 24. The third most consumed product was *Guliyan* with a total score of 23, the least most preferred is the *Koko* with a total score of 22. This exercise shows that *Tuozaafi, Pito, Tubaani* and *Banku* are the most preferred, with the least most preferred been *Koko*.

Paga Zenga community

The following were fermented foods consumed by the people in Paga Zenga community i.e. *Tuozaafi, Koose, Masa*, *Banku*, *Fuura*, *Kenkey*, *Pito* and *Tubaani*. Just like Tolibre and Paga Chiana, FPFs consumed in this community were mainly from plant cereals except *Tubaani* and *Koose* which are from leguminous sources. According to the two methods used (individual and group PRE), *Tuozaafi* was the most consumed in both methods (group preference ranking and individual method), but *Tubaani* was the least consumed according to the Preference ranking with 5.75 score (in table 8), while *Pito, Masa* and *Fuura* were the least consumed according to the individual method with only 1 respondent preferring them as shown in Table 5.

The decreasing order of preference (from table 5) is represented below:

- *Tuozaafi*
- *Banku*
- *Tubaani*
- *Kenkey*
- *Koose*
- *Pito*
- *`Masa*
- *Fuura*

Table 8. The consumed FPFs by the preference ranking exercise in Paga Zenga.

FPF local name	Attributes					Score	Rank
	Taste	Nutritive value	Socio-cultural value	Health beneficial value	Commercial value		
Banku	15	10	11	10	12	58	4
Koose	**19**	**17**	**19**	**16**	**19**	**90**	**2**
Masa	17	14	15	13	15	74	3
Pito	5	5	5	5	5	25	7
Tubaani	4	5	5	5	4	23	8
Kenkey	9	5	6	6	7	33	6
Tuozaafi	**20**	**19**	**20**	**20**	**17**	**96**	**1**
Fuura	10	10	10	9	9	48	5

According to the preference ranking table above, it could be noted that *Tuozaafi* was the group's most preferred with a total score of 96. This was followed by *Koose* with a total score of 90. The third most consumed FPF was *Masa*. *Masa* had a total score of 74 with the forth most preferred being *Banku* with a total score of 58. *Fuura* was the fifth most preferred with a total score of 48 and *Kenkey* being the sixth most preferred with a total score of 33. *Pito* was the seventh most preferred with a total score of 25. *Tubaani* was the eighth and least most preferred with a total score of 23.

Paga Kaakum community

The following were FPFs that were identified during the survey by the people of Paga Kaakum community i.e. *Koose*, *Dawadawa*, *Pito*, *Furufuru*, *Tubaani*, *Tuozaafi*, *Koko*, *Banku*, *Kenkey* and *Fuura*. During the individual method, (as shown in table 5), *Tuozaafi* was the most consumed with preference by 23 respondents and *Tubaani* been the least consumed with only 1 preference. During the preference ranking, *Koose* was the most consumed with a score of 25 and *Banku* been the least consumed with score of 13. This is represented in Table 9 below.

The decreasing order of preference (from table 5) is represented below:

- *Tuozaafi*
- *Banku*
- *Furufuru*
- *Kenkey*
- *Koose*
- *Koko*
- *Fuura*
- *Pito*
- *Dawadawa*

Table 9. The consumed FPFs by the preference ranking exercise in Paga Kaakum.

FPF local name	Attributes					Score	Rank
	Taste	Nutritive value	Socio-cultural value	Health beneficial value	Commercial value		
Tuozaafi	4	3	5	5	2	19	6
Banku	3	2	1	3	4	13	8
Fuura	5	4	4	4	4	21	4
Furufuru	4	4	4	5	4	21	4
Pito	3	5	5	5	5	23	3
Dawadawa	**5**	**5**	**5**	**5**	**4**	**24**	**2**
Kenkey	5	4	5	5	2	21	4
Koose	**5**	**5**	**5**	**5**	**5**	**25**	**1**
Koko	4	2	5	1	5	17	7
Tubaani	5	3	5	2	5	20	5

According to the preference ranking table above, it is noticeable that *Koose* was the most preferred by the people during the PRE as it has the highest in terms of ranking with a cummulative score of 25. The second (2nd) highest was the *Dawadawa* with 24. *Pito* ranked third (3rd) with 23, with *Fuura*, *Furufuru* and *Kenkey* ranking 4th with total score of

21, *Tubaani* ranking 5th with a score of 20, *Tuozaafi* ranking 6th with total score of 19, *Koko* ranking 7th with total score of 17 and *Banku* ranking 8th with only a total score of 13. According to their comparason, *Koose* was the most preferred FPF with *Banku* being the least.

4.2 To identify wild plant(s) that are used for preparing FPFs in Tolibre, Chiana, Paga Zenga and Paga Kaakum communities in Ghana.

Among all documented 5 plant species used for preparing FPFs (i.e. maize, millet, cowpea, sorghum, African locust bean), only the African locust bean (*Parkia biglobosa)* was identified as wild plant species that was used in the preparation of fermented plant foods (Kwaw, 2014).

4.3 To identify the storage and processing techniques used in the preparation of the particular fermented plant foods within Tolibre, Chiana, Paga Zenga and Paga Kaakum communities in Ghana

The traditional method of processing and storing of FPFs in the local communities have been elaborated in the Table 10. The table describes the traditional name of the FPFs, the vernacular names of the plants from which they are obtained, the botanical classification (species, family), part of the plant used, their mode of preparation and storage and their storage length according to experience and observations of the interviewees.

Table 10. Nomenclature, storage and processing of culinary plants among studied communities (Source: Author's personal observation, 2015). (En (English), Dag (Dagaarti), Twi (Twi), Kaas (Kaasen), Ha (Hausa) - the local languages spoken in studied communities).

Product	Plant vernacular name	Botanical species	Botanical Family	Plant part used	Mode of preparation and storage	Product storability (days)
Tuozaafi	Maize (En), Aburo (Twi), Kamaana (Dag) Millet (En), Eyuo (Twi), Zie (Dag)	*Zea mays L.* *Panicum milliaceum L.*	Poaceae	Seed	Dried Seeds (maize or millet) are fermented in water for 3 or more days and milled. They are then airdried and some portion is soaked in water to form slurry and some left in the dried powdery state. The slurry is soaked in water and added to already boiling water and stirred with rod. Powdered TZ is added to thicken and stirred. Salt is added to taste. TZ is ready and served with tradtional soups.	4
Banku	Maize (En), Aburo (Twi) Kamaana (Dag)	*Zea mays L.*	Poaceae	Seed	Dried Seeds are fermented in water for 3 or more days and milled. They are then airdried and soaked in water to form slurry. The slurry is fetched and diluted in water and added to an already boiling water and stirred.	3

					Salt is added to taste. The slurry is added to the boiling. mixture to thicken and stirred. *Banku* is ready and served with tradtional soups.	
Guliyan	Maize (En), Aburo (Twi) Kamaana (Dag) Millet (En) Eyuo (Twi) Zie (Dag)	*Zea mays L.* *Panicum milliaceum L.*	Poaceae	Seed	Dried Seeds are fermented in water for 3 or more days and milled. They are then airdried and some portion is soaked in water to form slurry and some left in the dried powdery state. The slurry is diluted and boiled in heating water and stirred. "Twe" - a powder from the baobab fruit, is added while being cooked. Salt is added to taste. *Guliyan* is ready as soon as it's well cooked.	3
Koose	Cowpea or Black eye pea (En) Benga (Dag)	*Vigna unguiculata* (L.) Walp.	Leguminosae	Pea	Dried Seeds are fermented in water for one or two days and dehulled They are then milled The content is diluted in water Salt, Vegetables and spices (Onion, chilli pepper, spring onions and eggs) are added The content is scooped unto heated frying vegetable oil Fried until it's browned and ready to be served.	2

Masa	Millet (En), Benga (Dag)	*Panicum milliaceum L.*	Poaceae	Seed	Dried Seeds are fermented in water about two days and dehulled. They are then milled and airdried. The content is diluted with water and then left to ferment overnight. Some salt is added to the quietly thick mixture and then fried in heating Shea oil or any vegetable oil.	2
Dawadawa	African Locust bean (Eng), *Dawadawa* (Twi) (Dag) (Kaas) Kal (Dag), Soumbala (Ha)	*Parkia biglobosa (Jacq.) G.Don*	Leguminosae	Seed	*Dawadawa* seeds are cooked and washed to remove seed coats. They are recooked. They are allowed to cool. The seeds are spread over ashes and covered with same ashes. Materials like boxes, polythene sheets are spread over them and dried. They are grinded into smaller shapes by pestles and mortar. They are moulded into round balls and ready for food.	Over 2 mths
***Kenkey* or (Dokunu)**	Maize (En), Aburo (Twi), Kamaana (Dag)	*Zea mays L.*	Poacae	Seed	Dried Seeds are fermented in water for 3 or more days and milled. They are then airdried. Water is added to form slurry and stirred. It is covered for a day to ferment.	3

					It is scooped into leaves. Then finally boiled.	
Pito	Sorghum (En) Millet (En), Benga (Dag)	*Sorghum bicolor* (L.) Moench *Panicum milliaceum L.*	Poaceae	Seed	Seeds are dried on clean floors. Water is sprinkled and covered with materials to maintain humidity. They are left to ferment and sprout while materials are removed on 3rd or 4th. The seeds are left to dry and milled. The content is soaked in water and cooked. The floating water (or liquid) is decanted and yeast added to increase fermentation. The product obtained is ready to be served as "*Pito*".	5

Koko	Millet (En), Benga (Dag) Maize (En), Aburo (Twi), Kamaana (Dag)	*Panicum milliaceum L.* *Zea mays L.*	Poaceae	Seed	Millet/Maize seeds are soaked over nights to ferment. The millet is rinsed in clean water. Spices (Pepper, Ginger, ethiopina pepper, meleguetta pepper) are added. The contents are milled. The milled content (powder) is then brought home to be soaked, inwater, stirred and sieved to obtain clear dissolved watery mixture. The sieved content is then collected and either boiled. Salt is added and stirred uniformly. The product is a thickened content that is served in a bowl, with sugar and sometimes milk added.	2
Furufuru	Millet (En), Eyuo (Twi) Zie (Dag)	*Panicum milliaceum L.*	Poaceae	Seed	The dried millet is soaked. Pepper, Ginger is added to the content and milled. It is Soaked for about 2 days again. Water is added and stired It is then sieved. Sugar and ” Kanafri” is added and kept in cold.refrigerator. *Furufuru* is best served cold.	3

Fuura	Eyuo (Twi) Zie (Dag)	*Panicum milliaceum L.*	Poaceae	Seed	Millet is soaked overnight, washed and sieved Spices like black pepper, cloves, chieves, ginger are added and milled Content is mould into balls and boiled. They are then pounded with pestel and mortar and moulded again. Flour is spread over the balls. They are then mashed. Milk, sugar is added to taste.	3
Tubaani	Cowpea or Black eye pea (En) Benga (Dag)	*Vigna unguiculata* (L.) Walp	Leguminosae	Pea	The beans are soaked in water overnight and dehulled. They are then dried and milled. Potassium bicarbonate (locally known as *kaun* is then added and scooped into leaves (usually plantain leaves) and cooked. Bambara beans could also sometimes be used in place of the cowpea.	3

4.4 Miscellaneous respondents' explanation

As mentioned by respondents during the survey, this section describes various other benefits (as energy, blood, vitamin and taste) obtained from eating FPFs. These are explained below:

Energy

In most of the indigenous communities visited, energy was the main benefit that was emphasized by the respondents. This was emphasized by about 98% of the respondents during interviews. It could be observed that the locals understand the significance of the carbohydrate contents of their food products. Abraham Zikewone, a 40 year old farmer in Tolibre, explained druing the interview that heavy weighted foods like *Tuozaafi* and *Banku* have always been the main source of his working energy on the farm.

Another participant, Lebtiyel Gilbert, a 30 year old farmer exclaimed that without his early morning *Pito*, farm work is always incomplete. "*Pito* is always my fuel for the day's activity".

Blood

More often than not, the respondents who mentioned energy as a health benefit often also mention "blood" as another benefit obtained from consuming some fermented products. They explained that food products like *Pito, tumpaani*, *Dawadawa*, *Tuozaafi* were good sources of blood for the body's sustainability.

Vitamins

Vitamin was also a benefit that was pointed out by respondents during the data collection period. Some respondents explained that *Pito* which was a good source of vitamins to their foods. Meanwhile, the probiotic effects of fermentation already explain that Vitamins are additional benefits that are obtained as a result of food fermentation.

Taste

The fermented foods give additional flavor and taste to food products. Food products like *Dawadawa* is a traditional product from the African locus bean fruit. The sweet fragrance/aroma of the *Dawadawa* after fermentation, which is produced as a result of the fermentation processes on the locust bean. The *Dawadawa* is mostly used as a spice for soups and stews.

5 DISCUSSION

Among all four studied communities, food insecurity was generally found to be high as already documented by several researches, with women and children been the highest victims (FAO, 2006; Nyanteng and Asuming – Brempong, 2003). The main causes are poverty, natural disasters, low yields, over dependence on subsistence and rain-fed agriculture, lack of market assess and high post-harvest losses (FAO, 2002; PTT, 2011).

Even though all four communities were different in proximity and locations, food patterns across all remained very similar especially with FPFs like *Tuozaafi*, *Pito*, *Banku*, *Kenkey*, *Koko*, *Koose* and *Dawadawa*. The foods were mostly staple and found everywhere as the plants from which they are obtained are generally hardy and able to withstand the excessive amounts of droughts. Other food crops cultivated by the people were Jute, Yams, Tomatoes and Pepper. As the individual method (face to face interview), the PRE was likewise used to document consumed FPFs and their preference according to focus groups. However, even though the group preference ranking showed some differences in terms of preferences as compared to the individual preferences obtained from face to face interviews, the PRE was able to identify each FPF and assess the reason for the group's choice according to taste, perception of nutritive value, socio-cultural value, perception of health beneficial value and monetary value based on their opinions as indicated in section 3.3.2. For example, in Tolibre, the preference ranking table recorded that *Banku* was the most consumed with *Dawadawa* been the least consumed, while on a more individualized basis (in the face to face interview), *Tuozaafi* was the most consumed while *Koko* and *Tubaani* were the least consumed.

Likewise in Paga Kaakum, during the preference ranking, *Koose* was the most consumed and *Banku* been the least consumed, while during the individual method, *Tuozaafi* was the most consumed and *Tubaani* been the least consumed.

On the other hand, in Paga Chiana, the trend for the most consumed FPFs remained similar with *Tuozaafi* and *Kenkey* being the most consumed in group preference ranking and *Tuozaafi* was again the most consumed in the individual method, with *Koko* been the least consumed during the PRE and *Kenkey* been the least during the individual method.

During the group PRE and the individual interview in Paga Zenga, *Tuozaafi* was the most consumed in both methods (group preference ranking and Individual method), but *Koko* was the least consumed according to the Preference ranking, while *Pito*, *Masa* and *Fuura* were the least consumed according to the individual method. During the Individual method in Paga Chiana, *Guliyan* and *Pito* were not mentioned as consumed during the individual method but were mentioned during the PRE. Similarly, *Kenkey* and *Fuura* were not mentioned as consumed during the group PRE in Paga Kaakum but were mentioned during the Individual method. This was due to the reason that during the PRE, the decisions of some members of the group were easily influenced by other members who had more influence or authority, either by power or age (for example, household heads and other elderly members of the group were easily able to influence decisions of the other household members or younger mebers in the group). This forms the weakness of the group PRE in comparison to individual method.

Generally, across all communities, most of the FPFs were mostly obtained from cereal sources with no other FPFs obtained from dairy, fish, fruit, vegetable or meat products. This agrees with the assertion made by (PoABTFF, 1992; Gaffa et al., 2002) that in most African foods, foods from cereals account for more than 60 percent of food materials used in the preparation of local fermented foods and are mostly eaten extensively as staple foods, for example maize, sorghum, millet, and rice.

During the survey, in all communities, the African locust bean (*Parkia biglobosa*) was the only wild plant that was used for fermentation purposes in their culinary cuisines. It has nicely scented aromatic seeds when dehulled and fermented (called"*Dawadawa*") producing great additions to local soups, sauces and stews. These soups, sauces or stews are usually eaten with a very wide variety of main meals in local cuisines (Kwaw, 2014). Its local preparation is illustrated in the Table 10.

The processing and storage of FPFs are done in unique traditional methods. Although the processing and storage procedure of the various FPFs were time demanding to prepare (usually days), their preparation were not very complicated. Most People living in these areas are not able to engage the use of sophisticated technological equipment in the processing and storage of their daily food products, and this could be largely due to issues of poverty, lack of adequate electricity to power them and technical know-how on their

usage. The mode of preparation was mostly manually by hand and semi-automated (usually with the use of grind mills) to help in cases where manual applications weren't very efficient. In accordance to Oyewole and Isah (2012) the hygienic conditions under which FPFS were been prepared in the communities were usually very bad. In addition, according to the interviewees, continuous heating of these FPFs was able to prolong their shelf lives thus increasing the storability. As such they can usually stay longer than the mentioned storability period in the Table 10.

The high average frequency of citation (consumption) that was obtained in every community as illustrated in Table 5 further explains the rate at which FPFs are been relied upon for sustainability, availability, assess and stability. According to the results of this research, Paga Kaakum had the lowest average frequency of citation in terms of FPFs as results showed that in every two days, FPFs were consumed at least once. Tolibre, Paga Chiana and Paga Zenga showed a higher increase in consumption of FPFs as the people of these communities consumed FPFs once every day.

As explained by Nyanteng and Asuming – Brempong (2003) as well as Oyewole and Isah (2012), even though production of these food crops provided income or revenues, they also help to ensure that household members were able to have available and stable food. For example, in Tolibre the 58 households that constitued 465 HH members were actively consuming FPFs. This illustrates the extent to which FPFs are helping to solve issues of food insecurity among the local households. This also applies to Paga Chiana, Paga Zenga and Paga Kaakum.

Although there has not been much research carried out to assess the effects of high HH members on food security, it was realised that the higher the number of HH members living together in a household, the higher the vulnerability to poverty and consequently food insecurity (Olayemi, 2012). Therefore, it is recommended that further studies should be carried out in the area of investigating the effects of HH members on food security in these localities.

6 CONCLUSION

In conclusion, twelve types of fermented plant foods were cosumed within Tolibre, Paga Chiana, Paga Zenga and Paga Kaakum communities, from which nine of them (i.e., *Tuozaafi, Banku, Furufuru, Kenkey, Koko, Fuura, Pito, Guliyan* and *Masa*) were from cereal sources while the other three FPFs (i.e., *Dawadawa, Koose, Tubaani*) were from leguminous sources. According to the individual method, the most consumed FPF was *Tuozaafi* and the least was *Masa* across all communities. Similarly to the individual method, in PRE *Tuozaafi* was also the most consumed FPF, while *Koko* was the least consumed across all communities. *Dawadawa* was the only wild plant that was used for fermentation purposes in the local cuisine of the interviewed communities. Finally, the storage and processing techniques that were applied for culinary purposes in the preparation of FPFs in Tolibre, Paga Chiana, Paga Zenga and Paga Kaakum were documented, which included various manual and semi-automated methods. From this research it can be concluded that fermentation enhances food security, improves nutritional quality, enhance socio-economic value, enhances antibiotic property properties, reduce hunger, enhance food detoxification and cheese coagulation. Meanwhile, developed or advanced techniques for the production (processing and storage) of locally FPFs should be encouraged as this will increase food quality, production and reduce food spoilage. In relation to available literature, concerned personnel and associations should put more efforts into providing available information in books and on internet about poor communities like Tolibre and Paga Chiana which had very limited available literature.

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APPENDICES

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Appendix 1. Community entry

Appendix 2. Individual method

Appendix 3. Focus Group interviews

Appendix 4. FPFs consumed in studied communities (Source: Author's Personal Observation, 2015)

Tuozaafi

Furufuru

Koko

Dawadawa

Koose

Pito

Fuura

Kenkey

Maasa

Tubaani

Banku

Appendix 5. Different Preparation techniques of selected FPFs and a community house in Paga Zenga (Source: Author's Personal Observation, 2015).

Preparation of Kenkey

Preparation of Maasa

Preparation of Tuozaafi / Banku

Preparation of Pito

Preparation of Koose

Community house in P. Zenga

Appendix 6: Informed Consent Handout

INFORMED CONSENT HANDOUT

Informed Consent Handout Kingsley Buaben Obeng

Question:

Are you a user of any fermented food product? (If yes, then continue.)

Question:

Would you be willing to let me read a statement about my research interests? (If yes, then read the following.)

Statement:

I am a research student from the Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences. I am also Ghanaian. I was born in Accra and came to Czech Republic alone in 2014 when I was twenty four years old. I grew up in Accra. At the Czech University of Life Sciences Prague I am studying Tropical Crop Management and Ecology in Prague. I am gathering this type of information through interviews with men and women from different generations.

Question:

Would you be willing to participate in this research and allow me to interview you about food? Data from the interviews will be processed anonymously (using only number codes). A summary of the research will be written in English; I will give you a copy. Would you be willing to allow me to publish the results of these studies? I will receive no money for the results of this work.

Statement:

If at any time during the course of my research, I ask you questions or ask you to do something that you do not feel is appropriate or makes you feel uncomfortable, please let

me know and we will not continue. I want to be respectful of your personal and cultural views.

Following completion of the survey

Question:

May I visit with you again to conduct the second part of the survey? (If yes, then arrange for a convenient time to return.)

Contact information:

If you have any questions about this research or need to contact me, please reach me at 00233-247933510 or +420776391604. If you cannot obtain satisfactory answers to your questions or have comments or complaints about your treatment in this study, contact: doc. Ing. Zbyněk Polesný, Ph.D., Department of Crop Sciences and Agroforestry, Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Phone: +420 224382167.

Appendix 7. Research Questionnaire

Research Questionnaire

Data about the informant: Date:

Name:
Gender:
Age/age range:
Occupation/livelihood:
Region:
Community:
Ethnicity:
Number of household members:

Questions:

1. What food do you normally eat? What did you eat yesterday?

2. List the plants which you use in your daily cuisine

2.1. Which of these plants you cultivate?

2.2 Do you collect some of these plants in the wild?

3. List the plants which you eat occasionally (once per month or less frequently)

4. Can you explain how you use each particular plant? (*Ask informants according to the appropriate table below*)

5. Generally, how often do you eat fermented plant foods?

6. Who eats fermented plant foods in your household? A) Whole family, B) mostly men, C) mostly women, D) mostly parents, E) mostly children, F) mostly elderly members

Table 1. Cultivated plants used for food purposes

Local name and part of the plant [1]	**Is the plant available all year round?** *Note for researcher:* If not then ask informant to specify the season)	**What do you do with the plant after you harvest it?** [2]	**Why do you process the plant?** [3] *Note for researcher:* ask this question only if the informant answers for the previous question that he process the plant.	**Which type of processing do you use?** [4]	**Can you describe in detail how do you process the particular plant step by step?** [5] *Note for researcher:* Use this question mainly for plants processed at least partially through some type of fermentation. In case of enough time or if the practice seems to be interesting you can also document other types of traditional processing aside of fermentation.	**How long time you can usually store particular fermented plant product with no signs of spoilage?** *Note for researcher:* Ask this question only in case of plants being processed through fermentation	**Is the plant product produced through fermentation good for health?** *Note for researcher:* If the answer is "Yes" always ask why?

Table 2. Wild plants used for food purposes

Local name and part of the plant [1]	**Is the plant available all year round?** *Note for researcher:* If not then ask informant to specify the season)	**What do you do with the plant after you harvest it?** [2]	**Why do you process the plant?** [3] *Note for researcher:* ask this question only if the informant answers for the previous question that he process the plant.	**Which type of processing do you use?** [4]	**Can you describe in detail how do you process the particular plant step by step?** [5] *Note for researcher:* Use this question mainly for plants processed at least partially through some type of fermentation. In case of enough time or if the practice seems to be interesting you can also document other types of traditional processing aside of fermentation.	**How long time you can usually store particular fermented plant product with no signs of spoilage?** *Note for researcher:* Ask this question only in case of plants being processed through fermentation	**Is the plant product produced through fermentation good for health?** *Note for researcher:* If the answer is "Yes" always ask why?

Notes on tables:

1 After filling the questionnaire ask each informant to show you all the plants mentioned "on site" and make the pictures of plants. In case of wild plants also collect plant samples for herbarium reference collection. Do not forget to code the pictures and plant samples and associate it with corresponding plants documented in the questionnaire.

[2] Informant will probably respond something like: e.g. we eat it fresh/raw; we store it directly without any post-harvest processing and we use it for meal preparation when needed; it needs further processing prior to use for meal preparation. We can also expect that informant will mention some post-harvest handling like drying of the seeds and possibly their cleaning from the impurities, etc.

3 The reasons could be for example: e.g. the plant/plant part is not edible in the fresh form – then ask why?; the processing increase subsequent storability of the plant product (the product can be stored for a longer time); the processing gives a special properties to the product, e.g. special taste or health-beneficial properties.

4 Here we can expect that people will mention several types of processing practices they use for different plants (if some of them are processed using fermentation it should be mentioned here)

[5] Optimally, this question should be complemented with direct observation of people during the task - to see how they practically process the plant.

Appendix 8. Preference ranking exercise Questionnaire

Contribution of fermented foods to food security
Preference Ranking Exercises

Community:
Score 5 = most tasteful; Score 1 = least tasteful

Multidimensional preference ranking (direct matrix ranking)

Product(s)	Taste	Perception on nutritive value	Socio-cultural value	Perception on health-beneficial value	Monetary Value	Other value(s)	**TOTAL**	**Ranking**

NB: This exercise can be performed individually or in group – in the latter case, a consensus (if necessary through vote) is reached within the group.