

**Indigenous alcoholic beverage production
in rural villages of Tanzania and Cameroon**

Ryosuke Kubo

Acknowledgments

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Chapter 1: Introduction

1-1. Alcoholic beverage and brewing culture

1-1-1. Definition of alcoholic beverage

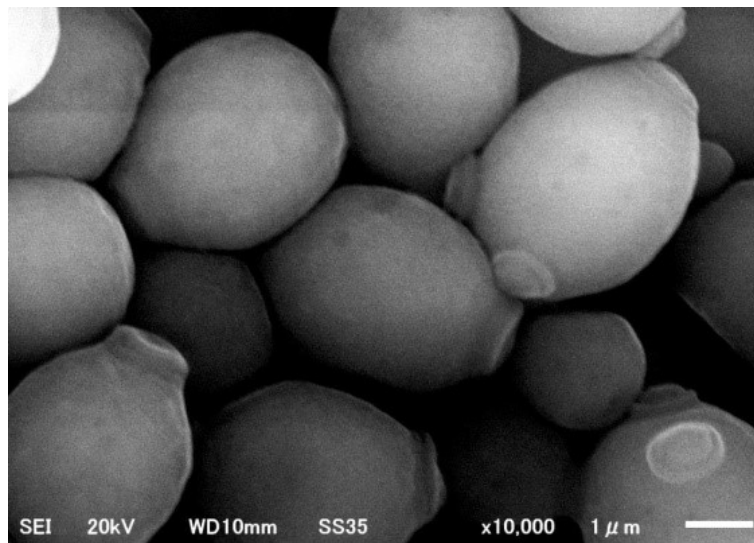
Alcoholic beverage is a drink containing alcohol and having intoxicating effect. In the Liquor tax law of Japan, alcoholic beverage is defined as “a drink containing more than 1% of alcohol” (Yoshizawa, 1995). Ethanol (C_2H_5OH) is the most important ingredient of alcoholic beverage. It is produced from fermentable saccharides in alcoholic fermentation performed by yeast. After drinking alcoholic beverage, ethanol in alcoholic beverage is absorbed in a stomach first (20% of total amount), and the rest is absorbed in small intestine. Absorbed ethanol is spread into each part of human body with blood streams, and finally, reaches to a brain and suppresses its function. A decline of brain function is the basis of drunkenness. Drunkenness brings refreshing feeling and reduction of language and physical functions (Yoshizawa, 1995).

A part of ethanol which was absorbed in the body is excreted by respiration. However, most of absorbed ethanol is metabolized in the liver. An enzyme in the liver named alcohol dehydrogenase oxidizes ethanol into acetaldehyde (CH_3CHO), and it is oxidized by another enzyme (aldehyde dehydrogenase) into acetic acid (CH_3COOH). Acetaldehyde has strong toxic effect, and causes headache, palpitations and blushing after drinking alcohol (Yoshizawa, 1995).

1-1-2. Classification of alcoholic beverage

Alcoholic beverages are classified into three types by their producing methods, fermented, distilled and mixed alcoholic beverages. Furthermore, fermented alcoholic

beverage can be divided again into two classifications, sugar-based and starch-based alcoholic beverages. Ethanol is produced by alcoholic fermentation, which yeast (mostly *Saccharomyces cerevisiae*) engages in, from fermentable saccharides such as glucose, fructose, maltose and sucrose (Picture 1.1).



Picture 1.1 *Saccharomyces cerevisiae*

As juice of fruits such as grape (*Vitis vinifera*), sap of palm tree and sugar cane (*Saccharum officinarum*) and diluted liquid of honey contain fermentable saccharides, they can be fermented directly by yeast and become alcoholic beverage. The alcoholic beverage thus produced is called as “sugar-based alcoholic beverage”, or is also referred as “wine” (Fig. 1.1).

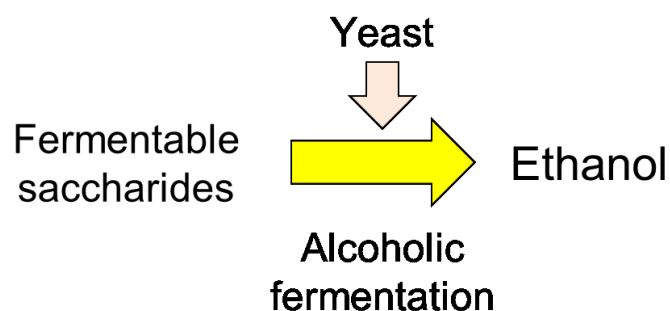


Fig. 1.1 Mechanism for producing sugar-based alcoholic beverage

On the other hand, cereals such as barley (*Hordeum vulgare*) and rice (*Oryza sativa*), which are materials of beer and Japanese *sake*, respectively, are mainly composed of starch, and it cannot be used directly as a substrate for alcoholic fermentation by yeast. Therefore, in beer and *sake* production, the starch in barley and rice should be firstly degraded into fermentable saccharides such as glucose and maltose by the effect of starch degrading enzyme, amylase.

Starch degradation is named saccharification, and saccharification needs a source of amylase. For brewing alcoholic beverage from starchy material, malt, fungus and saliva are used as amylase sources. Beer is a typical alcoholic beverage produced with malt as an amylase source for saccharification. Fungi such as *Aspergillus*, *Rhizopus* and *Mucor* are used as amylase sources in alcoholic beverage production in Asia. An alcoholic beverage using fungus is represented by Japanese *sake*. *Chicha* is a representative alcoholic beverage produced with saliva as an amylase source. It was produced in the ancient Inca Empire, and still barely exists in South America (Yamamoto, 2008). This kind of alcoholic beverage was also produced in Okinawa prefecture in southern part of Japan (Ankei, 2008). Alcoholic beverages made from starchy materials through saccharification using amylase are called as “starch-based alcoholic beverage” (Fig. 1.2). These kinds of alcoholic beverage are also referred as

“beer”.

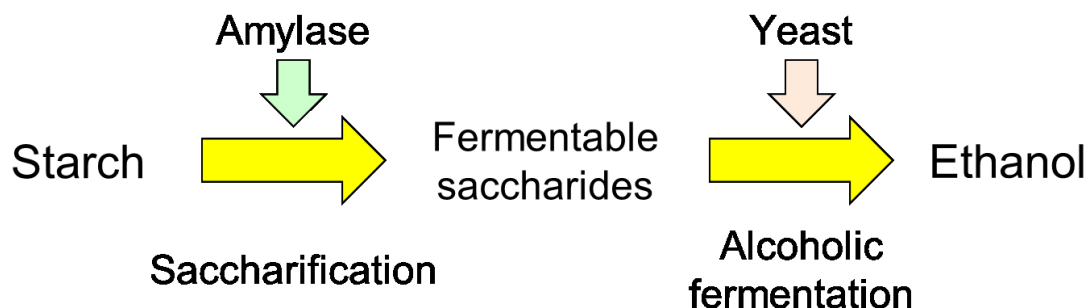


Fig. 1.2 Mechanism for producing starch-based alcoholic beverage

Distilled alcoholic beverage can be obtained by distillation of fermented alcoholic beverages, which are described above, and fermented mashes containing ethanol. Representative distilled alcoholic beverages are whisky, brandy, vodka and Japanese *shochu*. Among them, whisky and brandy are matured for several years in casks.

Finally, mixed alcoholic beverage is prepared by adding saccharides, fruits juice, flavors and colorants into alcoholic beverages.

1-1-3. History of alcoholic beverage

The origin of alcoholic beverage dates back to pre-historical period (Damerow, 2012). The oldest archaeological findings of alcoholic beverage were excavated in the early Neolithic village of Jiahu in Henan province of China. The findings were shards of pottery jars, and it was suggested that the brewing with rice, honey and fruits, hawthorn fruit (*Crataegus pinnatifida* or *Crataegus cuneata*) and/or grape, was carried out as early as the seventh millennium before Christ (BC) (McGovern *et al.*, 2004). At Godin Tepe, a site nearby Zagros Mountains of Iran, which was under strong Mesopotamian

influence, pottery vessels which were evidently used for fermentation or storage of alcoholic beverage was found out, and the findings date back to the late fourth millennium BC (Michel *et al.*, 1992; 1993).

The brewing of the Sumerian society in ancient Mesopotamia is described in cuneiform texts of the third millennium BC. It is documented that beer was no longer simply an agricultural product of the rural settlements in the period but was rather belonged to the products subjected to the centralized economy of Sumerian society (Damerow, 2012). The *Hymn to Ninkasi* is a Sumerian poem and one of the oldest recipes for brewing beer written in 1,800 BC. The poem suggests that, in the Sumerian brewing, two different kinds of bread (*bappir* and *titab*) were prepared first with un-malted and malted grain, respectively, and then were mixed each other to prepare sweet wort (*dida*). After that, *dida* was fermented, followed by filtration to obtain beer (Ellison, 1978; Damerow, 2012).

In that period, barley and emmer wheat were used as raw materials for brewing beer (Ellison, 1978). Kavanagh concluded that the brewing had encouraged human to develop plant domestication and cultivation, especially of the cereals such as barley and emmer wheat (*Triticum dicoccum*) (Kavanagh, 1994). Katz and Voigt also insisted that the brewing had contributed to change the human livelihood from hunting-and-gathering to agriculture (Katz and Voigt, 1986). Many scholars insist that the brewing had taken significantly important role in the dawn of the cereal cultivation in the Western Asia.

On the other hand, in the Eastern and Southern Asia, Yoshida discussed that an alcoholic beverage made of germinated rice had begun to be produced in 3,000-2,000 BC in the regions along the Ganges, and the invention of the alcoholic beverage using fungi as an amylase source occurred around Assam region in northeast India (Yoshida,

1993). In China, an alcoholic beverage with barley malt was produced in 4,000 BC, and this type of alcoholic beverage is replaced by that with fungus in later period (Yoshida, 1993).

In the beginning period of brewing, alcoholic beverages were consumed as a source of nutrition, drinking water, reward for labor work and symbolic item for ritual and royal ceremonies (Neumann, 1994; Delwen, 1996; 1997). However, the roles of alcoholic beverages in the society have been recently changed to some extent. The roles of alcoholic beverage in the present society are considered to be 1) served on ceremonial occasions, 2) communication tool, 3) easing stress, 4) accompanying with dinner and 5) source of tax (Yoshizawa, 1995). In all cases, alcoholic beverage has taken important role in human society.

1-2. Alcoholic beverages in sub-Saharan Africa

1-2-1. Outline of sub-Saharan Africa

From cultural viewpoint, African continent is divided into two parts, North Africa and sub-Saharan Africa, by the Sahara Desert as a border. Sub-Saharan Africa is defined as an area where lies south of the Sahara Desert. In contrast to the fact that North Africa is regarded as the culture using stone, the culture of sub-Saharan Africa is composed of soil, tree and grass (Kawada, 2010). As the material culture of sub-Saharan Africa is composed of stuffs decaying with time such as soil, tree and grass, its culture has been handed down orally, whereas the history of North Africa has been described on stone or paper (Kawada, 2010).

The vegetation in sub-Saharan Africa is divided into six types, Equatorial Forest, Subtropical Woodland, Tree-and-shrub Savanna, Desert, Grassland and Montane

(Okitsu, 2005). Equatorial Forest is located in the wet region surrounding equator. Tree-and-shrub Savanna spreads on the north of Equatorial Forest. On the south of Equatorial Forest, Subtropical Woodland is located until latitude 20°S. From the south edge of Subtropical Woodland, Tree-and-shrub Savanna spreads until the southern end of African continent. Other vegetation is scattered throughout sub-Saharan Africa.

In sub-Saharan Africa, means for acquiring foodstuffs are classified into four types, agriculture, stock rising, hunting-and-gathering and fishing. Agricultural people are most dominant and widely distributed throughout sub-Saharan Africa. Fundamentally, the people in Subtropical Woodland and Tree-and-shrub Savanna engage in the cultivation of cereals, and that in Equatorial Forest depends on the cultivation of vegetative crops. Hunting-and-gathering is represented by Pygmy people in the tropical forest of central Africa and bushman in the arid area of southern Africa. Cattle rising, the most important activity in stock rising, reached into sub-Saharan Africa from the Asian Continent via Egypt (Kawada, 2010).

1-2-2. Agriculture and the food culture in sub-Saharan Africa

A total of 58% of people inhabit in African continent engage in agriculture (Kawada, 2010). In addition, agriculture is one of the most important export and internal industries for African countries (Kawada, 2010). Therefore, agriculture is one of the most important activities in sub-Saharan Africa.

Major staple crops cultivated in agricultural societies of sub-Saharan Africa are cereals, such as maize (*Zea mays*), sorghum (*Sorghum vulgare*), pearl millet (*Pennisetum glaucum*), rice and finger millet (*Eleusine coracana*), and vegetative crops, such as cassava (*Manihot utilissima*), yams (*Dioscorea* spp.) and bananas (*Musa* spp.) (Kiple and Ornelas, 2014). Among these crops, sorghum, pearl millet, finger millet,

African rice (*Oryza glaberrima*) and white Guinea yam (*Dioscorea rotundata*) were domesticated in sub-Saharan Africa (Nakao, 1966; Hoshikawa, 1987; Kiple and Ornelas, 2014). The other crops were historically introduced from the other continents. In the present, from the viewpoint of staple crop, the diets in sub-Saharan Africa are largely divided into four types, “millets in the Sahara region”, “vegetative crops in central region”, “maize in southeastern region” and “rice in western region” (Ankei, 2014). In addition to the staple crops, cowpea (*Vigna sinensis*), gourd (*Lagenaria leucantha*), sesame (*Sesamum indicum*), okra (*Hibiscus esculentus*) and others were also domesticated in sub-Saharan Africa and consist of the important portion of diet (Nakao, 1966; Hoshikawa, 1987).

Usually, the daily diet of sub-Saharan Africa is composed of one staple food and one side dish (Ogawa, 2004). Staple food is cooked with starchy material such as cereal and vegetative crop, and is served with a side dish which is normally a stew cooked with vegetable, meat, fish and so on (Picture 1.2). The combination of staple food and side dish is the base of the diet in sub-Saharan Africa.



Picture 1.2 A daily meal of agriculturalists in sub-Saharan Africa: the combination of one staple food and one side dish

As described above, staple crops in sub-Saharan Africa are basically divided into cereals and vegetative crops, which are mainly cultivated and used in the arid and the humid regions, respectively. Although different kinds of staple crops are cultivated under different climates, these two kinds of staple crops are cooked in similar ways throughout agricultural societies of sub-Saharan Africa including both arid and humid regions (Kasori, 1981). In agricultural societies of sub-Saharan Africa, cereals and vegetative crops are generally cooked into stiff porridge. Stiff porridge is the most basic and popular form of staple food in sub-Saharan Africa, which is cooked by stirring flour of cereal or vegetative crop with boiled water (see Picture 2.1 and 2.2 in Chapter 2). In case of vegetative crop, another type of stiff porridge is also cooked by pounding boiled vegetative crop using mortar and pounder.

At the mealtime of sub-Saharan Africa, those staple foods are eaten through swallowing rather than chewing, because the cooking processes such as milling and

pounding make the tissue of cereal and vegetative crop being easily digested without masticating (Ogawa, 2004). To enable stiff porridge to be swallowed without chewing, many kinds of sticky source are cooked with okra, leaf of baobab (*Adansonia digitata*) and other wild vegetables as side dish throughout agricultural societies of sub-Saharan Africa. Furthermore, in Ethiopia, there are ethnic tribes who drink alcoholic beverage as a staple food (Ogawa, 2004; Sunano, 2013). It is suggested that the use of alcoholic beverage is linked with the food culture of swallowing in sub-Saharan Africa.

1-2-3. Role of indigenous alcoholic beverage in sub-Saharan Africa

Alcoholic beverage, in particular indigenous alcoholic beverage, takes important role in agricultural societies of sub-Saharan Africa. In relation to the term of “indigenous”, Itani defined the indigenous agriculture as “agriculture which has been practiced for long period in the region, and adapted to its climate and culture” (Itani, 2002). The materials used for the indigenous alcoholic beverage production are principally determined by the climate of the region. The brewing techniques for producing the indigenous alcoholic beverages are influenced by the cultural taste of the region. Therefore, from these points of view, the indigenous alcoholic beverage is defined as “an alcoholic beverage which has been produced for long period in the region, and adapted to its climate and culture”.

Agriculturalists in sub-Saharan Africa are divided into hundreds and thousands of ethnic groups, and therefore, a great variety of indigenous alcoholic beverages are produced and consumed (Platt, 1955). The indigenous alcoholic beverages in sub-Saharan Africa are categorized into three types, sugar-based, starch-based and distilled alcoholic beverage (Yoneya and Miyamoto, 1999). Those alcoholic beverages are utilized as a refreshment and communication tool as in other regions of the world

(Yoshizawa, 1995). In addition, as described above, the indigenous alcoholic beverage is often taken as a source of nutrition (Madovi, 1981; Yoneua and Miyamoto, 1999; Sunano, 2013). Its use prevents diseases such as beriberi, which is developed by nutritious shortage of vitamin B1, because vitamin B1 is synthesized during fermentation process of alcoholic beverage (Yoneya and Miyamoto, 1999). A study about Dirashe people in Ethiopia, who consume alcoholic beverage as their staple food, revealed that larger amount of calorie could be ingested if cereal materials, sorghum and maize in this case, are cooked into liquid alcoholic beverage (Sunano, 2013). During the labor on field, the indigenous alcoholic beverage is used as an energy source, because it contains easily digestible saccharides and vitamins (Faparusi, 1970; Takamura, 2014). In addition to as the source of nutrition, the indigenous alcoholic beverage is important as drinking water (Platt, 1955; Abegaz *et al.*, 2002a), because the growth of harmful microorganisms which cause food poisoning is suppressed in the course of fermentation (Lyumugabe *et al.*, 2010).

In addition to nutritional importance, the indigenous alcoholic beverage also has social importance. Like as societies in other areas of the world, the indigenous alcoholic beverages in sub-Saharan Africa are used as a symbolic item in religious and royal ceremonies (Madovi, 1981; Benhura, 1989; Wazaki, 1990; Willis, 2002). Another way for using the indigenous alcoholic beverage in sub-Saharan Africa is to offer it as an inducement and a reward for cooperative work such as opening field, weeding, building house and so on (Platt, 1955; Madovi, 1981; Kakeya and Sugiyama, 1985; Benhura, 1989). In Bemba society of northeastern Zambia, people ask the help from other villagers for holding cooperative work by offering an alcoholic beverage made with finger millet (Kakeya and Sugiyama, 1985). In addition, producing the indigenous alcoholic beverage is an important activity to earn cash income for women (Kakeya and

Sugiyama, 1985; Tanaka, 2012). For example, the brewing is the most important source of cash income for women in Botswana, and it is also stated as the main income source for women in Tanzania (McCall, 2001). In sub-Saharan Africa, the brewing is basically regarded as female labor, while most of other activities for earning cash income are classified as male labor (Jiggins, 1989; Wazaki, 1990; Sugiyama, 2007). Therefore, the brewing is one of the precious opportunities for women to access cash income, especially for singles and widows who do not have the labor force of adult male in the members of the family.

1-3. Study objectives

As described above, the indigenous alcoholic beverage production is an important activity in agricultural societies of sub-Saharan Africa. In Logone Plain of northern Cameroon, it was estimated that one-third of the total production of sorghum is directly eaten, another one-third is consumed as alcoholic beverage and the rest is destroyed by wild animals or bush fire (Platt, 1955). Furthermore, the indigenous alcoholic beverages account for about half of total alcohol consumption (including commercial beverage) in sub-Saharan Africa (Fig. 1.3). These data show how important the indigenous alcoholic beverage is in sub-Saharan Africa.

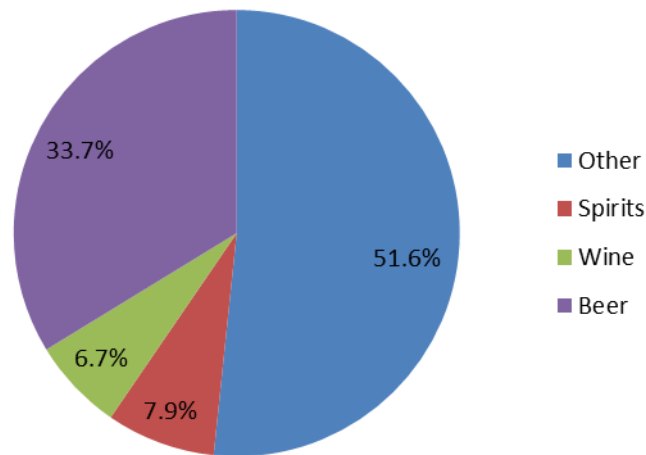


Fig. 1.3 The ratio of alcoholic beverage consumption in sub-Saharan Africa (most of “other” is derived from the consumption of the indigenous alcoholic beverage) (based on WHO, 2014)

Since the indigenous alcoholic beverage production is the important activity in the agricultural society of sub-Saharan Africa, the knowledge about it is necessary to understand the culture of sub-Saharan Africa. A number of researchers have studied about the indigenous alcoholic beverage production of sub-Saharan Africa, and several studies described the detailed methods of the production (Muller, 1970; Ankei, 1986; Mwesigye and Okurut, 1995; Yoneya and Miyamoto, 1999; Tiisekwa, 2000; Bvochora and Zvauya, 2001; Sunano, 2013).

It is supposed that different indigenous alcoholic beverage productions are practiced under different regions, because different climates of the regions affect the available raw materials for the indigenous alcoholic beverage production. In addition, the difference of the raw materials causes the difference of the brewing techniques, because different brewing techniques which are suited to different characteristics of the

raw materials must have been established in the course of the development of the indigenous alcoholic beverage production. However, most of past studies were carried out in only one study area, or focused on only one kind of indigenous alcoholic beverage. Therefore, the difference of the indigenous alcoholic beverage productions among different regions, which have different climate, vegetation and culture, has not been clarified.

In sub Saharan-Africa, climate, vegetation and culture are diverse. That is, the indigenous alcoholic beverage production, which is greatly affected by the climate, vegetation and culture in the region, is also diverse. Therefore, for further understanding about the indigenous alcoholic beverage production in sub-Saharan Africa, the comparative study must be carried out in more than two regions which have different climate, vegetation and culture. In this study, the indigenous alcoholic beverage productions in two different regions of sub-Saharan Africa were clarified. In addition, the effectiveness of the brewing techniques practiced in the regions was evaluated and compared from food scientific viewpoint. The objectives of this study are: 1) to clarify the details of the indigenous alcoholic beverage productions in different regions of sub-Saharan Africa, 2) to evaluate the effectiveness of the brewing techniques in the regions and 3) to compare their features.

Chapter 2: Study areas and methods

2-1. Reasons for selecting the villages in Tanzania and Cameroon as study areas

Field study for investigating the indigenous alcoholic beverage production in sub-Saharan Africa was carried out at two villages located in Tanzania and Cameroon (Fig. 2.1). Reasons for selecting the villages as study areas for investigating the indigenous alcoholic beverage production are as follows.



Fig. 2.1 Study areas: Bupigu village in Tanzania and Andom village in Cameroon

Tanzania is one of the prosperous African countries in the alcohol consumption (11th country in 46 African countries), and the country where the largest variety of indigenous alcoholic beverages exist according to the report issued by WHO (WHO,

2014). In addition, 87% of total alcohol consumption in Tanzania is dominated by the consumption of the indigenous alcoholic beverage (Fig. 2.2) (WHO, 2014). From these reasons, it is supposed that Tanzania is one of the most prosperous African countries in the indigenous alcoholic beverage production. Furthermore, the Eastern Africa, where Tanzania is located, is the origin of finger millet, which is one of the most popular materials for the indigenous alcoholic beverage production in sub-Saharan Africa (Hilu and de Wet, 1976; Hoshikawa, 1987). Therefore, Tanzania is expected to have long history in the indigenous alcoholic beverage production.

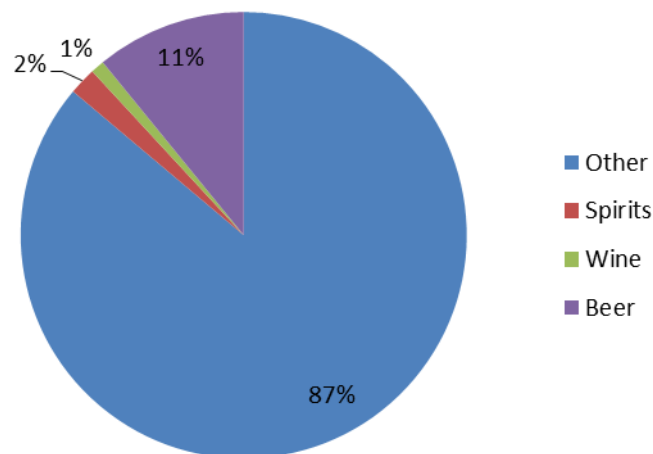


Fig. 2.2 The ratio of alcoholic beverage consumption in Tanzania (most of “other” is derived from the consumption of indigenous alcoholic beverage) (based on WHO, 2014)

In addition, most of brewing cultures in the world are accompanied with cereal cultivation (Yoshida, 1993). The fact that many of archaeological evidences about alcoholic beverage production have been found in the Western Asia, where one of the

oldest cereal cultivation is established, suggests a strong relationship between the brewing culture and cereal cultivation (Michel *et al.*, 1992; 1993). Following this trend, most parts of Tanzania are located in the region with cereal cultivation in sub-Saharan Africa (Ankei, 2014). By these reasons, I selected a village in Tanzania named Bupigu as a representative of the indigenous alcoholic beverage production in sub-Saharan Africa.

On the other hand, vegetative crops such as banana, cassava and yam are cultivated as important staple crops in certain regions of sub-Saharan Africa (Ankei, 2014), and are often utilized for the production of indigenous alcoholic beverages. Such vegetative crops are mainly cultivated in the tropical rain forest in/around Congo basin (Nakao, 1966; de Wet and Huckbay, 1967; Ambe and Foaguegue, 1993; Ankei, 2014).

The southern part of Cameroon is classified as the region with cassava-corn-plantain utilization or so-called “Yam-belt”, which is prosperous in the cultivation of vegetative crop (Nakao, 1966; Ambe and Foaguegue, 1993). Therefore, in the region, the existence of the habit to produce indigenous alcoholic beverages made of vegetative crops is expected. For these reasons, I decided to carry out field study in a village in Cameroon named Andom as a representative of the indigenous alcoholic beverage production in the region with vegetative crop utilization.

2-2. The study area (1): Bupigu village in Tanzania

2-2-1. General features of Tanzania

Tanzania is located in the eastern part of Africa. In the country, 47,783,000 people inhabit in 947,303 km² of the total surface area (United Nations, 2014b). The country is divided into 26 administrative regions (Arusha, Dar es Salaam, Dodoma,

Iringa, Kagera, Kigoma, Kilimanjaro, Lindi, Manyara, Mara, Mbeya, Morogoro, Mtwara, Mwanza, Pemba North, Pemba South, Pwani, Rukwa, Ruvuma, Shinyanga, Singida, Tabora, Tanga, Zanzibar Central/South, Zanzibar North and Zanzibar Urban/West), and the capital city is named Dodoma. Tanzanian people consist of more than 120 ethnic groups, and each ethnic group speaks their own local language even though Swahili and English are established as official languages of the country. Christianity, Islam and other traditional religions are largely believed.

The land is composed of plains in coastal area, plateaus and mountains in inland area (Yoneyama and Itani, 1983). Climatic conditions are grouped into four main parts, the hot humid coastal plain, the semi-arid zone of the central plateau, the high-moist lake regions, and the temperate highland areas. In the highlands, temperatures range between 10-20°C, and the rest of the country has temperatures higher than 20°C throughout the year. Temperatures of the hottest period from November to February range 25-31°C, whereas that of the coldest period from May to August is 15-20°C (MFAIC Tanzania, 2014). The vegetation is mainly divided into three types, Tree-and-shrub savanna in eastern and central areas, Subtropical woodland in southwestern area, and Equatorial forest in northwestern area (Okitsu, 2005).

Tanzania was established in 1964 by uniting Tanganyika and Zanzibar. Since an old time, Arabian and Persian had engaged in trade along the coastline of Tanganyika. Tanganyika had been under the rule of Germany from 1885 and of United Kingdom after World War I, and was independent in 1961. Zanzibar was a territory of United Kingdom from the end of nineteenth century, and was independent in 1963 (Yoneyama and Itani, 1983).

2-2-2. General features of Bupigu village

Bupigu village belongs to Ileje district of Mbeya region. In the village, 1,153 people inhabit in 305 households. The major ethnic group in the village is *Walambia*, and the villagers speak the local language of the region named *Kindali* in addition to Swahili. Annual mean temperature and annual participation in Ileje district are 20.9°C and 1,401 mm, respectively (Climate-Data.org, 2014). The vegetation of Bupigu village and the surroundings is classified as Subtropical woodland (Okitsu, 2005).

Bupigu village is located along the boundary between Tanzania and Malawi. Therefore, the major ethnic group of the village (*Wlambya*) has cultural commonality with residents of the adjacent areas of Chitipa and Karonga in northern part of Malawi (Maegga *et al.*, 2006). Most of villagers engage in agriculture, in which various crops such as maize, finger millet, cassava, sweet potato (*Ipomoea batatas*), banana, kidney bean (*Phaseolus vulgaris*), and groundnut (*Arachis hypogaea*) are produced. Ileje district, which Bupigu village belongs to, is one of the centers for finger millet production in Tanzania (NBS Tanzania, 2003). Therefore, several villagers engage in finger millet cultivation.

2-2-3. Dietary habits in Bupigu village

Simplified dietary survey using 24 h recall method was carried out to obtain the basic information about the dietary habit of residents in Bupigu village. In the dietary survey, names of foods in every meal (breakfast, lunch, dinner and snack) which were consumed during the previous day of the interview were recorded. The number of interviewees was 40 (aged 12 - 62 years).

The result of dietary survey is shown in Fig. 2.3. The staple food most frequently consumed was stiff porridge (named *ugali* in Swahili) using maize (Picture 2.1). Stiff porridge like *ugali* is one of the most typical and widely consumed staple

foods in sub-Saharan Africa (Kasori, 1981). *Ugali* is prepared by stirring maize flour with boiled water on the fire (Picture 2.2). Traditionally, in Bupigu village, *ugali* had been cooked from finger millet (Picture 2.3). However, in the present, *ugali* from maize becomes more popular than that from finger millet, and *ugali* from finger millet is only taken in mountainous area in the village. According to the villagers, *ugali* made from finger millet has disappeared due to its unfavorable taste without simultaneous supply of beans, meat or milk and to potential cause of constipation, both of which suggest the effect of tannin a chemical compound contained in finger millet (Ramachandra et al., 1977; Narasinga Rao and Prabhavathi, 1982; Udayasekhara Rao, 1994). Since tannin combines with protein, it often causes astringent taste and indigestion by denaturing proteins composing tongue, intestine and digestive enzymes (Mangan, 1988; Osawa, 1990; Hladik and Simmen, 1996; Dykes and Rooney, 2007). Therefore, it would be reasonable to serve *ugali* from finger millet together with the side dishes such as beans, meat or milk in order to reduce astringent taste caused by tannin, because tannin could competitively be bound with proteins in these side dishes.

Kidney bean and green leaf relishes were the most popular side dishes in the diet of Bupigu village (Picture 2.4; 2.5). Kidney bean might be a main protein source in the diet of the village, because other protein sources such as meats, fish and milk were rarely accessible for ordinary villagers. Although a certain amount of protein is contained in maize, protein contained in cereals is lacking in lysine, one of the essential amino acids, which cannot be synthesized in human body (Bach Knudsen *et al.*, 1988). Therefore, it has to be taken from daily foods. Generally, beans such as kidney bean contain well-balanced essential amino acids, and the lack of lysine in cereal is compensated by lysine contained in beans (Blandino *et al.*, 2003; Sunano, 2013). The combination of cereals and beans, as a staple food and side dishes, respectively, could

be regarded as the typical and essential diet in the societies with cereal utilization of sub-Saharan Africa (Nakao, 1966), even though both maize and kidney bean are originated in the American continent.

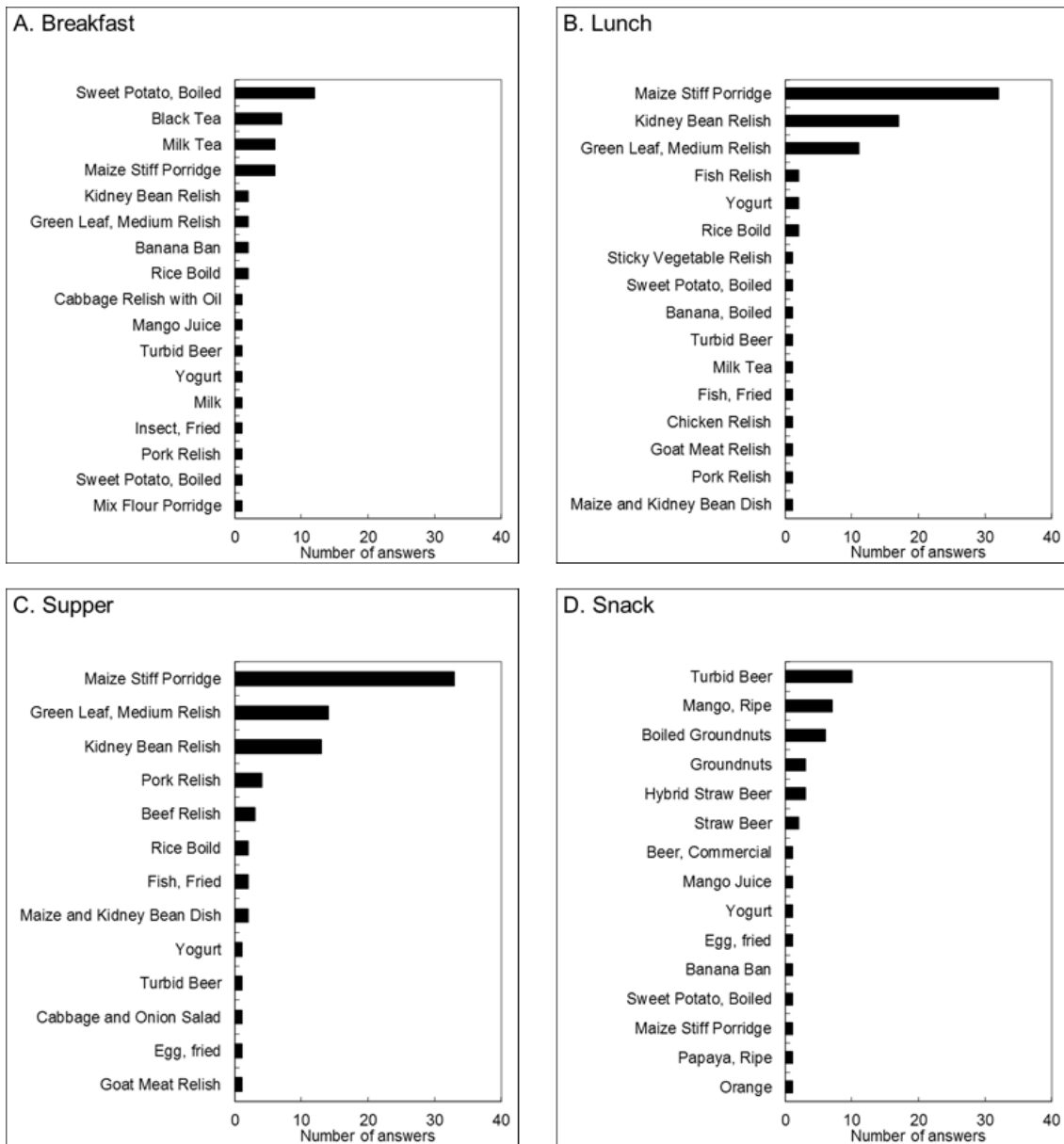


Fig. 2.3 The results of dietary survey using 24 h recall method in Bupigu village (A: breakfast, B: lunch, C: supper, D: snack)



Picture 2.1 *Ugali* using maize



Picture 2.2 Stirring *ugali* using finger millet



Picture 2.3 *Ugali* using finger millet



Picture 2.4 Kidney bean relish (*maharage* in Swahili)



Picture 2.5 Green leaf relish (*mboga za majani* in Swahili)

2-3. The study area (2): Andom village in Cameroon

2-3-1. General features of Cameroon

Cameroon is located in the central part of Africa. In the country, 21,700,000 people inhabit in 475,650 km² of the total surface area (United Nations, 2014a). The country is divided into 10 administrative regions (Adamawa, Centre, East, Far North, Littoral, North, Northwest, South, Southwest and West), and the capital city is named Yaoundé. Cameroonian people belong to more than 200 ethnic groups, and each ethnic group speaks their own local languages even though French and English are established as official languages of the country. Christianity, Islam and other traditional religions are largely believed.

The land is divided into the northern and southern parts by the mountainous area in the central part (Yoneyama and Itani, 1983). Annual mean temperature in the southern part is 26°C, and annual rainfall is 1,000-2,500 mm. On the other hand, the northern part has a climate characterized by dry and high- temperature throughout a year except for the rainy season from May to October (Yoneyama and Itani, 1983; Ambe and Foaguegue, 1993). Tree-and-shrub savanna vegetation is dominant in the northern part, whereas Equatorial forest dominates in the southern part (Okitsu, 2005).

Cameroon had been a territory of Germany from 1884, and after World War I, eastern and western parts of Cameroon became under the rule of France and United Kingdom respectively. Eastern and western part was separately independent from their suzerain countries in 1960 and 1961, respectively. After the independence, both parts were united to form a federal republic in 1961. In 1972, the federal system was abolished, and Cameroon became a unified nation (Yoneyama and Itani, 1983).

2-3-2. General features of Andom village

Andom village belongs to Lom-et-Djerem district of East region. In the village, more than 2,000 people inhabit in 192 households (Asano, 2012). The major ethnic group in the village is *Bambele*, and the villagers speak the local language of the region named *Bambele* in addition to French. Annual mean temperature and annual participation are 23.1°C and 1,458 mm, respectively (Shibata *et al.*, 2012). The vegetation of the region is classified as Forest-and-savanna mosaic (Okitsu, 2005).

Andom village is located in the southern plateau of Cameroon. The region surrounding the village is climatologically classified as Derived savanna which was originally forest (Ambe and Foaguegue, 1993). Therefore, the landscape of the village consists of both forest and savanna vegetation. The livelihood of villagers depends on both agriculture and hunting (Tanaka, 2012). Crops such as cassava, maize, sweet potato, macabo (*Xanthosoma sagittifolium*), banana and plantain (*Musa × paradisiaca*) are cultivated in the village.

2-3-3. Dietary habits in Andom village

The dietary survey was also carried out in Andom village by the same method with that used in Bupigu village (24 h recall method). The number of interviewees was 50 (aged 8 - 65 years).

The result of dietary survey is shown in Fig. 2.4. The staple food most frequently taken in Andom village was stiff porridge (named *couscous* in French and *ikéille* in *Bambele*) made of cassava (Picture 2.6). Stiff porridge is prepared by stirring cassava flour with boiled water like as *ugali* preparation of Bupigu village. However, not like as the preparation of *ugali* at Bupigu village, stiff porridge from cassava is not stirred on the fire. Cassava flour used for stiff porridge is prepared as follows, 1)

cassava tubers are peeled, 2) peeled cassava tubers are put into a bucket or metal pot and soaked into water (Picture 2.7), 3) the cassava tubers are left to stand for 2-3 days and lactic fermentation occurs during this period, 4) fermented cassava tubers are broken into lumps by machete (Picture 2.8) and the lumps are exposed to sunshine to be dried, and 5) the dried lumps are pulverized by mortar before cooking stiff porridge (Picture 2.7). In the village, stiff porridge is also prepared from maize or from mixed flour of cassava and maize. Although the most important staple food in the village is the stiff porridge from cassava, villagers believe that the stiff porridge from maize gives them more strength during labor in the field, and many of them actually prefer the stiff porridge prepared from mixed flour of cassava and maize to other two varieties.

Not like in Bupigu village, beans, except for groundnut, are not served as a side dish in Andom village. Instead, animal food products such as meat of wild games, fish and insects are utilized as protein sources. Among these protein sources, the meat of wild games was most frequently consumed. The culture with vegetative crops cultivation usually lacks the cultivars as a protein source (Nakao, 1966). In addition, total protein content of vegetative crops such as cassava is much smaller than that of cereals in spite of their well-balanced composition in the essential amino acids (MUHAS *et al.*, 2008). Therefore, in the dietary habits utilizing vegetative crops as staple foods, enough protein should be taken from the animal protein sources such as meat, fish and insect (Nakao, 1966; Koppert *et al.*, 1993). The result shows that the dietary habits in Andom village exhibit a typical feature of the society with vegetative crop utilization.

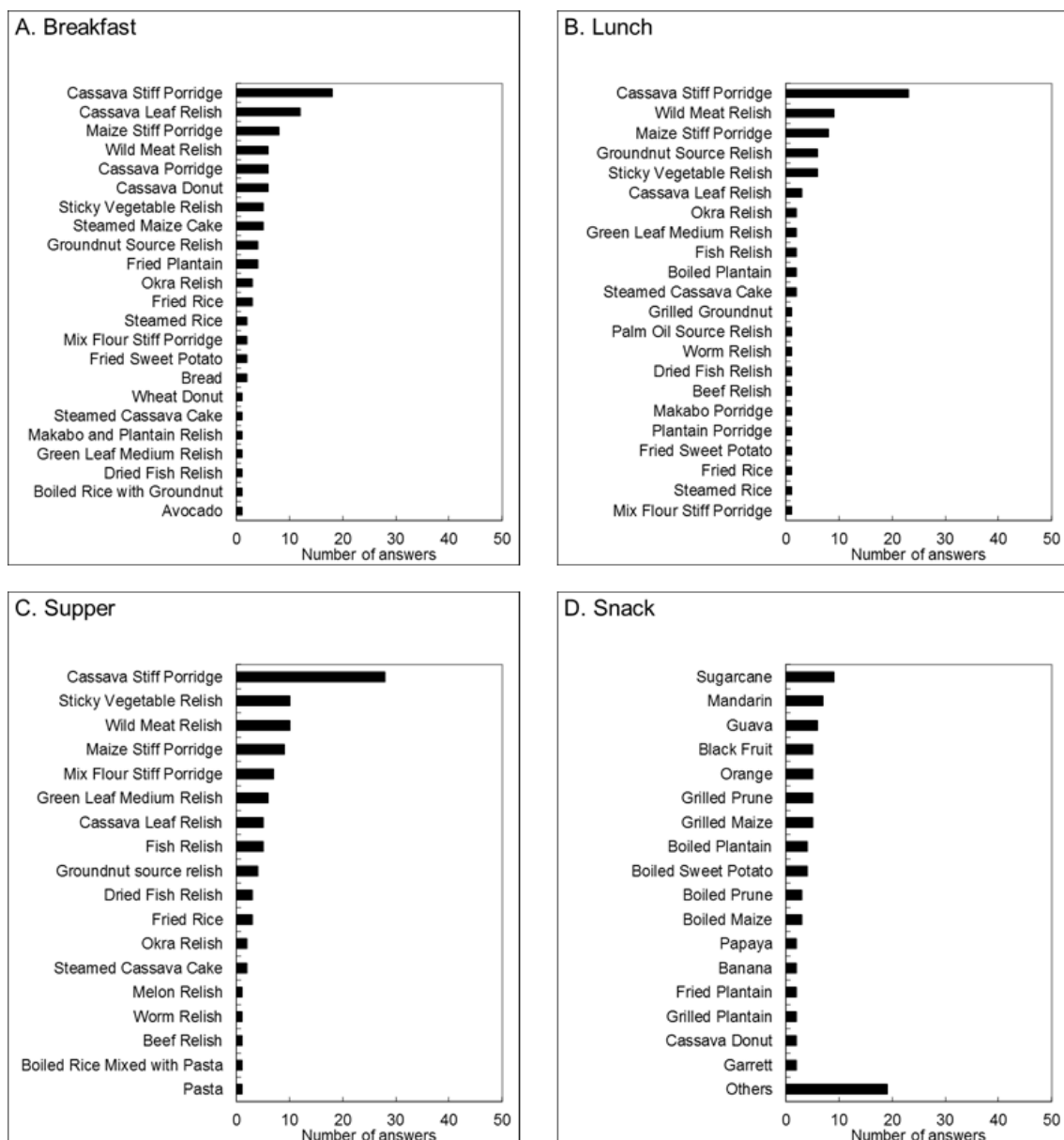


Fig. 2.4 The results of dietary survey using 24 h recall method in Andom village (A: breakfast, B: lunch, C: supper, D: snack)



Picture 2.6 *Ikéille* using cassava



Picture 2.7 Cassava tubers soaked into water



Picture 2.8 Breaking cassava tubers using machete



Picture 2.9 Dried cassava lumps

2-4. Study methods and periods

2-4-1. Survey on the detailed brewing methods of indigenous alcoholic beverages

The detailed brewing methods of indigenous alcoholic beverages in Bupigu and Andom villages were investigated through observation and interview surveys. Materials used in the production were identified, and their weight or volume was measured in each step of the production. In case that the mush for alcoholic beverage was heated or that for spirits was distilled, changes in the temperature of the mush or water for cooling vapor to be spirits were measured using an infrared thermometer (826-T3; Testo, Kanagawa, Japan).

2-4-2. Measurement of ethanol, glucose and lactic acid concentrations and the pH value of indigenous alcoholic beverages

The concentration of ethanol, glucose and lactic acid and the pH value of alcoholic beverages and their mush-like materials were measured on the spot. The measuring methods are as follows. Samples were collected and immediately centrifuged at 2,000 rpm for 3 minutes using hand-powered centrifuge (hand-powered centrifuge; AS ONE Corp., Osaka, Japan). The samples were diluted with water before centrifugation, if necessary. The supernatants obtained were filtered through a filter paper (Qualitative Filter Paper no. 2; Toyo Roshi Kaisha Ltd., Tokyo, Japan) and then through a membrane filter (0.45 μm Millex-HV Filter Unit; Millipore Corp., Cork, Ireland). Filtrates were used for the assay of ethanol, glucose and lactic acid concentrations.

The glucose and lactic acid concentrations of the filtrates were measured using portable devices for measuring glucose and lactic acid (Glutest Ace[®]; Arkley, Kyoto,

Japan), respectively. Before the measurements, the filtrates were diluted using a 1.82 M sodium phosphate buffer, pH 7.4. A 20 μ L of sample was used for the measurements.

The ethanol concentration of fermented alcoholic beverages and their mashes was measured using a measuring kit for the ethanol content of saliva (Q.E.D[®] Saliva Alcohol Test; OraSure Technologies Inc., PA, USA). On the other hand, in the case of the measurement of the ethanol concentration in spirits, the refractive index value of the samples was measured using an Abbe refractometer (FHR-1; TKG, Tokyo, Japan). The ethanol concentration could be calculated by the observed refractive index values using a standard curve from known concentrations of ethanol. The pH values were measured using a pH meter (B-212; Horiba Ltd., Kyoto, Japan).

All of the treatments and experiments were carried out in the villages using the instruments and reagents that were brought in, as described above.

2-4-3. Study periods in Bupigu village

The periods of field studies in Bupigu village are shown in Table 2.1.

Table 2.1 The periods of field studies in Bupigu village

Periods	The number of months
September to November in 2009	3 months
June in 2010	1 month
February to March in 2014	2 months

2-4-4. Study periods in Andom village

The periods of field studies in Andom village are shown in Table 2.2.

Table 2.2 The periods of field studies in Andom village

Periods	The number of months
September to December in 2011	4 months
September to November in 2012	3 months
July to August in 2013	2 months
July in 2014	1 month

Chapter 3: Indigenous alcoholic beverage production in Bupigu village

3-1. The detailed brewing methods of indigenous alcoholic beverages

The population of Bupigu village produces three kinds of indigenous alcoholic beverage (*pombe* in Swahili), *komoni* (maize turbid beer), *kimpumu* (straw beer), and *kiambule* (hybrid straw beer). *Komoni* originates from germinated maize (*kimea wa mahindi*) and germinated finger millet (*kimea wa ulezi*). *Kimpumu* is obtained from germinated finger millet, and *kiambule* is made with germinated maize and germinated finger millet like *komoni*.

Komoni is consumed directly without dilution, while both *kimpumu* and *kiambule* are diluted with hot water (1:1) before drinking. On adding hot water, the turbid suspensions of *kimpumu* and *kiambule* separate into three parts, the floating husk part (upper part), the clear part (middle part), and the precipitate part (lower part) (Fig. 3.1). A long straw is inserted into the clear part, and that part is drunk through it.

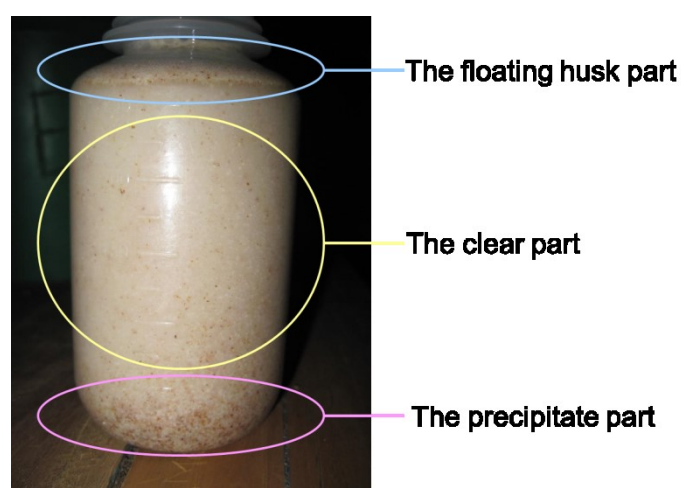


Fig. 3.1 Three parts of *kimpumu* after dilution with water: the floating husk part (upper part), the clear part (middle part) and the precipitate part (lower part)

To prepare each indigenous alcoholic beverage (i.e. *komoni*, *kimpumu* and *kiambule*), the producers first prepared two kinds of mush, *nyambo* (fermented mush) and *kikonde* (sweet mush), and later mixed them. Although all the three different alcoholic beverages were produced with both types of mush, the preparation methods of the mashes were distinct. The details of the manufacturing process of *nyambo* and *kikonde* for each alcoholic beverage are described in each alcoholic beverage production respectively.

3-1-1. Preparation of germinated cereals

The starting materials of the indigenous alcoholic beverages, germinated maize and finger millet (Picture 3.1; 3.2), were prepared as follows. Maize and finger millet seeds were soaked in water for 1 day, and the swollen seeds were put into a nylon bag for 2 days. Then, sprouts of maize and finger millet were spread on the floor of the room, sprayed and covered with a plastic sheet for 1 day. After that, sprouts of maize and finger millet were sun-dried for 2-3 days, and then turned to flour by pulverizing (Picture 3.3). The flour of the cereals was prepared in similar ways in the different households.



Picture 3.1 Germinated maize



Picture 3.2 Germinated finger millet



Picture 3.3 Saddle quern for pulverizing germinated cereals

3-1-2. *Komoni* production

Nyambo of *komoni* was prepared as follows (Fig. 3.2). Maize husks (3.33 kg) (Picture 3.4) were put into a plastic pot and soaked in water (10.6 L) for 3 days at room temperature (Picture 3.5). After soaking, the mush was transferred to a clay pot, and 11.9 L of water was added. The diluted mush was heated for 9 h while stirring occasionally (Picture 3.6), and then the pot was placed outside to cool for 3 h (Fig. 3.3). During this heating process, microorganisms cultured in the mush must be killed by high temperature. Before the heating process, the pH value of the mush decreased below 4, and this pH value suits with the growth of yeast and lactic bacteria without the contamination of other kinds of microorganisms (Mensah, 1997; Nout and Motarjemi, 1997; Abegaz *et al.*, 2002b; Oi and Kitabatake, 2003). However, many kinds of microorganism might exist in the beginning of the production, and they could disturb the satisfactory growth of yeast. Therefore, as the pH value of the mush maintained after the heating process, the process might contribute to provide suitable condition for yeast

growth by killing other kinds of microorganism proliferated in the mush. After the heating and cooling processes, the mush was transferred to a plastic pot and 500 g of the germinated maize flour was added, mixed well and left to stand for 2 days. The germinated maize added in this step is supposed to be a yeast source for alcoholic fermentation as described below.

The germinated maize flour was obtained from old maize seeds that had been stored for more than a year after harvest. According to the villagers, fresh maize seeds do not guarantee sufficient alcoholic fermentation and bring strong alcoholic taste, and therefore, the use of aged maize is necessary. During the storage of maize seeds, the yeast in the atmosphere probably adheres to the surface of the seeds. Therefore, by adding aged maize seeds to the mush, the yeasts may have been inoculated into the mush thus leading to an alcoholic fermentation. For that reason, it is supposed that aged maize is the source of the yeast for the fermentation.

During the 2 days, the pot containing the mush was occasionally moved outside to the sunshine, during which time the temperature of the mush increased (Picture 3.7). The warm temperature enhanced the growth and proliferation of yeast in the mush. After 2 days, 390 g of the germinated finger millet flour was added, the mixture was left to stand for about 7 h, and then 10.5 L of a different mush (*kikonde* of *komoni* described below) was added to give *nyambo* of *komoni*. The process to prepare *nyambo* of *komoni* lasted 6 days.

Changes in the concentrations of glucose and lactic acid and the pH value during the production of *nyambo* of *komoni* are shown in Fig.3.4. The glucose concentration was less than 1mM throughout the manufacturing steps. The lactic acid concentration was low until day 5, and increased to 9.6 mM on the last day, whereas pH value decreased to <5 on day 2. The decrease in the pH value indicated that the lactic

fermentation had started on day 1 and lactic acid was produced in sufficient amount to lower the pH value to 5, indicating that starch was hydrolyzed and the glucose produced was consumed for lactic fermentation. However, it was assumed that the lactic acid concentration was <0.80 mM until day 5 and could not be detected by the lactic acid measuring device. A low pH value is favorable for yeast proliferation and suppressed the growth of contaminating bacteria, with the exception of lactic acid bacteria (Mensah, 1997; Nout and Motarjemi, 1997; Abegaz *et al.*, 2002b; Oi and Kitabatake, 2003), meaning that suitable conditions for alcoholic fermentation by yeast and food safety are achieved by the preceding lactic fermentation. *Nyambo* of *komoni* obtained on the final day was a viscous liquid with no sweetness.

On the day 3 of the production of *nyambo*, the mush was ready after boiling for 9 h, after which it was cooled for 3 h at ambient temperature. During this period, the temperature of *nyambo* of *komoni* increased to 95°C , and it was maintained at $80\text{--}90^{\circ}\text{C}$ for 8 h, and then decreased by cooling (Fig. 3.3). This temperature treatment ensured that the starch included in the starting materials was completely gelatinized and that contaminating bacteria in the mush were killed. After heating, the germinated maize and finger millet flour were added successively. Since aged maize was chosen for this step, the addition of the flour of the germinated cereals was accompanied by the inoculation of yeasts and lactic acid bacteria, which could grow well in the presence of appropriate amounts of nutrients. In other words, *nyambo* of *komoni* appeared to be the source of yeast for the alcoholic fermentation in the following step.

Kikonde of *komoni* was prepared as follows. The germinated maize flour (2.31 kg), germinated finger millet flour (1.40 kg), and water (59.9 L) were mixed in a large vessel and heated for 5 h with occasional stirring. The temperature of the mush was maintained at around $50\text{--}70^{\circ}\text{C}$ for 5-6 h (Fig. 3.3). In this range of temperature, the

starch hydrolyzing enzyme (amylase) of the finger millet was stable and its activity was enhanced (Gimbi and Kitabatake, 2002). Therefore, the starch in the starting materials was hydrolyzed effectively during the heating process. After heating, the mush was transferred into several containers and cooled for 5 h (Fig. 3.3) (Picture 3.8). *Kikonde* of *komoni* contained large amounts of glucose (Table 3.1) and other saccharides. However, the lactic acid concentration was <0.80 mM, meaning that no lactic fermentation occurred, and the pH value was not as low as that of *nyambo*. *Kikonde* of *komoni* is sometimes served as a saccharified beverage for children, because it contains large amounts of saccharides and tastes sweet. When *kikonde* of *komoni* is drunk as a saccharified beverage, it is called *togwa* or *uji*. *Togwa* is drunk as a nutritious beverage because the carbohydrates of various molecular sizes contained in the beverage supply energy quickly and continuously, enabling people to perform hard and long-term labor work in the fields (Kitabatake *et al.*, 2003; Oi and Kitabatake, 2003).

Finally, *nyambo* and *kikonde* were mixed together and left to stand for 12 h. The obtained *komoni* was filtered using a nylon bag to give a translucent filtrate (Picture 3.9; 3.10). The analysis of this beer is given in Table 3.1.

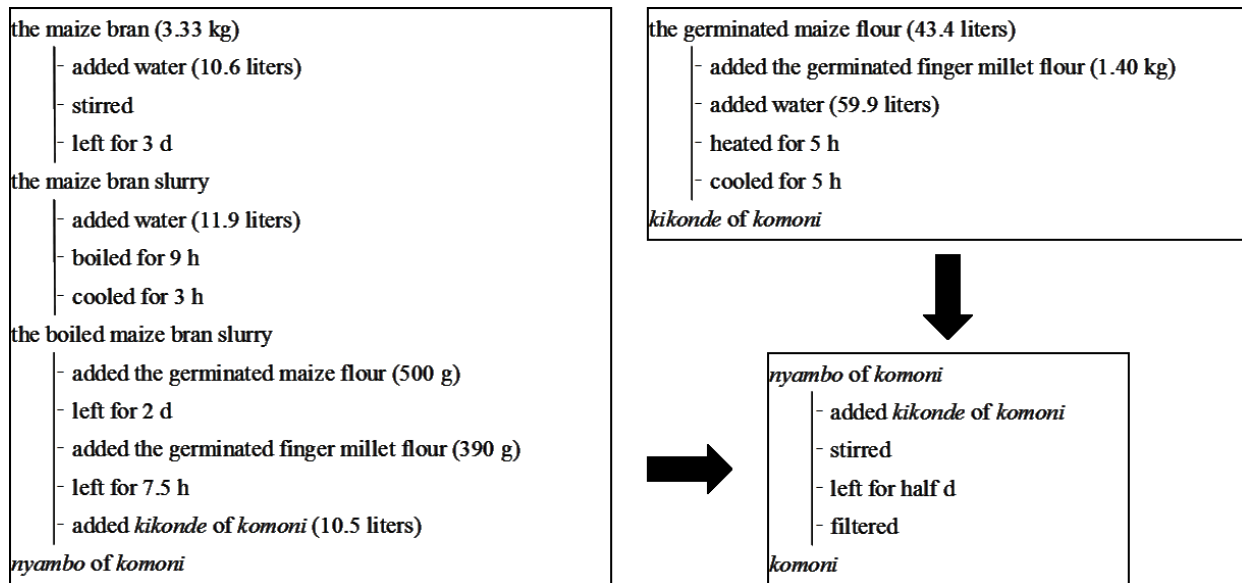


Fig. 3.2 Method for the production of *komoni*

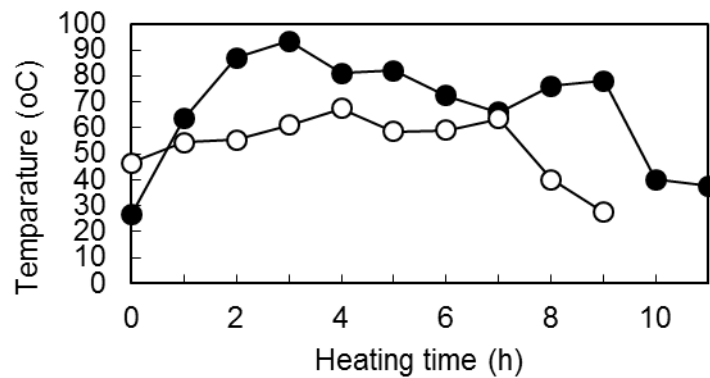


Fig. 3.3 Changes in the temperature of *nyambo of komoni* (●) and *kikonde of komoni* (○)

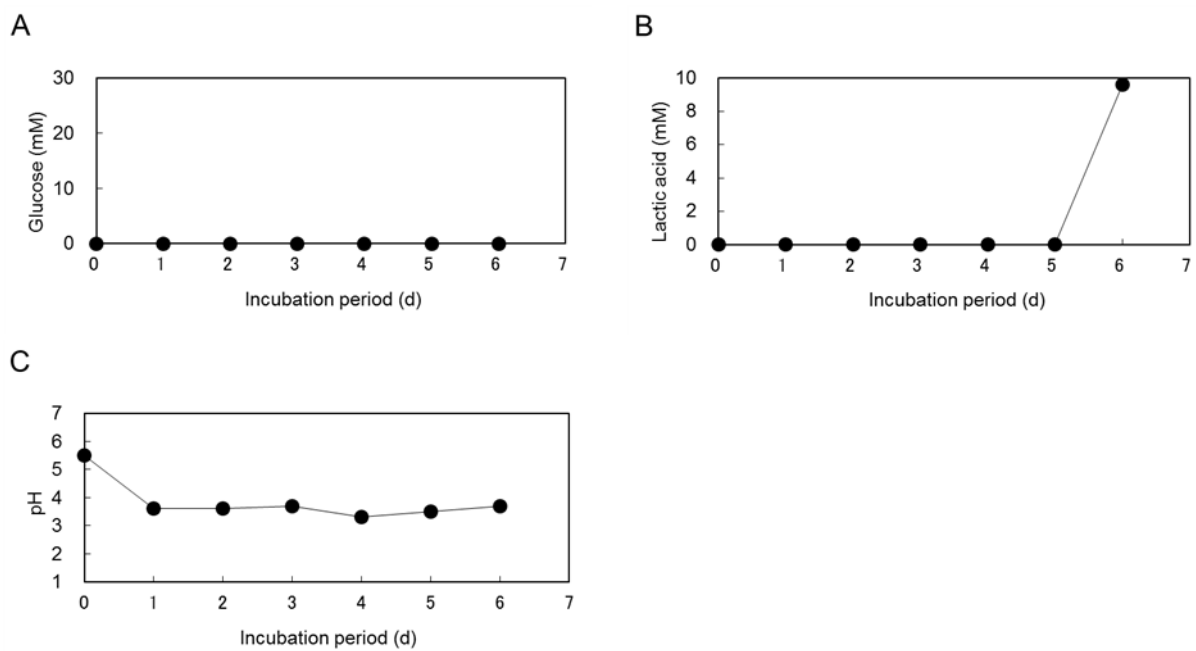


Fig. 3.4 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *komoni*

Table 3.1 The ethanol, glucose and lactic acid concentration and pH value of *nyambo* and *kikonde* of *komoni* and *komoni*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Nyambo</i> of <i>komoni</i>	-	<1.10	9.60	3.7
<i>Kikonde</i> of <i>komoni</i>	-	59.40	<0.80	5.0
<i>Komoni</i>	4.0	<1.10	2.60	4.0



Picture 3.4 Maize husks for *komoni* production



Picture 3.5 Maize husks soaked into water for 3 days



Picture 3.6 Boiling the mixture of maize husks and water for preparing *nyambo* of *komoni*



Picture 3.7 Exposing the mush for *nyambo* of *komoni* to sunshine; Bubbling suggesting the growth of yeast



Picture 3.8 Cooling *kikonde* of *komoni* in several containers



Picture 3.9 Filtrating *komoni* with a nylon bag



Picture 3.10 *Komoni*

3-1-3. *Kimpumu* production

The production of *kimpumu* is shown in Fig. 3.5. *Nyambo* and *kikonde* of *kimpumu* were prepared from germinated finger millet as a material. *Nyambo* of *kimpumu* was prepared as follows. The germinated finger millet flour (352 g) was put into a clay pot and boiling water (4.91 L, 96°C) was added. Then, the mush was stirred vigorously until it became smooth (Picture 3.11). After stirring, the temperature of the mush decreased from 60 to 40°C with time (Fig. 3.6). In this temperature range, the amylase in finger millet is stable and shows high enzyme activity (Gimbi and Kitabatake, 2002; Adewale *et al.*, 2006). The glucose concentration at the beginning of the preparation of *nyambo* of *kimpumu* was much higher than that of *komoni* and *kiambule* (Fig. 3.7). After the temperature of the mush was reduced, the mixture was left to stand for 6 days (Picture 3.12). During this period, the pot containing the mush was kept in the kitchen where hearth for cooking exists, and temperature of the mush

increased to about 30°C. This warming enhanced the growth and proliferation of the yeast in the mush. After 6 days, *nyambo* of *kimpumu* was obtained. The glucose concentration was <1.1 mM, the lactic acid concentration was 40 mM and the pH value was 3.4 (Table 3.2).

Successful fermentation of *nyambo* of *kimpumu* could be achieved by the effect of tannin contained in finger millet. Tannin is a kind of polyphenol contained in plant, and it combines with protein and forms stable complex (Heiser, 1988; Mangan, 1988; Osawa, 1990 Hladik and Simmen, 1996; Dykes and Rooney, 2007). As tannin combines with protein, it causes astringent taste, decreases nutritious value of foods and suppresses the growth of microorganisms (Mehansho et al., 1987; Mangan, 1988; Osawa, 1990; Hladik and Simmen, 1996; Dykes and Rooney, 2007). A lactic bacterium named *Lactobacillus plantarum*, which is widely distributed over lactic fermented foods, beverages and alcoholic beverages in Africa, is one of the microorganisms can decompose tannin by tannin degrading enzyme named tannase (Ngaba and Lee, 1979; Oyewole, 1997; Osawa et al., 2000). Therefore, tannin in finger millet could contribute to the growth of *Lactobacillus plantarum*, and *Lactobacillus plantarum* might decrease the pH value of the mush by producing lactic acid (Fig. 3.7). The condition of the mush in low pH value (around 4) suppresses the growth of microorganisms except for yeasts and lactic bacteria (Mensah, 1997; Nout and Motarjemi, 1997; Abegaz et al., 2002b; Oi and Kitabatake, 2003). In this mechanism, it is supposed that tannin in finger millet could contribute to successful fermentation of *nyambo* of *kimpumu*. Although the growth of yeast might also be affected by the growth suppressing effect of tannin, a past study suggests that *Saccharomyces cerevisiae*, which is the most common yeast used for brewing, has tannase (Aguilar et al., 2007).

Kikonde of *kimpumu* was prepared as follows. The germinated finger millet

flour (1.55 kg) was put into a clay pot with boiling water (10.5 L, 88°C). By vigorous stirring, the mixture became smooth, and the paste obtained was spread on a plastic sheet to cool for 3 h (Picture 3.13). This was *kikonde* of *kimpumu*. The temperature of the paste on the plastic sheet was maintained at around 40-60°C during the cooling procedure (Fig. 3.6). During this cooling time, glucose and other kinds of saccharide might be efficiently produced by the action of the amylase in the germinated finger millet. The glucose concentration of *kikonde* of *kimpumu* was higher than that of *komoni* and *kiambule* (Table 3.2).

Nyambo, *kikonde*, and 4.45 L of water were mixed together, and this mixture was left to stand for 1 day. The mush obtained was *kimpumu* (Picture 3.14). The mixture before 1 day alcoholic fermentation was also drunk as a saccharified beverage named *pupya* (Picture 3.15). The glucose concentration of *kimpumu* was <1.1mM, meaning that most of the starchy materials and saccharides, including oligosaccharides and glucose, would be converted into ethanol and lactic acid by the alcoholic and lactic fermentations, respectively. A high glucose concentration in *nyambo* was observed at an early stage of the production and this decreased at the later stage (Fig. 3.7), indicating that the glucose was used for the growth and proliferation of the yeast and lactic acid bacteria. The glucose concentration in *kikonde* of *kimpumu* was very high (Table 3.2) and supplied substrate for the alcoholic and lactic fermentations by the yeast and lactic acid bacteria. Owing to these effects, efficient alcoholic and lactic fermentations were achieved in the production.

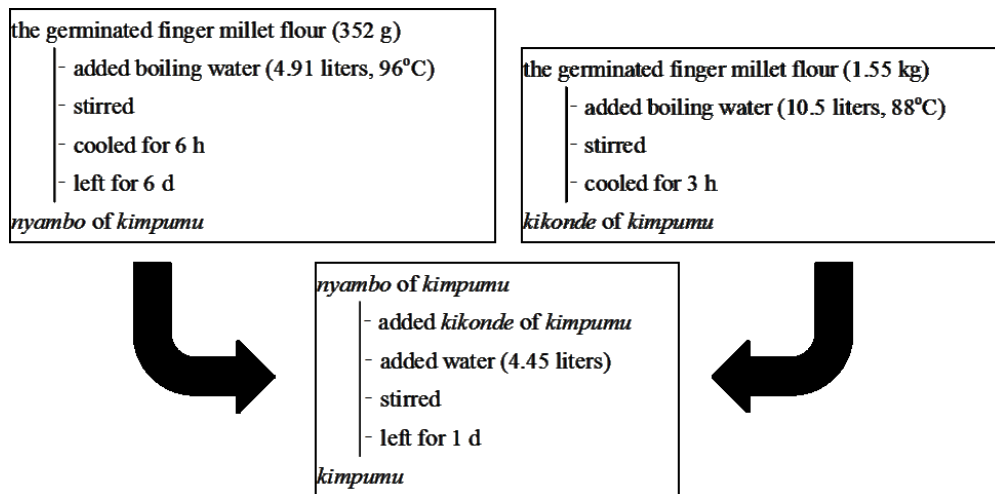


Fig. 3.5 Method for the production of *kimpumu*

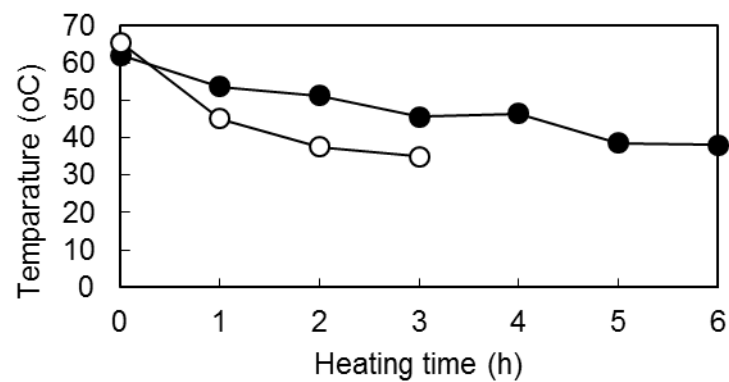


Fig. 3.6 Changes in the temperature of *nyambo* of *kimpumu* (●) and *kikonde* of *kimpumu*

(○)

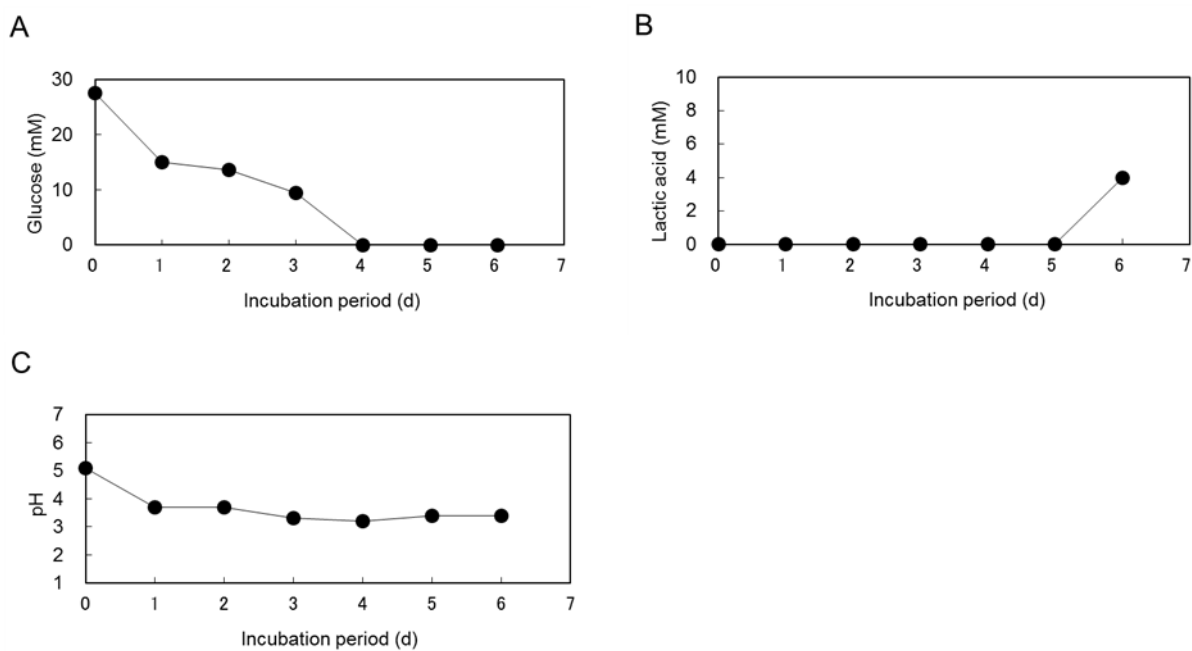


Fig. 3.7 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *kimpumu*

Table 3.2 The ethanol, glucose and lactic acid concentration and pH value of *nyambo* and *kikonde* of *kimpumu* and *kimpumu*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Nyambo</i> of <i>kimpumu</i>	-	<1.10	4.00	3.4
<i>Kikonde</i> of <i>kimpumu</i>	-	85.50	<0.80	4.3
<i>Kimpumu</i>	3.5	<1.10	15.20	3.8



Picture 3.11 Stirring germinated finger millet flour with boiled water in the preparation of *nyambo* of *kimpumu*



Picture 3.12 The mush for *nyambo* of *kimpumu*



Picture 3.13 Cooling *kikonde* of *kimpumu* on a plastic sheet



Picture 3.14 Enjoying *kimpumu* through a straw



Picture 3.15 Saccharified beverage “*pupya*”

3-1-4. *Kiambule* production

Nyambo of *kiambule* was prepared as follows (Fig. 3.8). The germinated maize flour (4.02 kg) was put into a clay pot, 7.54 L of water was added and the mixture was left to stand for 3 days (Picture 3.16). After 3 days, boiling water (30.0 L, 87°C) was added and the mush was heated for 4 h. After heating, the mush was spread onto a plastic sheet for 3 h to cool (Picture 3.17). The temperature of the mush during heating was maintained at around 60-70°C (Fig. 3.9). In this temperature range, the amylase in finger millet was still stable, although the amylase in maize was destroyed (Adewale *et al.*, 2006). Therefore, glucose was not produced in as large amounts in this step (Fig. 3.10). The heating process was necessary mainly to achieve gelatinization of the starch material. The cooled mush was put back into the clay pot, the germinated finger millet flour (156 g) was added and the mixture was left to stand for 2 days. After 2 days, warm water (0.57 L, 34,5°C) was added. By adding warm water, the mush maintained an optimum temperature for yeast growth. After 1 day, *nyambo* of *kiambule* was obtained.

Changes in the lactic acid concentration and pH value during the preparation of *nyambo* of *kiambule* were similar to those of *komoni* and *kimpumu* (Fig. 3.10).

Kikonde of *kiambule* was prepared as follows. The germinated finger millet flour (241 g) was put into a clay pot and boiling water (5.65 L, 93°C) was added. Vigorous stirring rendered the mixture smooth, which was then cooled on a plastic sheet to give a *kikonde* of *kiambule*. Since after the addition of the boiling water, the temperature of the mush was maintained at around 40-60°C for 3 h (Fig. 3.9), glucose was produced efficiently by the action of the amylase contained in the germinated finger millet. The glucose concentration of *kikonde* of *kiambule* was 29.3 mM, which was lower than that of *kimpumu*. This might be caused by the smaller amount of germinated finger millet flour in the suspension compared to that in *kimpumu* (i.e. 241 g flour/5.65 L water for *kiambule* against 1.55 kg flour/10.5 water for *kimpumu*). In *kikonde* of *kiambule*, no lactic acid was detected and the pH value was 5.7 (Table 3.3).

Finally, *nyambo* and *kikonde* were mixed and kept for 12 h to yield *kiambule* (Picture 3.18). The ethanol concentration was lower than that of *komoni* and *kimpumu* (Table 3.3). Because *kikonde* of *kiambule* had a relatively low glucose concentration, this meant that the fermentable substrate for alcoholic fermentation was lower, leading to a lower ethanol concentration.

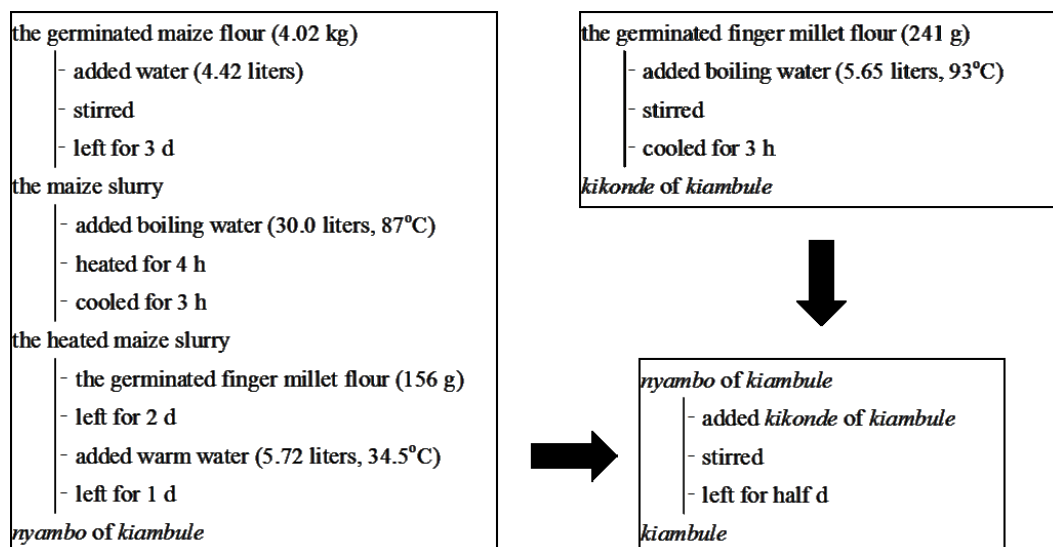


Fig. 3.8 Method for the production of *kiambule*

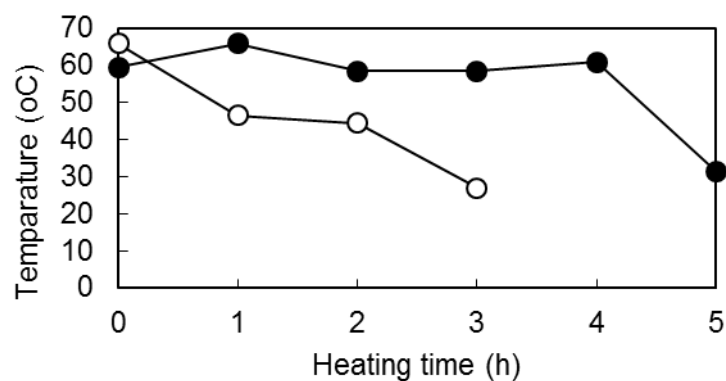


Fig. 3.9 Changes in the temperature of *nyambo* of *kiambule* (●) and *kikonde* of *kiambule* (○)

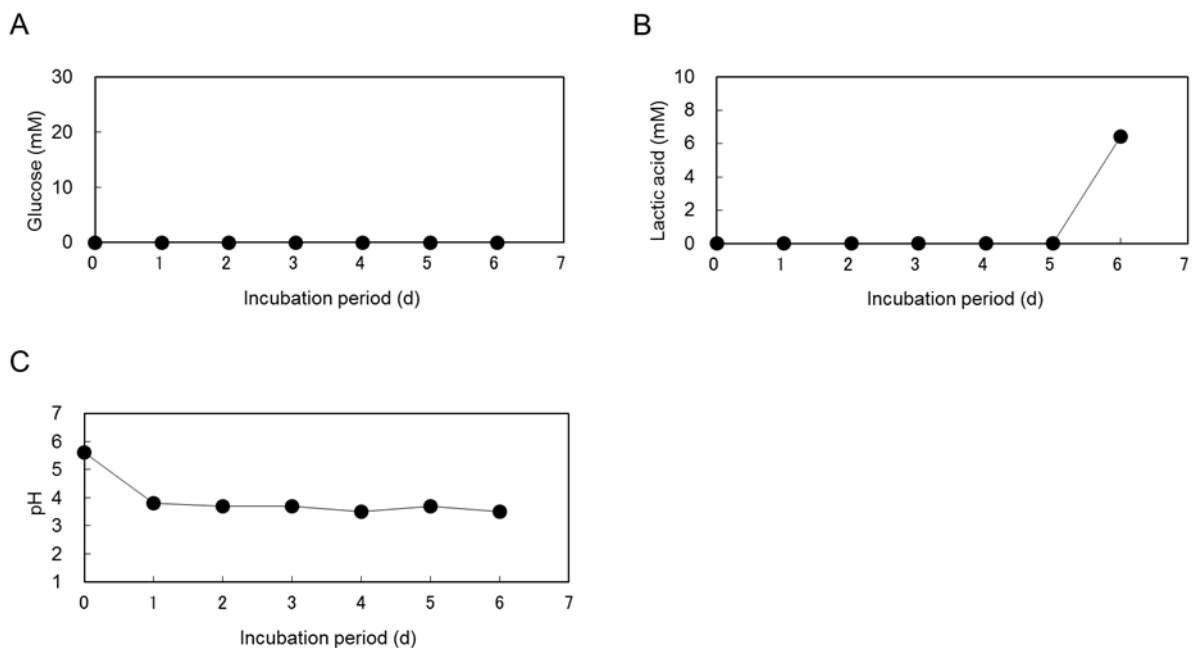


Fig. 3.10 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *kiambule*

Table 3.3 The ethanol, glucose and lactic acid concentration and pH value of *nyambo* and *kikonde* of *kiambule* and *kiambule*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Nyambo</i> of <i>kiambule</i>	-	<1.10	6.40	3.5
<i>Kikonde</i> of <i>kiambule</i>	-	29.30	<0.80	5.7
<i>Kiambule</i>	2.0	<1.10	7.20	3.7



Picture 3.16 The mixture of germinated maize flour and water in the preparation of *nyambo* of *kiambule*



Picture 3.17 Cooling the mush for *nyambo* of *kiambule* on a plastic sheet



Picture 3.18 Enjoying *kiambule* at a local bar

3-2. Discussion

In the course of the production of the indigenous alcoholic beverages, various manufacturing techniques effective in stabilizing and improving the quality of the products were observed. *Kikonde* was heated at nearly optimal temperatures for amylases to efficiently saccharify the starch in the materials. *Nyambo* appeared to be a culture medium of yeast, while *kikonde* was a source of saccharides for the fermentation. By mixing *nyambo* and *kikonde*, the yeasts from *nyambo* grew and proliferated by consuming the saccharides contained in *kikonde* as nutrients. The source of yeasts in *nyambo* appeared to be the germinated maize in *komoni* and finger millet in *kiambule*. In other words, yeast adhering to the maize and finger millet seeds was probably the source of the yeast for the alcoholic fermentations. After boiling *komoni* and heating

kiambule, germinated maize and finger millet flour were added. After this step, procedures to enhance the growth of the yeasts were carried out. In the course of *komoni* production, the mush to be *nyambo* of *komoni* was placed outdoors and exposed to sunshine. In the case of *nyambo* of *kiambule*, warm water was added, and the mush was kept at a slightly higher temperature. The brewers stated that these techniques accelerate bubbling of the mush. Therefore, it is supposed that the techniques enhance yeast growth. Additionally, only aged maize, which had been preserved for more than a year, allowing the yeasts in the environment to adhere to the surface of the seeds, was used to produce *komoni*. In case of *nyambo* of *kimpumu*, the source of the yeasts appeared to be the clay pot or the environment itself. The brewers stated that they always used the same clay pot to produce *kimpumu*, and that alcoholic fermentation did not proceed well when the clay pot was changed. In the course of the production of *nyambo* of *kimpumu*, some particular handling procedures that could enhance yeast growth were observed. *Nyambo* of *kimpumu* was placed in the kitchen where the temperature was warmer, allowing the yeasts to grow well.

Alcoholic beverage production has many steps in common with saccharified beverage (*togwa*) production (Kitabatake *et al.*, 2003). In the village, it was observed that *togwa* was produced as a by-product in the course of the brewing. Since alcoholic beverage production consists of two different steps (i.e. saccharification and fermentation), while saccharified beverage production needs only the saccharification step, alcoholic beverage production is more complicated than saccharified beverage production. To some extent, the production of alcoholic beverages seems to be derived from saccharified beverages. Additionally, saccharified beverages might be derived from a thin porridge (*uji*), while stiff porridge (*ugali*), which is a staple food, is produced from the same materials as the thin porridge. Based on these observations, we

have described a food processing structure using the cereal of the staple crop named the “*ugali-uji-togwa-pombe* pathway”.

In the village, a self-sufficient food habit still exists, and available food materials are limited. For this reason, limited food materials need to be processed into various products. The cereal of the staple crop is the most available food material in the village. Therefore, the “*ugali-uji-togwa-pombe* pathway” using cereals has been developed to provide different tastes, nutrients, and other food functions. Interestingly, the production technique of saccharified and alcoholic beverages is too complicated to have been developed spontaneously. Therefore, there must be specific reasons and particular processes for the development of the “*ugali-uji-togwa-pombe* pathway” that should be clarified with additional studies.

3-3. Conclusion

In the village, three different kinds of alcoholic beverages, *komoni*, *kimpumu* and *kiambule*, were produced. In the production of these alcoholic beverages, two different kinds of mush (i.e. *nyambo* and *kikonde*) were first manufactured, and then mixed at the end of the production process. This technique was effective in preventing contamination of harmful microorganisms into the alcoholic beverages. Moreover, germinated finger millet, which has a high amylase activity, was used as an amylase source for the saccharification of starch, and the saccharification step was carried out in the range of optimal temperatures for the action of amylases. The fermentation step was also conducted at the optimal temperature for the growth of the yeast. The brewing technique of the indigenous alcoholic beverage production in the village appears to be sophisticated, and the food processing structure using the cereal of a staple crop, called

the “*ugali-uji-togwa-pombe* pathway”, plays an important role in the dietary habit of the village.

Chapter 4: Indigenous alcoholic beverage production in Andom village

4-1. The detailed brewing methods of indigenous alcoholic beverages

In Andom village, eight kinds of indigenous alcoholic beverage (*melok* in *Bambele*) including three types of sugar-based alcoholic beverage: *matango* or *melok alain* (oil palm wine), *melok asse* (raffia palm wine) and *melok ykone* (plantain wine), one type of starch-based alcoholic beverage: *mbwara* (maize turbid beer), and four types of distilled alcoholic beverage: *kembé* (oil palm spirits), two types of *mebwalam* (cassava and maize spirits) and *kembé ykone* (plantain spirits), are produced and consumed.

Among the production of the three kinds of sugar-based alcoholic beverage, *matango* and *melok asse* are obtained by spontaneous alcoholic fermentation of oil palm (*Elaeis guineensis*) sap and raffia palm (*Raphia farinifera*) sap respectively, whereas *melok ykone* are produced from cut plantain. *Mbwara* is made with germinated and non-germinated maize. Four kinds of distilled alcoholic beverage are produced as follows. *Kembé* and *kembé ykone* are obtained by the distillation of the mixture of *matango* and sugar, and *melok ykone*, *matango* and sugar, respectively. In the village, there are two types of *mebwalam* that produced from each cassava and maize. *Mebwalam* of cassava consists of cassava, germinated maize, plantain, banana and sugar, but the contents can be changed according to the recipes. *Mebwalam* of maize is composed of germinated and non-germinated maize and sugar. The detailed methods for producing these alcoholic beverages are described below.

4-1-1. Preparation of germinated cereal

In Andom village, germinated maize was used as a source of amylase for the production of alcoholic beverages from starchy materials such as cassava and maize. The method for preparing germinated maize is as follows. Maize seeds were soaked in water for 1 day, and spread on banana leave (Picture 4.1). Maize seeds on the banana leave were covered with other banana leave, and the seeds were left to stand for 5-7 days with occasional spray. Within 5-7 days, maize seeds germinated and became sprouts. After that, sprouts of maize were sun-dried for 2-3 days (Picture 4.2). Dried germinated maize was turned to flour by pounding before use (Picture 4.3).



Picture 4.1 Spreading maize onto banana leaves



Picture 4.2 Drying germinated maize



Picture 4.3 Pounding germinated maize into flour

4-1-2. *Matango* production

Matango was obtained by spontaneous alcoholic fermentation of oil palm sap. The sap was tapped as follows. First, leaves of a palm tree were cut and removed, the tree was cut down, the top of the tree was tipped, and a bucket or bottle was attached to the top of the tree (Picture 4.4; 4.5; 4.6; 4.7). Oil palm sap was exuded from the tip and allowed to flow into the container (bucket or bottle) (Picture 4.8). Every day or half-day, palm sap was collected in the container and transferred to another plastic bottle. Exudation of oil palm sap continued for 3 or 4 weeks. Approximately 5 L of the sap could be obtained per day in the first week. In the second week, exudation gradually decreased to approximately 1.5-2 L of sap per day. A few hours after collection in the container, the oil palm sap was sweet with a slightly alcoholic taste. After extra few hours, an alcoholic odor and taste were detected, indicating that alcoholic fermentation had begun in the container, and oil palm sap was changed to *matango* (Picture 4.9). Alcoholic fermentation was also recognized by bubble formation.

Oil palm sap collected on the first day was kept at an ambient temperature, and glucose concentration, lactic acid concentration and pH value were measured every day (Fig. 4.1). Glucose concentration on the first day was approximately 40 mM, and it decreased quickly to reach a concentration of less than 1 mM on the second day (Fig. 4.1). Oil palm sap was sweet on the first day, but not on the second day. Initially, the lactic acid concentration was approximately 12 mM and the pH value was around 4.2. The lactic acid concentration increased slightly and the pH value decreased on the next day and on the third day (Fig. 4.1), suggesting that lactic fermentation occurred in the oil palm sap immediately after exudation and continued to some extent over the following days at a slow rate. This finding also suggested that the lactic acid bacteria and yeast inhabiting the tip of oil palm tree and/or the container, immediately

proliferated in the oil palm sap to reduce the pH value to around 4. The pH value on the first day was already around 4, a condition under which most bacteria cannot survive but yeast and many other fungi can (Mensah, 1997; Nout and Motarjemi, 1997; Abegaz *et al.*, 2002b; Oi and Kitabatake, 2003). It was assumed that, in this case, yeast would be present and this pH range was maintained during the fermentation. In the village, *matango* was consumed on the first or second day. Older *matango* kept for more than 2 days was used for the production of *kembé* (described below). The ethanol, glucose and lactic acid concentrations and the pH value of *matango* (which is after half day from tapping and different from *matango* for measuring the changes of chemical compositions) are shown in Table 4.1.

Matango is the most popular alcoholic beverage in the village, with villagers consuming large amounts of *matango* on various occasions such as gatherings, meetings, weddings and funerals, and it is offered to people who work in groups, for example, after working together in the field (Picture 4.10).

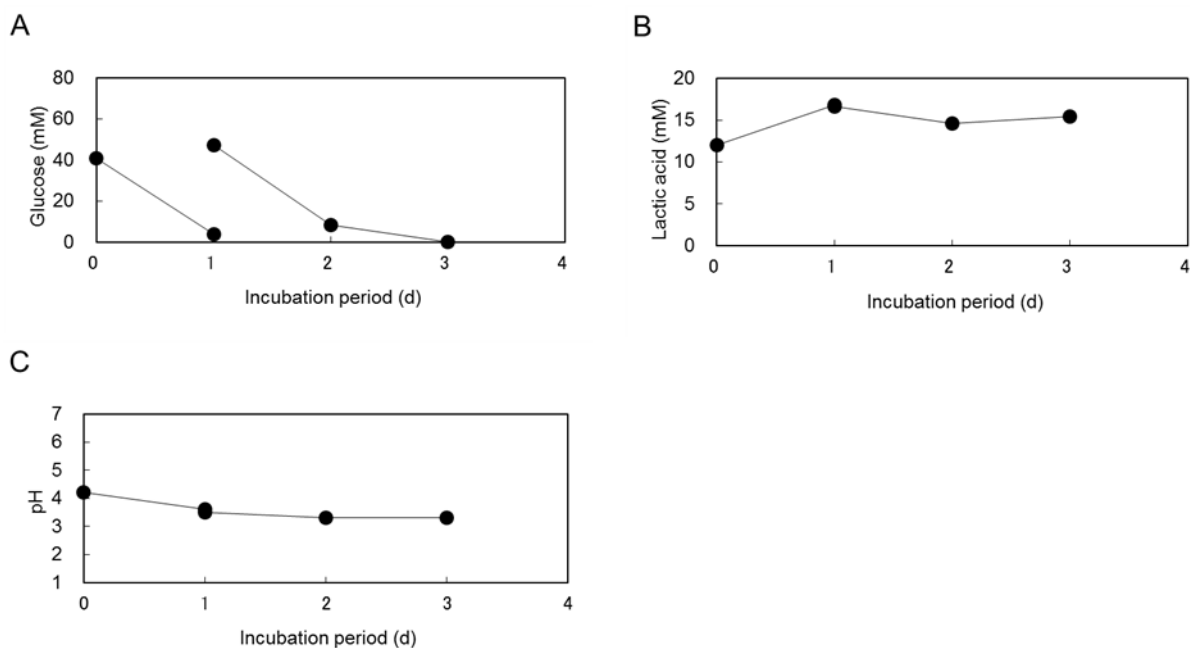


Fig. 4.1 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *matango* and *kembé* (sugar was added on second day after tapping)

Table 4.1 The ethanol, glucose and lactic acid concentration and pH value of *matango*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Matango</i>	4.5	70.00	16.80	4.3



Picture 4.4 Removing leaves of oil palm tree



Picture 4.5 Cutting down oil palm tree



Picture 4.6 Tipping the tip of oil palm tree



Picture 4.7 Attaching a bucket at the tip of oil palm tree, and covering with nylon sheet



Picture 4.8 Exuding oil palm sap from the tip of oil palm tree



Picture 4.9 *Matango*



Picture 4.10 Drinking *matango* at a field

4-1-3. *Melok asse* production

Melok asse was produced from raffia palm sap obtained from the raffia palm tree. Unlike *matango* production, the raffia palm tree was not cut down to collect the raffia palm sap. To collect the raffia palm sap, a man climbed a raffia palm tree (approximately 10 m tall) and cut the trunk of the tree (Picture 4.11). A bucket was placed where the gash had been made to collect the sap exuded from the tree (Picture 4.12). Twice a day in the morning and evening, the raffia palm sap collected in the bucket was transferred into a plastic bottle. A maximum of 40 L of sap was collected each day. Raffia palm sap could be obtained for 4-5 weeks from a single raffia palm tree, following which the tree died. During the collection weeks, the quantity of raffia palm sap obtained each day was not reduced. The taste and odor of the raffia palm sap altered with time after collection. Sweetness was reduced, while the alcoholic taste and odor increased. Raffia palm sap was converted to *melok asse*. No raffia palm trees were planted in the village and *melok asse* consumed in the village was brought in from a

neighboring village (Nika).



Picture 4.11 A man climbing raffia palm tree



Picture 4.12 Raffia palm sap exuded from the gash of raffia palm tree

4-1-4. *Melok ykone* production

Plantain is one of the staple crops for supporting daily dietary habit in the village. The producing method of *melok ykone* is as follows (Fig. 4.14). After ripening for 1 week after harvest, plantains (18 kg) were cut and water (2 L) was added (Picture 4.13). During this time, the mixture of plantain and water was not stirred. After 1 day, hot water (2.65 L, 77.5°C) was added, and the mixture was left to stand for 1 day. In this procedure, saccharides contained in ripen plantain might be extracted and transferred in the hot water. Finally, the water was filtered through a cloth and the filtrate was consumed as plantain wine (Picture 4.14; 4.15). During this period, alcoholic fermentation occurred, starch and saccharides were consumed by yeast, and ethanol was produced.

The ethanol, glucose and lactic acid concentrations and the pH value of *melok*

ykone are shown in Table 4.2. The ethanol concentration of *melok ykone* was low, while the glucose concentration was fairly high, resulting in a sweet beverage containing ethanol.

Table 4.2 The ethanol, glucose and lactic acid concentration and pH value of *melok ykone*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Melok ykone</i>	-	153.00	12.60	4.1



Picture 4.13 Cut plantain



Picture 4.14 Filtering the extract for *melok ykone*



Picture 4.15 *Melok ykone*

4-1-5. *Mbwara* production

Mbwara was prepared as follows (Fig. 4.2). Maize flour (14.7 kg) and water (25.0 L) were mixed and kept in a metal pot at a warm location (kitchen) on the first day. On the second day, moist maize paste was transferred to a nylon bag, on which a weight was placed to drain excess water for 1 day (Picture 4.16). During this step, the starch absorbed water and became swollen. After 2 days, the maize paste was placed on a hot metal board for heating and roasting (Picture 4.17). This constituted the gelatinization step for starch. Roasted maize paste was also eaten directly with or without sugar as a snack (*boséré*). After roasting, water (17.6 L) was added and the obtained mush was left to stand for 8 h. Next, germinated maize flour (1.1 kg), dried dregs from a previous filtration (676 g) and water (18.4 L) were added to the mush (Picture 4.18). The dried dregs from a previous filtration are leftovers after filtration of the mush in the previous *mbwara* production. It served as the source of yeast, and the villagers stated that the addition of the dried dregs induced bubbling. The mush was left to stand for 2 days. Bubbling was observed, and an alcoholic odor was detected. The change in the glucose concentration is shown in Fig. 4.3. Glucose in the mush appeared to be converted to ethanol through the action of yeasts during this step. The mush was diluted by adding 13.2 L of water and consecutively filtered through a coarse sieve made from wood, as well as fine sieve made from metal (Picture 4.19). The filtrate was *mbwara* and 48.8 L of *mbwara* was thus obtained (Picture 4.20).

The ethanol, glucose and lactic acid concentrations and the pH value of *mbwara* were recorded (Table 4.3). The ethanol concentration was 2.50% and lactic acid concentration was 6.40 mM. *Mbwara* was brownish and slightly sour. The villagers drink it at a warm or normal temperature. *Mbwara* was ordinarily brewed once per week and sold on the same day (every Thursday) in the village market. *Mbwara* is typically

consumed within one day of its production.

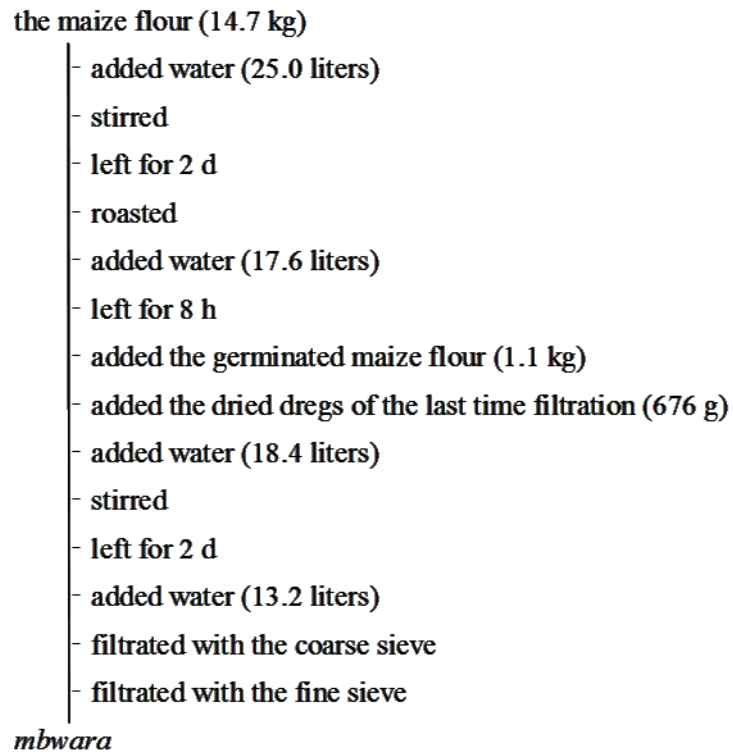


Fig. 4.2 Method for the production of *mbwara*

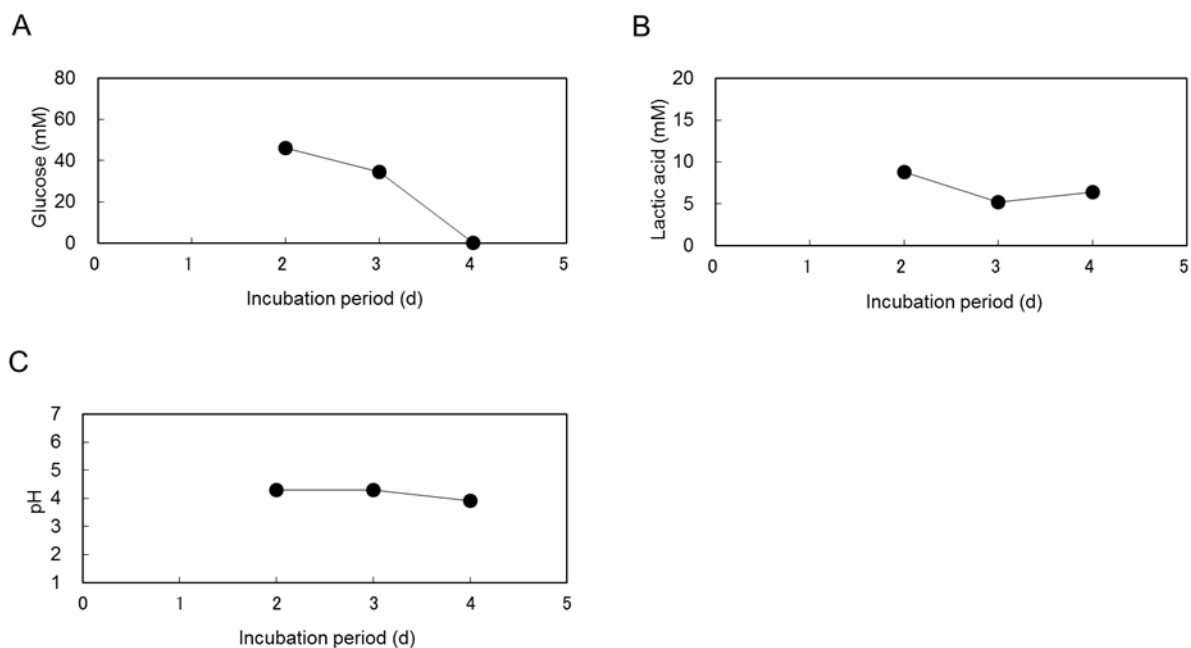


Fig. 4.3 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *mbwara*

Table 4.3 The ethanol, glucose and lactic acid concentration and pH value of *mbwara*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
<i>Mbwara</i>	2.5	<1.10	6.40	3.9



Picture 4.16 Draining water from the moist maize paste



Picture 4.17 Roasting the maize paste



Picture 4.18 The dried dregs from a previous filtration



Picture 4.19 Filtering the mash for *mbwara* through a coarse sieve



Picture 4.20 *Mbwara*

4-1-6. *Kembé* production

Oil palm sap was obtained as described above and was left to stand for 1 day at ambient temperature to become *Matango*. To 20 L of *matango*, 2 kg of sugar was added and mixed well, and this mixture was kept in a warm kitchen for 2 days. During this period, bubbling was observed. Distillation to enhance the ethanol concentration was carried out with a small (approximately 50 L volume capacity), simple and home-made distillation apparatus (Picture 4.21). Distillation was carried out for 2 h. Changes in the temperature of the cooling water were measured (Fig. 4.4).

Cooling water temperature at the beginning of distillation was 37°C and it was increased to 40°C after 1 h of distillation, reaching 52.5°C at the end of distillation. 5.00 L of *kembé* were obtained from 20.0 L of *matango*. When sugar was not added, smaller amounts of *kembé* were obtained.

The glucose concentration of *matango* increased following sugar addition and decreased after 2 days of fermentation (Fig. 4.1). Ethanol, glucose and lactic acid

concentrations and the pH value of *kembé* were recorded (Table 4.4)

At the beginning and the end of distillation, approximately 200 mL of distillate was collected to measure the ethanol concentration. The ethanol concentration of *matango* was 13.6%, while that of the distillate at the beginning of distillation was 49.4%, which was higher than that of the distillate at the end of distillation (10.7%). The obtained distillate was combined, and the ethanol concentration of the final product was 34.2%. The first distillate with a higher ethanol concentration is referred to as “*premier*”, and this is offered to neighbors and friends (Picture 4.22).

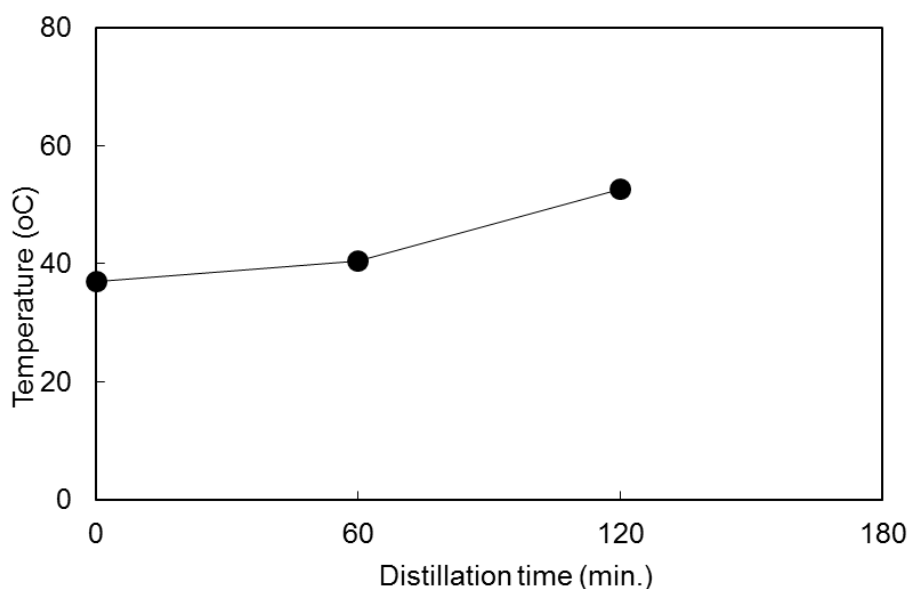


Fig. 4.4 Change in the temperature of cooling water during distillation of *kembé* (from 20.0 L unrefined to 5.00 L of the product)

Table 4.4 The ethanol, glucose and lactic acid concentration and pH value in the beginning and end of distillation and final product of *kembé*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
The beginning	49.4	<1.10	<0.80	4.7
The end	10.7	<1.10	<0.80	3.1
<i>Kembé</i>	34.2	<1.10	<0.80	3.5



Picture 4.21 The home-made distillation apparatus



Picture 4.22 “*Premier*”: the first distillate of *kembé*

4-1-7. *Mebwalam* (cassava) production (1)

Two methods are used in the village for the production of *mebwalam* using cassava. Both methods require a cassava tuber to be conventionally processed into a lump of dry cassava from a raw cassava tuber, before the production of alcoholic beverage. Cassava tuber were pared with a knife, soaked in water for several days, allowed to undergo anaerobic fermentation, mashed and then dried in the sun.

First method of *mebwalam* production from cassava is as follows (Fig 4.5). Water (15.4 L) was added to cassava lumps (25.1 kg) (Picture 4.23). Cassava lumps absorbed water and were placed in a nylon bag and then left in a warm location (kitchen) for 2 days. On the second day, a weight (heavy stone) was placed on the nylon bag to drain the water from the cassava lumps. Moist cassava lumps were roasted on a pan until the surface of the lumps became brown (Picture 4.24). During this step, the

cassava lumps absorbed a large amount of water, and starch granules of the cassava lumps swelled considerably. Under this condition, cassava starch was gelatinized by roasting, as the starch granules contained a sufficient amount of water for gelatinization. Gelatinization resulted in easy hydrolysis of the starch, which was saccharified by the amylase present in the germinated maize flour during the following process. Although most of the roasted cassava was used to manufacture *mebwalam*, some portions were also eaten, with or without sugar, by the villagers. When the roasted cassava was eaten, it was called as *mbosele* (Picture 4.25).

After roasting, water (28 L) was added to the roasted cassava and the mixture was kept for 1 day at ambient temperature. After 1 day, germinated maize flour (2.1 kg) and water (25.5 L) were added to the roasted cassava lumps, which were mixed well and left to stand for 2 days at ambient temperature. The glucose concentration increased 1 day after adding the germinated maize flour (Fig. 4.6). In this step, starch was degraded by the amylase present in the germinated maize flour. Separately, on the same day of adding water to the roasted cassava, round slices of banana (13.5 kg) and plantain (1.8 kg) were placed in a large metal pot and kept for 3 days. An odor of alcohol could be detected on the third day. Thereafter, the banana and plantain mixture was added to the cassava mush together with sugar (1.90 kg) and kept for 3 days at an ambient temperature. After this addition to the mush, the glucose concentration first increased and then decreased rapidly over time. During this period, bubbling occurred and an odor of alcohol was detected, indicating that the alcoholic fermentation has begun. The many types of saccharides from banana, plantain and sugar were consumed by the yeast for alcoholic fermentation. After 3 days of fermentation, the mixture was filtered through a punched metal plate. A turbid suspension containing ethanol was obtained, distilled and 17.9 L of *mebwalam* was obtained from 137 L of fermented

suspension (Picture 4.26; 4.27).

At the beginning and the end of the distillation, approximately 200 mL of distillate was collected, and the ethanol concentration and pH value of the distillate were measured (Table 4.5). The ethanol concentration was higher at the beginning (28.6%) of distillation than that at the end (7.80%), which was similar to the trend observed with *kembé*. The temperature of the cooling water during distillation is shown in Fig. 4.7. The temperature increased as the distillation process proceeds.

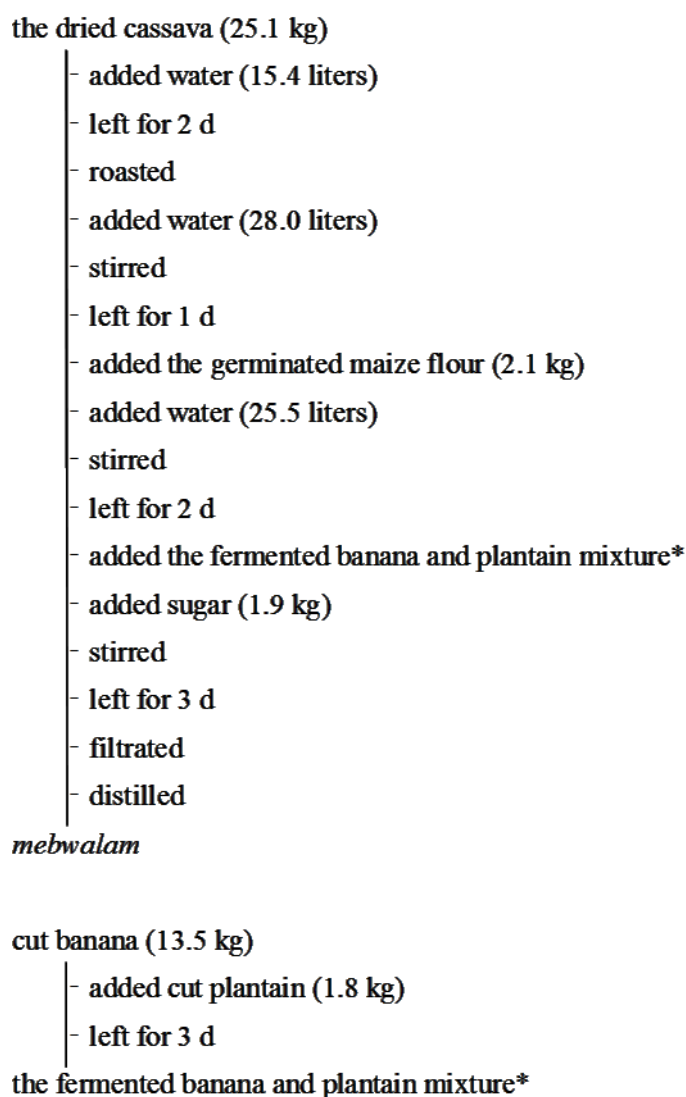


Fig. 4.5 Method for the production of *mebwalam* from cassava (1)

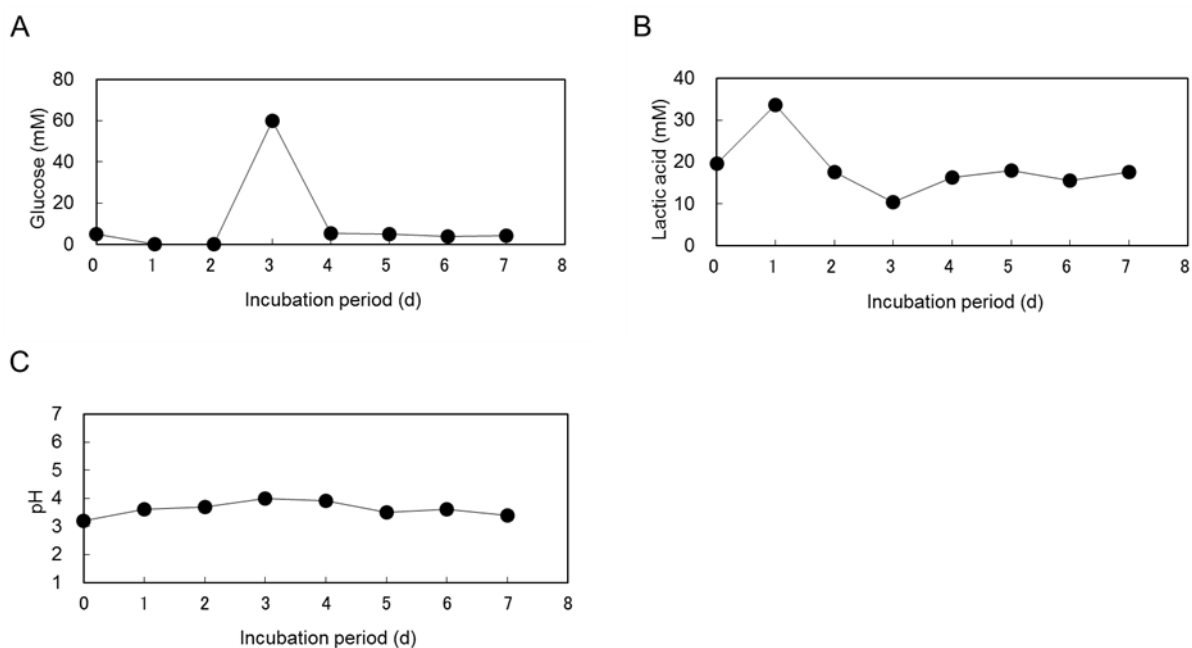


Fig. 4.6 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *mebwalam* from cassava (1)

Table 4.5 The ethanol, glucose and lactic acid concentration and pH value in the beginning and end of distillation and final product of *mebwalam* from cassava (1)

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
The beginning	26.3	<1.10	<0.80	3.7
The end	12.2	<1.10	<0.80	3.9
<i>Mebwalam</i>	20.7	<1.10	<0.80	3.4

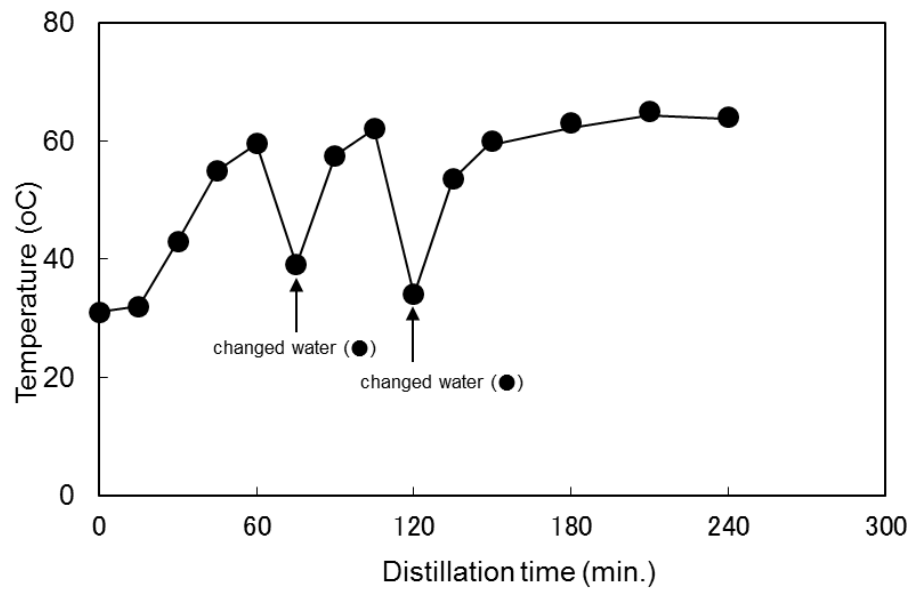


Fig. 4.7 Change in the temperature of cooling water during distillation of *mebwalam* from cassava (1) (from 101 L unrefined to 7.00 L of the product)



Picture 4.23 Moist cassava lumps



Picture 4.24 Roasting the cassava lumps



Picture 4.25 Roasted cassava lumps (*mbosele*)



Picture 4.26 Distillation of *mebwalam*



Picture 4.27 *Mebwalam*

4-1-8. *Mebwalam* (cassava) production (2)

Second method of *mebwalam* production from cassava is as follows (Fig. 4.8). Cassava flour (4.9 kg), which was obtained by milling the dried lumps of cassava as described above, was added to the distillation dregs (39.6 L, 79.5°C) and stirred well (Picture 4.28). Thereafter, the cassava flour and dregs mixture was left to stand for 3 days in a warm location (kitchen). In this step, starch in the cassava flour was gelatinized because the temperature of the dregs was sufficiently high to gelatinize the starch. Because the dregs of the previous distillation contained a large amount of lactic acid and showed a low pH value (Fig. 4.9), contamination with harmful bacteria that could disturb alcoholic fermentation was suppressed, providing suitable conditions for the growth of yeast. After the first 3 days of the gelatinization step, germinated maize flour (2.70 kg), mashed banana (2.10 kg) and water (150 L) were added to the mush, which was left to stand for 5 days at an ambient temperature. In this step, the glucose concentration increased (Fig. 4.9), and other low molecular saccharides were probably produced. These saccharides could be used for fermentation by yeast, which was carried out continuously in the same mush. At the beginning of the second day, bubbling was observed and an alcoholic odor was detected, indicating that the alcoholic fermentation had begun (Picture 4.29). During fermentation, the container containing the mush was kept tightly closed, suggesting that the anaerobic conditions were purposefully maintained to promote the alcoholic fermentation (Picture 4.30). Finally, the fermented mush was distilled in a similar manner to the other kinds of spirits. In the second method of production of *mebwalan* from cassava, 14.4 L of *mebwalam* was produced from 206 L of fermented mush.

Ethanol, glucose and lactic acid concentrations and the pH value of *mebwalam* from cassava were recorded (Table 4.6). The ethanol concentration at the beginning of

distillation (26.3%) was higher than that at the end of distillation and that of the final product, similar to the result observed in the production of *kembé*. At the end of distillation, the ethanol concentration decreased to 12.2%, while that of the final product was 20.7%. Temperature changes during the distillation process are shown in Fig. 4.10. The cooling water was changed twice during distillation to maintain the temperature 78.4%, which is the boiling point of ethanol. The ethanol concentration of the final product of *mebwalam* which was produced with the first method was higher than that of *mebwalam* produced with the second method. A large amount of saccharide source was added over the course of the first method of *mebwalam* production, relative to the second preparation method. Thus, a large amount of ethanol was produced with the first method of *mebwalam* production.

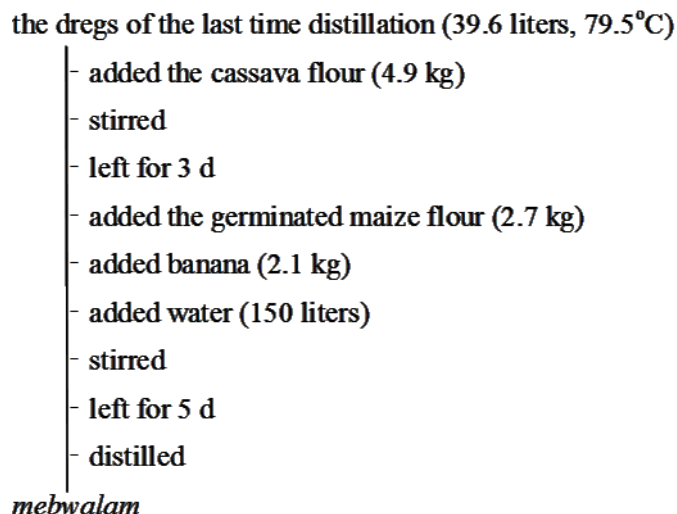


Fig. 4.8 Method for the production of *mebwalam* from cassava (2)

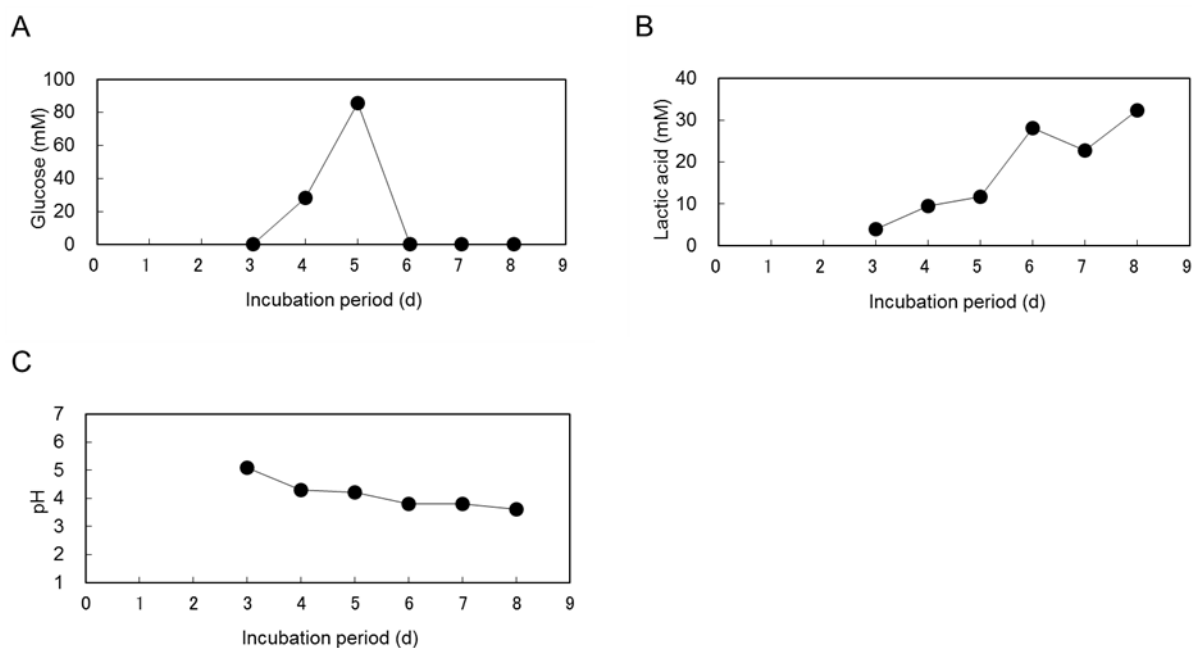


Fig. 4.9 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *mebwalam* from cassava (2)

Table 4.6 The ethanol, glucose and lactic acid concentration and pH value in the beginning and end of distillation and final product of *mebwalam* from cassava (2)

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
The beginning	28.6	<1.10	<0.80	4.3
The end	7.8	<1.10	<0.80	3.5
<i>Mebwalam</i>	22.5	<1.10	<0.80	3.7

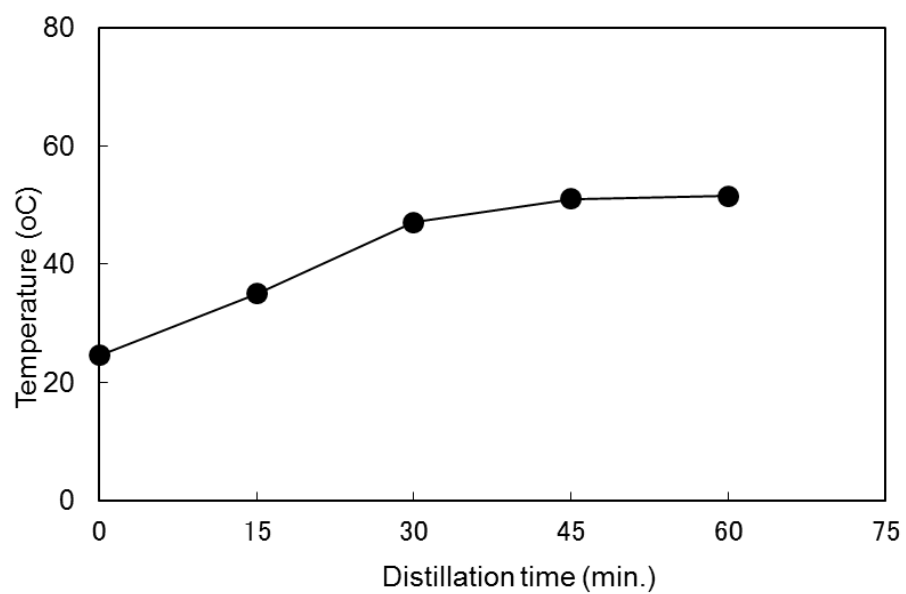


Fig. 4.10 Change in the temperature of cooling water during distillation of *mebwalam* from cassava (2) (from 30.6 L unrefined to 4.00 L of the product)



Picture 4.28 The dregs of the last time distillation



Picture 4.29 The bubbling mush for *mebwalam*



Picture 4.30 The tightly closed container containing the mush for *mebwalam*

4-1-9. *Mebwalam* (maize) production

Mebwalam from maize was prepared as follows (Fig. 4.11). Water (40.0 L) was added to maize flour (53.8 kg), passed through a coarse sieve, and mixed well (Picture 4.31). This solution was left to stand for 2 days in a warm location (kitchen). After 2 days, the maize was roasted in the same manner as described above. The roasted maize lump was eaten directly as with *mebwalam* from cassava and *mbwara* production process (Picture 4.32). After roasting, germinated maize flour (1.00 kg), dregs (17.6 L), the residue remaining after the last distillation, and water (66.1 L) were added together to the roasted maize (Picture 4.33). The dregs had the same effects as described above. After leaving the mixture for half of a day, germinated maize flour (1.60 kg) was added, and the mixture was left to stand for 1 day. After that, germinated maize flour (900 g) was added again, and the mush was left to stand for 1 day. Germinated maize flour (1.10 kg), banana (3.50 kg), sugar (2.00 kg), dried dregs from a previous distillation (150 g) and water (42.4 L) were added, and the mush was left to stand for 2 days (Picture 4.34). On the second day, 1.00 kg of sugar was added, and the mush was left to stand for 4 days in a container covered by a tight lid. Germinated maize flour and sugar were not added to the starchy mush all at once, but rather at several intervals. This method was preferred as it prevented a reduction in the reaction rate owing to the inactivation of amylase in the germinated maize flour, and osmotic effect owing to a high sugar concentration. The method was used to maintain favorable growth and proliferation conditions for the yeast. Finally, the mush was filtered and distilled, and the process for producing *mebwalam* from maize was complete. A total of 18.5 L of *mebwalam* was produced from 195 L of the mush. Changes in glucose and lactic acid concentration and the pH value during the production of *mebwalam* from maize are shown in Fig. 4.12.

The ethanol, glucose, and lactic acid concentration and the pH value of

mebwalam were measured (Table 4.7). The ethanol concentration at the beginning of distillation was 45.9%, which decreased to 11.6% at the end of distillation. The ethanol concentration of the final product was 28.9%, which was higher than that of *mebwalam* from cassava.

The temperature change during the distillation of *mebwalam* is shown in Fig. 4.13. The temperature was kept below 78.4°C, which is the boiling point of ethanol, similar to that used in the production of *mebwalam* from cassava.

the coarse maize flour (53.8 kg)

- added water (40.0 liters)
- stirred
- left for 2 d
- roasted
- added the germinated maize flour (1.0 kg)
- added the dregs of the last time distillation (17.6 liters)
- added water (66.1 liters)
- left for half d
- added the germinated maize flour (1.6 kg)
- stirred
- left for 1 d
- added the germinated maize flour (900 g)
- stirred
- left for 1 d
- added the germinated maize flour (1.1 kg)
- added banana (3.5 kg)
- added sugar (2.0 kg)
- added the dried dregs of the last time filtration (150 g)
- added water (42.4 liters)
- stirred
- left for 2 d
- added sugar (1.0 kg)
- stirred
- left for 4 d
- filtrated
- distilled

mebwalam

Fig. 4.11 Method for the production of *mebwalam* from maize

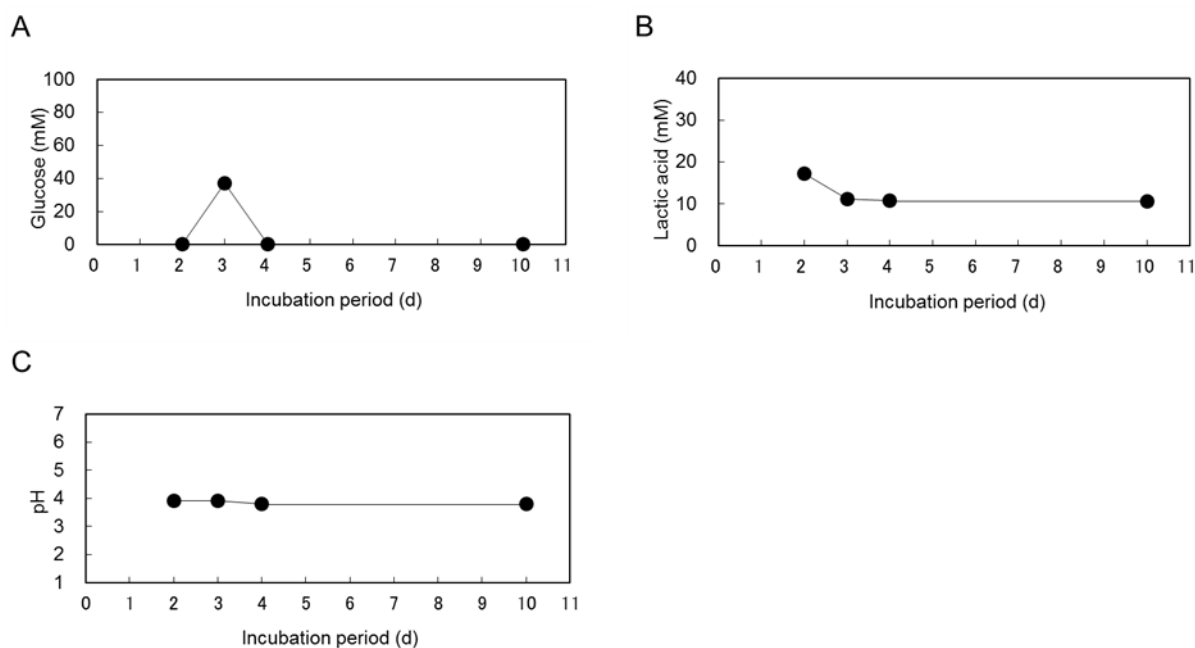


Fig. 4.12 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *mebwalam* from maize

Table 4.7 The ethanol, glucose and lactic acid concentration and pH value in the beginning and end of distillation and final product of *mebwalam* from maize

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
The beginning	45.9	<1.10	<0.80	4.2
The end	11.6	<1.10	<0.80	3.2
<i>Mebwalam</i>	28.9	<1.10	<0.80	4.1

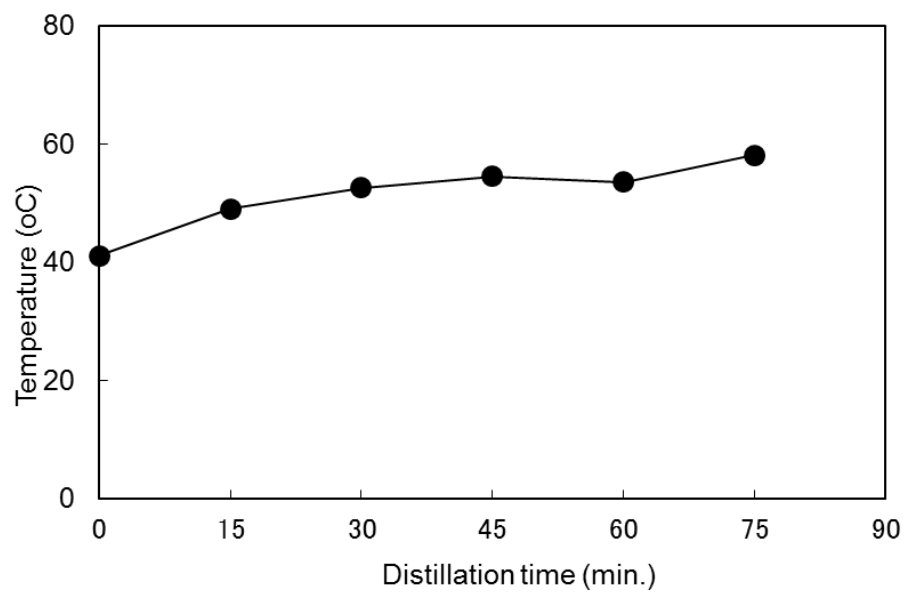


Fig. 4.13 Change in the temperature of cooling water during distillation of *mebwalam* from maize (from 45.4 L unrefined to 4.30 L of the product)



Picture 4.31 Maize flour for *mebwalam* production



Picture 4.32 Roasted maize flour (*mbosele*)



Picture 4.33 A part of the dregs of the last time distillation



Picture 4.34 The mush for *mebwalam*

4-1-10. *Kembé ykone* production

Kembé ykone was brewed as follows (Fig. 4.14). First, hot water (3.71 L, 75.5°C) was added to the plantain residue after making *melok ykone* (described above) and the mixture was left to stand for 4 days, during which the glucose concentration in the supernatant decreased (Fig. 4.15), and an alcoholic taste and odor were detected. On the fourth day, 20 L of oil palm sap and 1.90 kg of sugar were added, and the plantain was mashed by hand (Picture 4.35). The mush was stirred well and left to stand for 2 days. Finally, the mush was distilled, and 5.38 L of *kembé ykone* was produced from 43.2 L of mush (Picture 4.36).

The ethanol, glucose, and lactic acid concentration and the pH value of *kembé ykone* were measured (Table 4.8). During distillation, the ethanol concentration was initially 47.4%, and decreased to 19.8% at the end. The initial ethanol concentration was the highest among all of the spirits produced in the village. Distillate was collected and mixed, and the ethanol concentration of the final product was 36.2%, which was higher

than those of the other spirits.

The temperature change during the distillation of *kembé ykone* is shown in Fig. 4.16. The temperature was maintained below 78.4°C, close to the boiling point of ethanol.

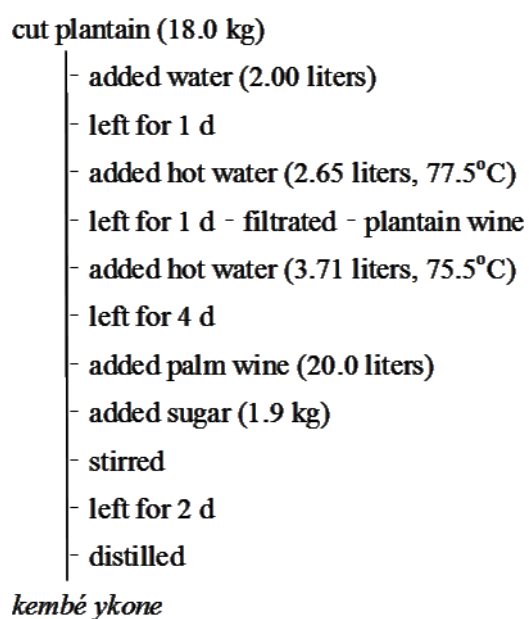


Fig. 4.14 Method for the production of *kembé ykone*

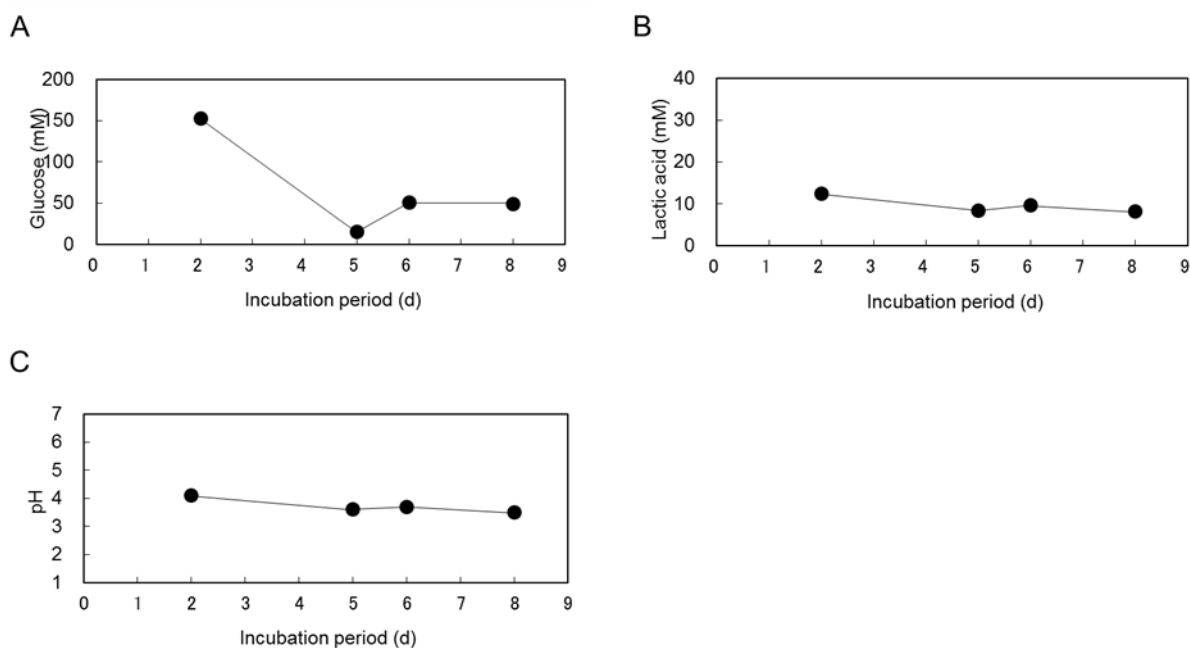


Fig. 4.15 Changes in (A) glucose concentration, (B) lactic acid concentration and (C) pH during the production of *kembé ykone*

Table 4.8 The ethanol, glucose and lactic acid concentration and pH value in the beginning and end of distillation and final product of *kembé ykone*

	Ethanol (%)	Glucose (mM)	Lactic acid (mM)	pH
The beginning	47.4	<1.10	<0.80	4.4
The end	19.8	<1.10	<0.80	2.8
<i>Kembé ykone</i>	36.2	<1.10	<0.80	3.3

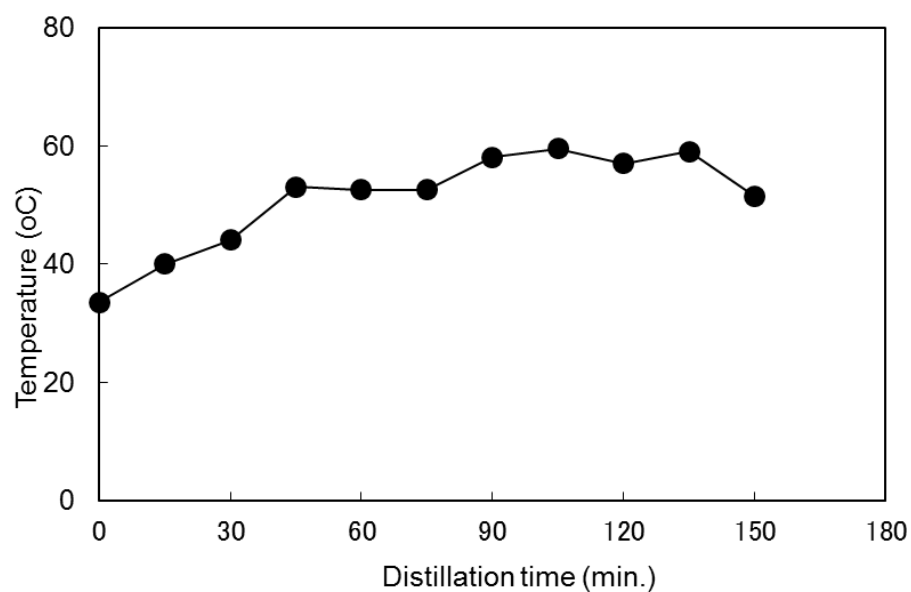


Fig. 4.16 Change in the temperature of cooling water during distillation of *kembé ykone*
(from 43.2 L unrefined to 5.38 L of the product)



Picture 4.35 Mushing the plantain in the mush for *kembé ykone*



Picture 4.36 Preparing distillation of *kembé ykone*

4-2. Discussion

In the village, germinated maize was used as a source of amylase for the production of alcoholic beverages. The optimal temperature of α -amylase from finger millet and sorghum, which are frequently used as amylase sources in the production of indigenous alcoholic beverages in sub-Saharan Africa, was in the range of 50-70°C (Gimbi and Kitabatake, 2002; Kitabatake *et al.*, 2003). However, amylase from maize is inactivated by heating to 50°C, while amylases from finger millet and sorghum are stable at 50°C (Adewale *et al.*, 2006). In the village, the mush for alcoholic beverage containing germinated maize, which is the source of amylase, was not heated intentionally, and alcoholic fermentation proceeded in ambient temperature. This suggests that the villagers understood that the amylase in germinated maize was

unstable above 50°C. The brewers mentioned that germinated maize is better to be prepared with old maize seeds, which are left to stand for 1 year after harvest. This technique is also observed in the brewing of Bupigu village, and its purpose is supposed that waiting adhesion of yeast to the maize seeds (see Chapter 2). Therefore, the use of aged maize seeds for making germinated maize in Andom village might also be conducted in anticipation of making the maize seeds be a yeast carrier.

The pH value of the dregs obtained in the last distillation, which were used for the next fermentation, was maintained below 5. Under this pH condition, proliferation and contamination of other bacteria could be repressed, more than the growth of yeast and lactic acid bacteria would be suppressed. Therefore, by using the dregs for following production of alcoholic beverage, yeast and lactic acid bacteria could take precedence for proliferation over other kinds of microorganisms. According to the villagers, the dregs obtained during the last distillation are important for a successful fermentation, because they accelerate the fermentation.

We clarified that the villagers made various efforts to enhance and stabilize the quality of the alcoholic beverages. The quality of alcoholic beverages is important for producers to generate income and to maintain good relationship with neighborhoods because alcoholic beverages are a source of reward for cooperative work and hospitality by hosts (e.g. attending union meetings, among other reasons). However, despite the various efforts of the brewers, ethanol could not be obtained efficiently from *mebwalam* (cassava and maize), which were produced from starchy material, compared to *kembé*. In *kembé* production, 9,443 kcal of ethanol was produced from 19,200 kcal of carbohydrates. Therefore, 49.2% of calories in carbohydrates were converted into ethanol. In contrast, the converting efficiency of calories from carbohydrate into ethanol of *mebwalam* from cassava which made with first method was 21.4% (from 103,780

kcal of carbohydrates to 22,260 kcal of ethanol), and that of *mebwalam* from maize was 15.2% (from 194,932 kcal of carbohydrates to 29,540 kcal of ethanol). In Andom village, germinated maize was used as a source of amylase in *mbwara* and *mebwalam* (cassava and maize) production. However, maize has low amylase activity compared to finger millet and sorghum, which are generally used in the production of alcoholic beverages in sub-Saharan Africa (Malleshi *et al.*, 1985; Adewale *et al.*, 2006). The low activity of the maize amylase is one of the reasons of the low ethanol producing efficiency in *mebwalam* production from both cassava and maize. Starch in cassava and maize are not saccharified efficiently by the germinated maize in the production of spirits from these materials.

In Andom village, the distilled alcoholic beverages are more popular than the starch-based alcoholic beverage such as *mbwara*. Distillation process might be necessary to produce “high-quality” alcoholic beverage, it means an alcoholic beverage with high ethanol concentration (Willis, 2002), because the amylase activity of germinated maize is not enough to supply fermentable saccharides efficiently for alcoholic fermentation. However, it is also supposed that brewers in the village have not needed to improve brewing techniques to enhance ethanol concentration of the starch-based alcoholic beverage, because they can use *matango* which can be obtained from naturally occurred alcoholic fermentation of oil palm sap.

4-3. Conclusion

In Andom village, many types of alcoholic beverage made from various materials are produced and consumed. In these alcoholic beverages, *matango* is the most important for solidarity confirmation, religious rituals, remuneration for group

labor work and income generation. In contrast, the starch-based alcoholic beverage does not have social importance except for as a refreshment and source of cash income. In the village, the distilled alcoholic beverages are more popular than the starch-based alcoholic beverage. As germinated maize which is used as an amylase source has low starch degrading activity, brewers might need to distill alcoholic beverage to enhance its ethanol concentration.

Chapter 5: Comparison of the indigenous alcoholic beverage production between Bupigu and Andom villages

5-1. Brief introduction and the summary of the indigenous alcoholic beverage production in Bupigu and Andom villages

In previous two chapters, the detailed producing methods of the indigenous alcoholic beverages in Bupigu and Andom villages were clarified. The results of field study revealed that the brewing techniques in two villages had both similarities and differences. The summary of the indigenous alcoholic beverage production in Bupigu and Andom villages are shown in Table 5.1. In this chapter, the features of the indigenous alcoholic beverage production in Bupigu and Andom villages are compared and, based on the comparison, discussion is given on the reasons why specific indigenous alcoholic beverages and brewing techniques are established in two villages.

5-2. Differences in the materials and utilization of the indigenous alcoholic beverage

The results of field study show that there were differences in the materials and utilization of the indigenous alcoholic beverage between Bupigu and Andom villages (Table 5.1). The materials used in the indigenous alcoholic beverage production of Bupigu village were only cereals such as maize and finger millet. On the other hand, in Andom village, various kinds of materials including tree sap, vegetative crops, and cereal were used for the production. In addition, only the starch-based alcoholic beverage was produced and consumed in Bupigu village, whereas the sugar-based and

distilled alcoholic beverages were more popular than the starch-based alcoholic beverage in Andom village.

Table 5.1 Summary of the results of the field studies about indigenous alcoholic beverage production in Bupigu and Andom villages

Types of mterials	Bupigu village		Andom village	
	Cereal		Tree sap, vegetative crops and cereal	
Types of popular alcoholic beverage	Starch-based alcoholic beverage		Sugar-based and distilled alcoholic beverage	
Place to enjoy alcoholic beverages	Local bar (<i>kilabu</i>)		Tent in front of a house (<i>hangar</i>)	
Amylase source for saccharification	Germinated finger millet		Germinated maize	
Germination period of cereals	3 days		Not strictly decided	
Temperature in saccharification	Optimal range of temperature for amylase (50-70° C)		Ambient temperature	
Use of saccharified beverage	Used		Not used	
Use of aged maize as a yeast source	Used		Used	
Temperature management tequniques of mush for fermentation	Keeping in a kitchen, exposing to sunshine		Keeping in a kitchen, exposing to sunshine	
pH management techniques for preventing spoilage of mush	Mixing <i>nyumbo</i> with <i>kikonde</i>		Use of the drgs of distillation	

In Bupigu village, the alcoholic beverage most commonly used for social occasion was *kimpumu* (straw beer). *Kimpumu* was used for cooperative work named *ndanjila* in local language of the village. When a farmer needs to collect manpower for cultivating a field or building a house, a woman in a family brews *kimpumu* and a man invites neighbors. *Kimpumu* is offered as a reward after finishing the labor. *Ndanjila* is, in particular, held to open new field for finger millet cultivation, because much labor for slash-and-burn practice is needed. A part of finger millet harvested in the field is used for *kimpumu* production for opening another field.

On the other hand, *matango* (oil palm wine) was the most important alcoholic beverage in social occasions of Andom village. It is offered in cooperative work as a reward and in ritual situations such as wedding and funeral. In Andom village, oil palm tree is utilized not only for tapping *matango* but also for squeezing cooking oil from fruits, extracting body oil from seeds, making a roof from leaves and building houses and tents and making beds and chairs with rachis (Picture 5.1). The leaves of oil palm trees are also used as decoration by standing them along a road when a ceremony is held (Picture 5.2). In addition to giving sap for *matango*, oil palm tree contributes in many ways to the life of Andom village.



Picture 5.1 A bed made from rachis of oil palm tree



Picture 5.2 Leaves of oil palm tree used as decorations of a ceremony

The most important indigenous alcoholic beverage in Bupigu village was *kimpumu* produced from finger millet, a traditional staple crop in the village. In the village, the indigenous alcoholic beverages were produced from only cereals which are

utilized as staple crops. On the other hand, in Andom village, cassava, a staple crop in the village, was used as a raw material in *mebwalam* (cassava spirits) production. However, it had only little importance in social occasions compared to *matango*. In addition, the production procedure required the use of germinated maize, a kind of cereal, as an amylase source. In *Rubishi* (banana wine) production performed in northwestern part of Tanzania, germinated sorghum is used for degrading starch contained in banana, a kind of vegetative crop (Picture 5.3). Sub-Saharan Africa basically belongs to the region utilizing germinated cereals for the brewing as an amylase source (Chon, 1995) and, therefore, germinated cereal is fundamentally necessary for the production of the starch-based alcoholic beverage. Taking these facts into account, it is supposed that cereal cultivation is an essential factor for the production of starch-based alcoholic beverage even in the regions dominated by vegetative crop cultivation. This supposition corresponds with the fact that most of brewing cultures in the world accompanies with cereal cultivation (Yoshida, 1993).



Picture 5.3 The mush for *rubishi* (husks of sorghum float on the surface)

The place to enjoy the indigenous alcoholic beverages was also different between Bupigu and Andom villages. In Bupigu village, the indigenous alcoholic beverages produced in each household were collected in a local bar (*kilabu* in Swahili) and are sold there (Picture 5.4; 5.5). In the local bar, twice a week, pork or goat was slaughtered and its meat was sold as dressed meat, grilled meat and soup. Villagers enjoyed the indigenous alcoholic beverage with the meat in the bar. The indigenous alcoholic beverages in Bupigu village are not preservable, because microorganisms contained in them are still alive and fermentation still continues when they are consumed. Therefore, they must be finished within one or two days. However, it is practically difficult for the brewers to inform enough number of customers that the indigenous alcoholic beverage was prepared and was ready for enjoy within limited period. As the villagers know that there are the indigenous alcoholic beverages in the local bar every day, the brewers can always find the customers in the local bar. Hence the presence of local bar is important for both customers and brewers to avoid spoiling the unsold products.

By contrast to Bupigu village, in Andom village, the indigenous alcoholic beverages were usually enjoyed in a tent (*hangar* in French) built in front of the brewer's house (Picture 5.6). When the indigenous alcoholic beverage was produced or collected, a bottle with the alcoholic beverage was put on a desk under the tent. Villagers found the sign of the alcohol and visited the tent to drink it. Sellers were mostly women and they sometimes sold an indigenous alcoholic beverage produced by other brewers. In the tent, commercial bottled beer and packed spirits were also sold in addition to the indigenous alcoholic beverages. *Matango* is an alcoholic beverage taken with living microorganisms and is the most popular one in the village. The fermentation process of *matango* is still continuing when it is consumed and, therefore, it must be

finished within one or two days after the tapping. In case that *matango* is not finished within two days, the old *matango* is used as a material for *kembé* production. Since the distilled alcoholic beverage can be preserved for a long period, the brewers do not have to seek enough customers to finish it within few days. The use of the distilled alcoholic beverages in Andom village is fit to the style for selling the indigenous alcoholic beverages.



Picture 5.4 A local bar (*kilabu*) in Bupigu village



Picture 5.5 People of Bupigu village enjoying indigenous alcoholic beverage inside
kilabu



Picture 5.6 People of Andom village enjoying indigenous alcoholic beverage under
hangar

5-3. Differences in the brewing techniques for saccharification

There were three differences in the brewing techniques for saccharification between Bupigu and Andom villages, the cereal used as an amylase source, the period for germination and the temperature in the saccharification process.

First, germinated finger millet was used as an amylase source in the indigenous alcoholic beverage production of Bupigu village, whereas germinated maize was used in Andom village (Table 5.1). Finger millet is one of the most popular materials and the amylase sources in the brewing of sub-Saharan Africa (Hilu and de Wet, 1976; Shayo *et al.*, 2001; Gimbi and Kitabatake, 2002). It has high amylase activity compared to other cereals cultivated in sub-Saharan Africa (Malleshi and Desikachar, 1986; Gimbi and Kitabatake, 2002; Adewale *et al.*, 2006) and, therefore, it can degrade starch and provide substrate for alcoholic fermentation efficiently. The activity of germinated finger millet is maximized at 3 days of germination (Malleshi and Desikachar, 1986; Nirmala *et al.*, 2000). It is consistent with the period for which the brewing at Bupigu village employs. Therefore, in the brewing technique of Bupigu village, efficient starch degradation was guaranteed not only by the selection of cereals with a high amylase activity but also by setting the appropriate germination period to maximize its activity. In addition, in the course of the production, the mush containing germinated finger millet was heated in the range of temperature at which the amylase in finger millet can degrade starch effectively (Gimbi and Kitabatake, 2002; Lyumugabe *et al.*, 2010). It must contribute to effective saccharification. That is, in the indigenous alcoholic beverage production of Bupigu village, effective saccharification was enabled by the combination of the strong amylase source, appropriate germination period and enough high temperature for maximizing the enzymatic activity.

On the other hand, in Andom village, germinated maize was used as an amylase source in the production of the indigenous alcoholic beverages from starchy materials. The amylase activity of maize is weaker than that of finger millet (Malleshi and Desikachar, 1986; Adewale *et al.*, 2006). Therefore, effective starch degradation is not expected in this case. The germination period of maize in Andom village was 5-7 days. However, it was more flexible among brewers and not precisely defined compared to that of finger millet in Bupigu village. Not like in the case of Bupigu village, the mush containing germinated maize was not heated in the course of the production. That is, saccharification was carried out in ambient temperature. Therefore, effective starch degradation is not expected in the indigenous alcoholic beverage production of Andom village compared to that of Bupigu village. On the other hand, it can also be supposed that, in the indigenous alcoholic beverage production of Andom village, saccharification is carried out in ambient temperature deliberately for retaining the amylase activity of germinated maize, because the amylase of maize is denatured when it is heated over 50°C (Adewale *et al.*, 2006).

Compared to Bupigu village, the techniques for saccharification in Andom village seems not to be sophisticated in terms of the effectiveness in starch degradation. It is supposed that the lack of effective techniques for saccharification causes flourishing production and consumption of the distilled alcoholic beverage and infrequent use of the starch-based alcoholic beverage. In addition, the use of sugar or banana in *mebwalam* production might compensate the weakness of amylase activity in germinated maize. However, in another viewpoint, it is supposed that effective techniques for saccharification has not been needed to be developed in the indigenous alcoholic beverage production of Andom village, because *matango*, which is the most important indigenous alcoholic beverage in the village, can be obtained from

spontaneous alcoholic fermentation of oil palm sap without saccharification process.

Saccharified beverage, which is produced by degrading starch in the materials into fermentable saccharides, was consumed only in Bupigu village, whereas it is lacking in Andom village. This difference is caused by the difference in the brewing techniques in saccharification which are carried out in each village. Saccharified beverage has sweet taste and high fluidity (Svanberg and Lorri, 1997). These properties can be obtained only if starch in the raw material is effectively saccharified. The combination of effective techniques for saccharification in Bupigu village enables to produce sweet and fluid saccharified beverage. It is used as a weaning food for small children, because it has low viscosity suitable for easy digestion and high nutritive value per volume (Brandtzaeg *et al.*, 1981). Furthermore, it is also used as an energy drink in the time of hard work such as farming (Kitabatake *et al.*, 2003).

5-4. Similarities in the brewing techniques for fermentation

Although many differences were found in the general brewing culture and the brewing techniques for saccharification between Bupigu and Andom villages, it was revealed that two villages have similarities in the brewing techniques for fermentation (Table 5.1). The similarities are as follows.

Firstly, aged maize, which is stored for more than one year after harvest, was used as a yeast source in the indigenous alcoholic beverage production of both Bupigu and Andom villages. Brewers in Bupigu village mentioned that fresh maize does not bring sufficient alcoholic fermentation of the mush and strong alcoholic taste of the product, and believed that the use of aged maize is necessary for successful alcoholic beverage production. In the same manner, brewers in Andom village mentioned that the

addition of aged maize brings swift bubbling, which means swift alcoholic fermentation, of the mush. Yeasts in atmosphere are supposed to adhere to maize surface during storage, and with this process, aged maize may become a yeast source for the alcoholic beverage production. In addition to aged maize, dried dregs from a previous filtration, which are leftovers of the mush after filtration in last time production, were also used as a yeast source in *mebwalam* production in Andom village.

Secondly, in the indigenous alcoholic beverage production of both villages, the mush for alcoholic beverage were kept in kitchen, or exposed to sunshine, in order to increase its temperature and to encourage yeast growth and alcoholic fermentation (Picture 5.7). For example, in Bupigu village, the mush for *nyambo* of *kimpumu* was intentionally stored nearby cooking fire in the course of the production. The brewer said that keeping the mush warm helps swift occurrence of bubbling. In addition, the mush for *nyambo* of *komoni* was exposed to sunshine during the production for increasing its temperature. As the technique observed in *kimpumu* production, this technique is also to encourage the swift bubbling of the mush as well as the swift yeast growth and alcoholic fermentation. These techniques were also applied in Andom village. Like in the *kimpumu* production in Bupigu village, the mush for *mebwalam* is kept nearby cooking fire for enhancing its temperature. In *kémbe* and *kembé ykone* production, the mixture of *matango* and sugar and the mush for *kembé ykone* were exposed to sunshine as observed in *komoni* production of Bupigu village, under the intention for accelerating yeast growth and alcoholic fermentation.

Finally, the technique to avoid contamination of harmful bacteria into the mush by lowering its pH value was commonly observed in the indigenous alcoholic beverage production of both villages. The fundamental brewing method in Bupigu village was to mix two kinds of mush, *nyambo* and *kikonde*. Between them, *nyambo* was a lactic

fermented mush containing lactic acid, and took a role of a culture of yeast. In the production of all three kinds of indigenous alcoholic beverages in Bupigu village, the pH value of *nyambo* showed below 4, at which the growth of microorganisms except for yeast and lactic bacteria is suppressed (Mensah, 1997; Nout and Motarjemi, 1997; Abegaz *et al.*, 2002b; Oi and Kitabatake, 2003). At the end of the production, *nyambo* was mixed with *kikonde* and the yeast cultured in *nyambo* made alcoholic fermentation using fermentable saccharides contained in *kikonde*. Fermentable saccharides in *kikonde* are consumed as nutrients not only by yeast but also by other kinds of microorganism. Therefore, it is easily spoiled by the proliferation of harmful microorganisms, if it is left to stand for long period. However, by mixing with *nyambo* after finishing *kikonde* preparation, yeast in *nyambo* may proliferate immediately and produce enough amount of ethanol to suppress the growth of other microorganisms.

In Andom village, the technique for lowering the pH value was observed in *mebwalam* production. The technique was the use of the dregs after distillation. The dregs are the leftovers after distillation process of *mebwalam* production. In *mebwalam* production, two methods for using the dregs were observed. First one is to start the production with the dregs as a starter mush. In the beginning of the production, the materials such as cassava flour and germinated maize flour were added into the dregs. Second method is to add a part of the dregs into the mush for *mebwalam* including other materials. The use of the dregs does not mean the inoculation of microorganisms such as yeast and lactic bacteria, because they must be killed in the course of distillation. However, as the pH value of the dregs was below 4, the technique might work for decreasing the pH value of the mush and contribute to protect it against contamination of harmful microorganisms.



Picture 5.7 Exposing the mush for *kembé ykone* to sunshine

5-5. Conclusion

In this chapter, the differences and similarities between the indigenous alcoholic beverage production of Bupigu and Andom villages were discussed. In Bupigu village, only the starch-based alcoholic beverage made from cereal was produced and consumed, and it had social importance. On the other hand, in Andom village, various materials including tree sap, vegetative crops and cereals were used for the indigenous alcoholic beverage production and the sugar-based and the distilled alcoholic beverages were more popular than the starch-based alcoholic beverage.

The brewing techniques for saccharification seem to be more sophisticated in Bupigu village. Efficient saccharification is more important in the production of the starch-based alcoholic beverage than that of the sugar-based and the distilled alcoholic

beverages. Therefore, developing the brewing techniques for saccharification is more crucial in the indigenous alcoholic beverage production of Bupigu village than that of Andom village. The difference of efficiency in the brewing techniques for saccharification might be relevant to the difference in the use of saccharified beverage between two villages, because its production needs effective starch degradation.

Although different brewing techniques for saccharification were observed between Bupigu and Andom villages, similar brewing techniques were practiced in fermentation processes. The indigenous alcoholic beverage productions in both villages require efficient brewing techniques for fermentation, because efficient fermentation is necessary for regardless of the sugar-based, starch-based and distilled alcoholic beverage productions.

Chapter 6: Conclusion and the future study

6-1. Conclusion

In this study, the detailed method of the indigenous alcoholic beverage production in Bupigu and Andom villages were clarified. In addition, the brewing techniques in the two villages were evaluated from food scientific viewpoint. Furthermore, the revealed characteristics of the indigenous alcoholic beverage production in the two villages were compared.

The brewing techniques for saccharification in Bupigu village, where only the starch-based alcoholic beverages are utilized, were effective in degrading the starch in the materials into the fermentable saccharides. The effective brewing techniques for saccharification helped the brewers to increase the ethanol content of the starch-based alcoholic beverages. On the other hand, the brewing techniques for saccharification in Andom village were not sophisticated compared to those of Bupigu village. However, since the sugar-based and the distilled alcoholic beverages are obtainable as well as the starch-based alcoholic beverage in Andom village, the villagers can enjoy the indigenous alcoholic beverages with enough amount of ethanol even though the effective brewing techniques for saccharification are not established.

Different from the brewing techniques for saccharification, those for fermentation were similar between the indigenous alcoholic beverage productions of the two villages. Alcoholic and lactic fermentation are similarly important in the production of the sugar-based, the starch-based and the distilled alcoholic beverages. Therefore, the incentive to develop the brewing techniques for fermentation might have existed in the indigenous alcoholic beverage productions of both Bupigu and Andom villages.

These facts, the different brewing techniques for saccharification and the similar brewing techniques for fermentation, suggest that the brewing techniques in the two villages have been developed according to the practice of drinking and the obtainable raw materials of the indigenous alcoholic beverages. That is, the indigenous alcoholic beverage productions in the two villages have been adapted to the climates and the cultures of the regions with long period.

6-2. The future study

This study revealed the high effectiveness of the brewing techniques in Bupigu village. The brewing technique to mix two different kinds of mush, which are the sources of yeast and fermentable saccharides respectively, was observed not only in Bupigu village but also in the indigenous alcoholic beverage production of Zimbabwe (Bvochora and Zvauya, 2001). In addition, the straw beer like *kimpumu* in Bupigu village is widespread through sub-Saharan Africa (Kakeya and Sugiyama, 1985; Mwesigye and Okurut, 1995; Yoneya and Miyamoto, 1999; Ankei, 2002; Sugiyama, 2007). Furthermore, the existence of the straw beer was described in the monuments of ancient societies (Ellison, 1978; Katz and Voigt, 1986; Yoshida, 2008a; Damerow, 2012), and the straw beer is produced and consumed in a number of societies in the Southern and Southeastern Asia (Yoshida, 1993; Lisdiyanti and Kozaki, 2005; Kimata, 2008; Yoshida, 2008b; Miura, 2009). Therefore, the indigenous alcoholic beverage production of Bupigu village can be typical of not only that in sub-Saharan Africa but also that in the societies with cereal utilization in the past and present world. A challenge to clarify the alcoholic beverage production in the ancient period through the investigation into that of sub-Saharan Africa should be carried out in the future, because the indigenous

alcoholic beverage production in sub-Saharan Africa and ancient societies have a lot of common features (Delwen, 1997).

Finger millet and sorghum are domesticated in sub-Saharan Africa, and often used for the indigenous alcoholic beverage production (Hilu and de Wet, 1976; Nout and Davies, 1982; Mukuru *et al.*, 1992; Ekundayo, 1996; Shayo *et al.*, 2001; Gimbi and Kitabatake, 2002; Pale *et al.*, 2010). High amylase activity of these cereals is the advantageous feature for brewing alcoholic beverage (Malleshi and Desikachar, 1986; Gimbi and Kitabatake, 2002; Adewale *et al.*, 2006). In the indigenous alcoholic beverage production of Bupigu village, finger millet was used as an amylase source. In the production, the sophisticated brewing techniques to make the most of its amylase activity were carried out. The result suggests the importance of the indigenous alcoholic beverage production in the utilization of finger millet, and it might apply to the case of sorghum. In addition, since the brewing techniques have been sufficiently developed to make the most of the capacity of these cereals, the tight relationship between the indigenous alcoholic beverage production and the cereals should have been last for a long period. Kavanagh concluded that the brewing had encouraged human to develop plant domestication and cultivation (Kavanagh, 1994). Katz and Voigt also insisted that the brewing had contributed to change the human livelihood from hunting-and-gathering to agriculture (Katz and Voigt, 1986). Therefore, the great contribution of the indigenous alcoholic beverage production to the cereal domestication in sub-Saharan Africa is expected. The dynamics of the indigenous alcoholic beverage production and the cereal domestication in sub-Saharan Africa must be studied in the future study.

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