Improvement in Traditional Technology of Rice and Millet Based Fermented Beverages of Arunachal Pradesh, North East, India through Scientific Approach

Karuna Shrivastava, Greeshma A. G., and Brijesh Srivastava

Abstract**—** *Apong* and *Madua Apong*, two commonly used beverages of Arunachal Pradesh produced traditionally from rice and millet respectively under uncontrolled fermentation; resulting in low productivities. The present study was conducted with the main aim of improving traditional bioprocessing. The improved production technology for above two ethnic drinks was developed by applying scientific tactics. As a result, more quantity of *Apong* (6-7L/kg) and *Madua Apong* (5-6L/kg), was extracted under laboratory condition as compare to traditional preparations (3-4L/kg). Biochemical analysis shows higher alcohol contents (7.6 %) with lesser carbohydrate (7.1g/100g) total reducing sugar (5.2%) and ash contents (1.02%) in laboratory prepared *Apong* as compare to traditionally prepared (8.5g/100g, 6% and 1.03-1.04 respectively) beverage. Similar results were also obtained in laboratory prepared versus traditionally prepared *Madua Apong* (alcohol-7.8%/5.5-6.2%; carbohydrate-5g/100g/5.5g/100g; total reducing sugar-3.2%/4%).

Improved quality with enhanced shelf life (3-5 days) of product could be achieved through simple techniques like pasteurization and clarification as compare to earlier practice (1-2 days) at room temperature. These beverages were then evaluated through sensory analysis by a panel of local experts at 05 point scale (very good, good, fair, poor and very poor). The laboratory prepared fresh Apong (either pasteurized or clarified) was rated as superior (5 points) with very good taste and no off-odours; however sample subjected to both techniques showed a poor after taste, moth feel and astringency hence rated as very poor (1 point) by expert panel. But no change in the taste was recorded in the case of *Madua Apong* even after pasteurization and reported as very good by expert panelists. It was concluded that the fermentation rate, yield and nutritional quality of traditionally prepared alcoholic beverages may be enhanced by using pure yeast strain(s) under aseptic conditions without change in their organoleptic properties. This work is the first of its kind and may help to set-up cottage/small scale industry of fermented traditional beverages for improved livelihood.

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I. Introduction

THERE are wide variety of fermented products produced worldwide that have not received the scientific attention they deserve [1]. The production of fermented foods and beverages still remains today largely a traditional family art done in homes in a crude manner which result in low yield and poor quality [2]. There is no control in fermentation and purity of the prepared drink. Shelf life of traditionally prepared drink remains too low due to the presence of high microbial load as well as solid particle deposits. Growth of any yeast other than the desired strains during fermentation and maturation or any yeast after packaging lead to off-flavours and turbidity, essentially the beer spoils.

Among various types of indigenous fermented beverages prepared and consumed by different ethnical groups of Arunachal Pradesh for centuries, *Apong and Madua Apong* are two most commonly used drinks [3]-[5]. Ever since the process technology of fermented beverage preparation took place in pure traditional way, there is no control in fermentation and purity of the prepared product. Consequently, the production has not reached the status of even a cottage industry in this region, although these drinks contribute to a large proportion of the daily food intake especially in rural areas. In urban areas also, they are required on all occasions, customary ceremonies, rituals and other important events and not restricted to even children and women.

Growth of any yeast other than the desired strains during fermentation and maturation or any yeast after packaging \ lead to off-flavours and turbidity, essentially the beer is spoiled [2]. Good manufacturing and hygiene practices are needed to prevent these outcomes. Shelf life of traditionally prepared drink is too low due to the presence of high microbial load as well as solid particle deposits. Selection and development of potent microbial strain(s), control and manipulation of fermentation conditions may increase the efficiency of fermentation process and increased recovery of product [6]-[8]. Purification and sterilization of the drink may also help to increase the shelf life of the prepared drink. Application of modern techniques to improve the home made beer process technology may help local people to get better quality and

quantity of product [9]. Considerable ranges of modern technologies are now being applied for improving traditional fermentation technology and thus upgrading the quality as well as quantity of final product. The newer methods can be applied in various fields like development of raw materials for fermentation as well as starter culture (s), pure microbial cultures, improvement in fermentation process for commercialization and popularization of indigenous fermented foods [2].

Traditional fermentation practices are labour intensive, time consuming and craft-based resulting with lower productivity due to the factors like crude handling, lesser shelf life and lack of homogeneity [[2] despite the dawn of science and technology. Studies were conducted to overcome these hardships and propose an easy technology through scientific approaches to the local people to improve their livelihood quality/quantity of fermented product with enhanced shelf life. The results are presented and discussed here in detail.

II. Materials And Methods

Tribal community inhabiting in Arunachal Pradesh of India prepare the rice and millet based traditional fermented beverages using mixed microbial starter cultures under uncontrolled conditions. This may affect the reproducibility, taste and shelf life of the beverage drinks. In order to improve the traditional process technology, the rice (*Apong*) and millet (*Madua Apong*) beverages were prepared in the laboratory using laboratory prepared starter cultures consisting of *Saccharomyces cerevisiae* (YTCC 53 of departmental culture collection) under hygienic conditions.

A. Preparation of starter culture in the laboratory

The starter culture was prepared in the laboratory aseptically under standard conditions using rice and pure culture of *Saccharomyces cerevisiae* (YTCC 53). Yeast cell suspension was prepared by mixing two loopful of pure yeast cells in 100 ml sterile distilled water and incubated at 28^0 C for four days. 100 g glutinous rice soaked in 1 liter of water for half an hour, washed, dried in an electric drier and then powdered by an electric mixer grinder. In a sterile steel vessel, rice powder and yeast cell suspension were mixed using a sterile spatula and kept in an incubator at 28^0 C for two days. After incubation, the mixture was molded into small flat cakes having 10 g weight each using gloves wore hands. The cakes were then dried in a drier at 30^0 C for two days and kept in sterile air tight bottles for further use.

B. Preparation of Apong (rice beverage) and Madua Apong (millet beverage) using laboratory prepared starter culture under standard conditions

To prepare the *Apong*, 1 kg of cleaned and washed rice was soaked in 2 liters of water for about 3 hours or till the rice become soft. This rice was cooked for 5-10 minutes to become softer. The cooked rice was spread over pre-sterilized steel trays for cooling. The rice was covered with thin muslin cloth to avoid contamination due to dust, flies and insects. After cooling, 40 g (four balls) powdered laboratory prepared starter culture was added to rice and mixed with sterile spatula. For proper and even mixing, the batch may be mixed with gloves wore hand to maintain sterility. The total weight of the batch was about 1.8 kg after mixing. The rice starter mixture was kept in sterile, dried steel vessels having tight lids and kept for fermentation for 4 days at 30° C. The batch was harvested after fermentation indicated by strong alcoholic smell. This fermented batch was mixed with potable water in wide open container and stirred. The one liters of water was used for every 250-300 g of fermented batch. This mixture was filtered with plastic sieve and muslin cloth and the filtrate was called *Apong*.

For *Madua Apong*, 1 kg of cleaned millet was roasted over medium flame for 30minutes. This was then soaked in 2 liters of water for about 3 hours and cooked for 10-15 minutes till it become soft. The cooked millet was cooled by spreading over a pre-sterilized steel tray. The tray was covered with thin muslin cloth to avoid contamination. After cooling, 40 g (four balls) powdered laboratory prepared starter culture was added with cooked millet and mixed with sterilized spatula. For proper and even mixing, gloves wore hands were used in order to maintain sterility. The total weight of the batch found to be 1.7 kg after mixing. This mixture was kept in sterile, dried steel vessels having tight lids and kept for fermentation for 6 days at 30°C. The batch was harvested after fermentation, which was indicated by good alcoholic smell. This fermented batch was transferred to container having perforation in bottom which is covered with single layer muslin cloth. Boiling potable water was slowly sprinkled/ poured slowly over the mixture at a rate of 2 liter/hour. The filtrate collected at the bottom of the container is called *Madua Apong*. About 6 liters of water was used for 1 kg of raw millet. The quality of drink varies from good to fair depends upon the time of collection of filtrate. Very first collected filtrate was of the best quality in terms of alcoholic taste with pleasant aroma, golden in color and transparent.

C. Biochemical and nutritional analysis of traditionally as well as laboratory prepared beverage samples

Traditionally prepared *Apong* and *Madua Apong* samples collected during survey were analyzed for their biochemical and nutritional properties such as Moisture content, Acidity, Alcohol contents, Ash contents, Carbohydrate and Reducing sugar following the standard methods of measurement [10]-[12]. Laboratory prepared *Apong* and *Madua Apong* samples were also tested for all above parameters and results were compared with that of traditional ones. The alcohol content in the early stages of fermentation of beverages is too low for an intoxicating effect (Rose 1997).

D. Improvement in traditional bioprocess technology of laboratory prepared beverages

Laboratory prepared beverages were filled in 50 ml centrifuge tubes and the clarification was done with centrifuge at 8000 rpm for 10 minutes. The clear supernatant was taken and used as beverage. The clarified as well as unclarified beverages were also subjected to pasteurization by holding technique [13].

E. Sensory analysis of traditionally as well as laboratory prepared beverage samples

Sensory analysis of laboratory prepared un-pasteurized, pasteurized, centrifuged and both pasteurized and centrifuged samples was carried out by expert panelist. Ten numbers of local expert persons, who were usually consuming these traditional alcoholic beverages, were selected for the sensory evaluation. The sensory analysis was evaluated on 5 point scale such as very poor (1), poor (2), fair (3), good (4), very good (5) based on different parameters such as color, aroma, bitterness, clarity, alcoholic taste, mouth feel, after taste, astringency and general acceptability. Prior to the presentation of the product, each sample was coded and placed along with a glass of water (to rinse the mouth) in the laboratory. The panelists were instructed to evaluate each sample by blind tasting as per the score card.

G. Study on storage or shelf life of laboratory prepared beverages

The shelf life of improved beverage samples prepared in the laboratory was studied by keeping in separate sterile sample bottles of 100ml capacity at room temperature (25-30^0 C) in ten replicates for ten days. One bottle from each samples were harvested every day for its biochemical and sensory analysis up to 10th day.

III. Results And Discussion

A. Laboratory fermentation of two traditional beverages under standard conditions

Apong and *Madua Apong* were prepared well under standard laboratory conditions and standardized by emitting good alcoholic smell after 4 days and 6 days respectively. About 6-7 liters of *Apong* was extracted from 1 kg of rice in laboratory condition, where as it was 3-4 liters only under traditional conditions. Laboratory prepared *Apong* appeared in pure white color with good alcoholic flavor. Similarly, about 5-6 liters of laboratory prepared *Madua Apong* was extracted as compared to traditional conditions (3-4 liters) in clear, golden yellow color emitting strong alcoholic smell. All these provided an evidence for good fermentation rate under laboratory conditions. The pure starter culture is generally not used in traditional bioprocesses and it contains unwanted microorganisms from environment as spontaneous fermentation of cereals during fermentation of traditional foods and/or beverages are essentially the micro-flora of the raw materials and equipment [14] and [15. Millets, Sorghum, maize etc. but not the rice are also some of the common substrates usually used in Africa for producing a wide variety of beverages [16]. Cereal malt is one of the main raw materials used to prepare various traditional alcoholic beverages of West Africa : *dolo* (Mali, Burkina Faso), *tchoukoutou* and *chakpalo* (Benin, Togo, Niger, Côte d'Ivoire), *burukutu* or *pito* (Nigeria, Ghana), *dam* (Togo), but also non-alcoholic beverages like *gowé* (Benin).

B. Biochemical and nutritional properties of traditionally as well as laboratory prepared Apong and Madua Apong

The biochemical and nutritive properties of traditional (**Table I)** as well as laboratory prepared alcoholic beverages were analyzed and compared with the aim of improvement, to help the local people prepare better quality drinks with ease in their prevailing procedure. In general, it was found that laboratory prepared beverages have higher nutrient contents as compared to traditional (**Table II & Table III**) prepared drinks.

Biochemical/nutritive analysis of *Apong* shows that the laboratory prepared beverages have higher alcohol contents i.e.

TABLE I
BIOCHEMICAL COMPOSITION / NUTRITIVE VALUES OF THE TRADITIONALLY PREPARED ALCOHOLIC BEVERAGE SAMPLES

S. No.	Samples	Moisture content (%, wb)	Acidity (%)	Alcohol (%)	Carbohydrate (mg/g)	Ash g/100g)	Reducing Sugar (%)
1	A-1	87.0	1.03	5.0	7.0	0.1	6.0
2	A-2	86.0	1.0	5.0	7.5	0.2	5.2
3	A-3	90.0	1.0	4.5	7.2	0.3	5.2
4	A-4	85.0	1.02	4.5	8.0	0.1	6.0
5	A-5	87.0	1.02	4.2	8.5	0.1	5.0
6	A-6	91.0	1.18	5.0	8.3	0.1	5.2
7	A-7	88.0	1.0	5.5	8.5	0.1	5.0
8	A-8	90.0	1.0	4.5	7.5	0.3	6.0
9	A-9	90.0	1.0	4.4	8.7	0.1	5.8
10	A-10	86.0	1.02	4.2	8.0	0.2	6.0
11	A-11	85.0	1.01	5.5	8.5	0.1	5.2
12	A-12	90.0	1.02	5.5	7.9	0.1	5.1
13	A-13	86.0	1.0	6.0	8.0	0.2	5.5
14	A-14	90.0	1.0	5.5	8.0	0.3	5.5
15	A-15	88.0	1.0	5.5	8.5	0.2	5.5
16	A-16	92.0	1.02	5.5	8.0	0.3	6.0
17	A-17	89.0	1.02	5.5	8.5	0.2	5.2
18	A-18	90.0	1.02	5.5	7.6	0.2	6.0
19	A-19	91.0	1.02	5.5	8.0	0.2	5.2
20	A-20	90.0	1.03	5.5	8.2	0.2	6.0
21	A-21	90.0	1.01	5.4	7.6	0.2	5.1
22	M-1	90.0	1.0	5.5	5.0	0.1	3.8
23	M-2	90.0	1.0	5.8	5.5	0.1	3.8
24	M-3	90.0	1.0	5.8	5.5	0.1	4.0
25	M-4	90.0	1.0	5.5	5.5	0.1	3.8
26	M-5	93.0	1.0	6.2	5.5	0.1	4.0
27	M-6	90.0	1.0	5.5	5.0	0.1	3.0
28	M-7	92.0	1.0	6.2	5.0	0.1	3.0

(wb – wet basis)

TABLE II
COMPARISON OF NUTRITIVE/BIOCHEMICAL PROPERTIES OF TRADITIONALLY AS WELL AS LABORATORY PREPARED *APONG*

Sl. No.	Nutritive/biochemical properties	*Apong*	
		Traditionally prepared	Laboratory prepared
1	Moisture content (%,)	87-90	90-91
2	Acidity	1.03 -1.04	1.02
3	Alcohol (%)	4.2 -5.5	7.6
4	Carbohydrate (g/100g)	7.0 - 8.5	7.1
5	Ash (g/100g)	0.1 - 0. 3	0. 2
6	Reducing Sugar (%)	5.1 – 6.0	5.2

7.6 % than traditionally prepared *Apong* (4.2-5.5%) where as the carbohydrate content and total reducing sugar of laboratory prepared *Apong* was foundwith slightly lesser values (7.1g/100g and 5.2% respectively) as compare to traditionally prepared (7-8.5g/100g and 5.1-6% respectively) *Apong*. The ash contents of lab prepared *Apong* was recorded as 1.02%, as compare to

TABLE III
COMPARISON OF NUTRITIVE VALUE OF TRADITIONALLY AND LABORATORY PREPARED *MADUA APONG*

Sl. No.	Nutritive/biochemical properties	*Madua Apong*	
		Traditionally	Laboratory

		prepared	prepared
1	Moisture content (%,)	92-93	93-94
2	Acidity	1.0	1.0
3	Alcohol (%)	5.5 - 6.2	7.8
4	Carbohydrate (g/100g)	5.0 - 5.5	5.0
5	Ash (g/100g)	0.1	0.1
6	Reducing Sugar (%)	3.8 - 4.0	3.2

traditionally prepared (1.03-1.04%). Other parameters like moisture contents and acidity showed no noticeable differences and were recorded as 87-91% and 0.02-0.03 g/100g respectively. The comparison of biochemical/nutritional values of laboratory and traditionally prepared *Madua Apong* showed higher alcohol content (7.8 %) than traditionally prepared one (5.5-6.2%) where as the carbohydrate content and total reducing sugar of laboratory prepared *Madua Apong* was found to be lesser (5g/100g and 3.2% respectively) as compare to traditionally prepared (5.5g/100g and 4% respectively) beverage. Similarly, the parameters like moisture contents, ash contents and acidity showed no noticeable differences and were 92-94%, 0.1 g/100g and 1.0 % respectively. *Madua Apong* of Arunachal Pradesh normally has higher alcoholic contents among other beverages. Many of the African traditional cereal fermented beverages had lesser alcohol contents ranging from 1.63 – 5.2 % [16] as compare to 4.2 – 6.0% and 5.5 – 6.2% in traditionally prepared Apong and Madua-Apong respectively reported in our studies. The percentage of alcohol increased greatly up to 8.1% in case of Apong prepared through improved technology of clarification through centrifugation and 7.8% through pasteurization. Apong is considered as a low alcoholic beverage; consumed by adults as well as women including children [3]. The low alcohol Ethiopian beverage Karibo is also consumed by both adults and children [14] and remains a part of their diet.

In several African countries, traditional cereal fermented beverages are consumed as dietary items due to their high nutritional value as they satisfy hunger [16]. They are as a source of energy providing important nutrients to contribute to the diet of the population [2], [17] - [19]. Reference [16] also reviewed biochemical composition parameters of a number of alcoholic and non-alcoholic beverages of Africa such as Calories (Kcal/100 ml), Moisture (g), dry matter (%), Protein (g), Lysine (g/100 of proteins), Fat (g) and Total sugars (g), Vitamins etc.

Increase in alcohol content and decrease in carbohydrate and total reducing sugars of the laboratory prepared beverages proved a high rate of fermentation by degrading more starch in standard conditions. Comparatively high ash contents in traditionally prepared beverages may be due to the presence of more unfermented cereal particles or contaminants. Absence of bacterial contaminants in both preparations was evidenced by low acidity.

C. Improvement in traditional bioprocess technology of laboratory prepared beverages

The simple technique of clarification or centrifugation and pasteurization of traditionally prepared beverages have resulted with higher yield and improved biochemical properties as compare to traditionally prepared beverages (Table IV, V and VI). To improve the Keribo, an Ethiopian traditional fermented beverage, brewers usually refresh it through over fermentation by adding sugar to the primary product [14].

D. Sensory evaluation

Fermentation makes the beverages palatable by enhancing its aroma and flavor. These organoleptic properties make fermented beverages more popular than the unfermented one in terms of consumer acceptance [20]. The sensory evaluation report of laboratory prepared un-pasteurized, pasteurized, centrifuged and both pasteurized and centrifuged samples were performed with a panel of experts (**Table IV**). The results shows that laboratory prepared *Apong* has very good mouth feel, pleasant aroma, alcoholic taste, after taste, comparatively fair color and clarity with no off-odours as compared to traditionally prepared ones and rated as very good (5 points) by panel of experts. The sensory evaluation of clarified/pasteurized *Apong* was also reported as very good with 5 points however samples subjected to both centrifugation and pasteurization showed a poor after taste, moth feel and astringency hence, rated as poor (1 point). This may be due to the exposure of centrifuged beverage sample to a higher temperature that might have denatured the organoleptic properties and rated by panel of expert as inferior. The no change in the taste recorded in the case of *Madua Apong* even after pasteurization may be due to the absence of solid particles hence reported as very good (5 points) by expert panelists.

During cereal fermentations, several organic acids and volatile compounds are formed, which contribute to a complex blend of flavours in the products [16]. The sensory characteristics of a number African traditional cereal fermented beverages have been described and it has been emphasized that alcoholic beverages are effervescent aspect refreshing quality.

E. Extension of shelf life

The total shelf life of *Apong* and *Madua Apong* prepared through traditional method generally remains very short and recorded as 1-2 days only (**Table VII**) in our studies. With the aim to increase their shelf life, a few simple techniques were applied such as clarification by centrifugation and sterilization through pasteurization. This can also be easily adopted by traditional practitioners in some ways and help to keep the drink for a longer period without changing their organoleptic properties. This study was conducted during the month of March to April and this period generally experiences 28-30^0 C atmospheric temperature in capital complex area of Arunachal Pradesh. Observations on nutritional/biochemical properties of the laboratory prepared beverage samples were recorded up to ten days (**Table V and VI**). No changes were recorded in the

TABLE IV
SENSORY EVALUATION OF LABORATORY PREPARED *APONG* AND *MADUA APONG* BEVERAGES

Sample	Aroma	Color	Bitterness	Clarity	Alcoholic taste	After taste	Mouth feel	Astringency	General Acceptability
Apong (fresh)	G	F	P	F	G	G	VG	F	VG

Apong (pasteurized)	G	F	P	F	G	F	VG	F	VG
Apong (Centrifuged)	G	G	P	G	G	G	VG	G	VG
Apong (Centrifuged & pasteurized)	G	P	P	G	F	P	P	P	P
Madua Apong (fresh)	G	G	P	G	VG	G	VG	F	VG
Madua Apong (pasteurized)	G	G	P	G	G	G	G	F	VG

VG-Very Good, G-Good, F Fair, P-Poor, VP-Very Poor

moisture contents of all the four *Apong* (fresh, pasteurized, centrifuged and centrifuged / pasteurized) samples till 6th day. Alcohol contents, acidity, carbohydrate contents and total reducing sugars of the fresh *Apong* samples was found in the decreasing order after 2nd day where as there was no change in the alcohol contents, carbohydrate and total reducing sugars in other three *Apong* samples till 6th day. From the 7th day, the parameters such as moisture contents, alcohol contents, carbohydrate and total reducing sugars were found decreasing by 0.5 to 1 units. In the case of fresh *Madua Apong* samples, there were changes in their acidity, alcohol contents, carbohydrate contents and reducing sugars after 3rd day where as there was no change in these parameters of pasteurized *Madua Apong* samples up to 6th day. Other parameters like acidity and ash contents showed no changes till 10th day. The shelf life of traditionally prepared beverages was recorded 1-2 days for both *Apong* as well as *Madua Apong* however the shelf life or acceptability of lab prepared *Apong* was increased by 2-3 days and *Madua Apong* by 3-4 days. Centrifuged *Apong* samples also had a good mouth feel and acceptance up to 3-4 days of preparation. Pasteurized *Apong* and *Madua Apong* samples stayed acceptable up to 4-5 day of extraction. Generally these beverages were deteriorating due to presence of suspended solid raw materials and microbial population in the finished products. This may be the reason for short shelf life of the prepared drink. Therefore, the efforts were made to clarify the beverage with centrifugation and sterilize them by pasteurization. The results of shelf life studies show that shelf life of *Apong* and *Madua Apong* could be extended to 4-5 days instead of 1-2 days in the traditional process following easy procedures.

TABLE V
CHEMICAL COMPOSITION OF THE *APONG* PREPARED IN THE LABORATORY UNDER STANDARD CONDITIONS

Sample preparation	Chemical composition	Days									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Apong (fresh) prepared in laboratory with traditional Starter cultures	Moisture content (%,wb)	91	91	91	91	91	91	90	89	89	89
	Acidity	1.0	1.0	1.01	1.01	1.01	1.02	1.02	1.02	1.03	1.05
	Alcohol (%)	7.6	7.6	7.8	8.0	8.2	8.0	8.0	7.6	7.6	7.5
	Carbohydrate (g/100g)	7.1	7.1	6.7	6.3	6.0	6.0	5.2	5.0	4.4	4.4
	Ash (g/100g)	1.02	1.02	1.0	1.0	1.0	1.0	1.0	0.09	0.09	0.09
	Reducing Sugar (%)	5.2	5.2	5.2	4.4	4.2	3.8	3.8	3.8	3.8	3.8
Apong prepared and centrifuged in the laboratory	Moisture content (%, wb)	93	93	93	93	93	93	92	90	90	90
	Acidity	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.04	1.06
	Alcohol (%)	7.6	7.6	7.6	7.9	7.9	8.0	8.0	8.0	8.1	8.1
	Carbohydrate (g/100g)	7.1	7.1	7.1	7.1	7.1	7.1	6.9	6.4	6.4	6.4
	Ash (g/100g)	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
	Reducing Sugar (%)	5.2	5.2	5.2	5.2	5.2	5.2	5.0	5.0	5.0	5.0
Apong prepared and pasteurised in laboratory	Moisture content (%, wb)	91	91	91	91	91	91	90	89	89	89
	Acidity	1.02	1.02	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.04
	Alcohol (%)	7.6	7.6	7.6	7.6	7.6	7.6	7.8	7.8	7.8	8.0
	Carbohydrate (g/100g)	7.1	7.1	7.1	7.1	7.1	7.1	6.8	6.8	6.8	6.8
	Ash (g/100g)	1.02	1.02	1.02	1.02	1.02	1.02	1.0	1.0	1.0	1.0
	Reducing Sugar (%)	5.2	5.2	5.2	5.2	5.2	5.2	5.0	4.8	4.8	4.8
Apong prepared, centrifuged and pasteurised in laboratory	Moisture content (%, wb)	93	93	93	93	93	93	92	92	92	91
	Acidity	1.02	1.02	1.02	1.02	1.02	1.02	1.04	1.04	1.04	1.04
	Alcohol (%)	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.9	7.9	8.0
	Carbohydrate (g/100g)	7.1	7.1	7.1	7.1	7.1	7.1	6.8	6.8	6.8	6.6
	Ash (g/100g)	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
	Reducing Sugar (%)	5.2	5.2	5.2	5.2	5.2	5.2	5.0	4.8	4.8	4.8

TABLE VI
CHEMICAL COMPOSITION OF THE *MADUA APONG* PREPARED IN THE LABORATORY UNDER STANDARD CONDITIONS

Sample preparation	Chemical composition	Days									
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Madua Apong prepared in laboratory with traditional Starter cultures	Moisture content (%,wb)	95	95	95	94	94	94	95	95	95	95
	Acidity	1.03	1.03	1.03	1.04	1.07	1.07	1.07	1.09	1.09	1.1
	Alcohol (%)	7.8	7.8	7.8	7.9	7.9	8.0	8.0	8.1	8.1	8.1
	Carbohydrate (g/100g)	5.0	5.0	5.0	4.8	4.8	4.7	4.7	4.5	4.0	4.0
	Ash (g/100g)	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3
	Reducing Sugar (%)	3.2	3.2	3.2	3.0	3.0	2.8	2.8	2.6	2.4	2.4
Madua Apong prepared and pasteurised in laboratory	Moisture content (%, wb)	95	95	95	95	95	95	94	94	94	94
	Acidity	1.03	1.03	1.03	1.03	1.03	1.03	1.04	1.05	1.05	1.06
	Alcohol (%)	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
	Carbohydrate (g/100g)	5.0	5.0	5.0	5.0	5.0	5.0	4.9	4.8	4.8	4.6
	Ash (g/100g)	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06
	Reducing Sugar (%)	3.2	3.2	3.2	3.2	3.2	3.2	2.8	2.8	2.8	2.8

Keribo is a cereal based traditional fermented beverage of Ethiopia [14] produced on small-scale using locally available equipment and has short shelf-life and consumed within short period of its production. It was found that people tend to consume more than they require because these people cannot afford cooling devices to extend the keeping quality of the beverage which could result in further fermentation with final sour taste. Because of its low alcohol, the beverage has been consumed by both adults and children. This study documented information about ingredients and equipments used which could serve as useful and informative baseline data for further studies to scale-up this product.

The shelf life extension of sorghum beer (*Chibuku*), a popular fermented beverage in African countries, may be done by removing the second conversion of malt [21]. They have found that through this process, the shelf life of *Chibuku* increased from 120 hours to 172 hours. Similar study was reported earlier [22] for the shelf life extension of rice beer produced in Tropical African counties.

Removal of solid particles through sedimentation and filtration increases the shelf life of rice beer from 48 hours to 196 hours. Improved flavor without changing the color and texture of *Fufu*, a fermented Cassva product in Nigeria was attained by grating the Cassava stem before fermentation [23]. It also reported significant change in the microbial flora associated with cassava fermentation, may be the reason for improved flavor. Fermented foods, unlike non-fermented foods, have a longer shelf-life, making fermentation a key factor in the preservation [16]. Fermented cereal beverages contains organic acids (e.g. lactic, acetic, propionic and butyric acids) produced during fermentation which prolong beverage shelf-life by lowering the pH to below 4 or 3. This helps to restrict the growth and survival of spoilage organisms and some pathogenic organisms such as *Shigella, Salmonella* and *E. coli*.

The whole process of the traditional alcoholic beverage preparation was being done in uncontrolled conditions, that might have affecting the quality and quantity of the prepared drink and responsible for short shelf life. The fermentation process for alcoholic beverages is still being carried out by the traditional village art method and with no scientific input. There

TABLE VII
SHELF LIFE ANALYSIS OF LABORATORY PREPARED BEVERAGES

Name of beverage	Shelf life (days)
Traditionally prepared *Apong*	1-2
Laboratory prepared fresh *Apong*	2-3
Pasteurized *Apong*	4-5
Centrifuged *Apong*	3-4
Traditionally prepared *Madua Apong*	1-2
Laboratory prepared fresh *Madua Apong*	2-3
Pasteurized *Madua Apong*	4-5

is need to apply modern biotechnological techniques such as use of pure or improved strains and by improving traditional food processing technologies. Clarification and pasteurization techniques may be helpful in increasing the shelf life of prepared drink without changing the nutritional value and acceptability. The fermented beverages also have therapeutic values. The health benefits of these beverages are expressed either directly through the interaction of ingested live microorganisms (bacteria or yeast) or indirectly because of ingestion of microbial metabolites produced during the fermentation process [24] [25].

It may be recommended that by following strict aseptic conditions and using pure starter culture(s) for fermentation, higher yield and good quality beverage can be assured. Spontaneous fermentation by substrate inhabiting micro flora also plays an important role. To improve the quality, quantity as well as shelf life of *Apong* and *Madua Apong*, the tribal people may adopt some easy techniques for clarification at house hold level also. Rotating the extracted beverage with the help of sterile spatula at high speed and keeping it undisturbed for some period of time may help in separating and depositing solid particles at the bottom and supernatant beverage can be consumed. Pasteurization of beverage may also be done at home by double boiling techniques. These simple and easy techniques may help in increasing shelf life of traditional alcoholic beverages and thus, local practitioners will be benefited.

The consumption of *Apong* and *Madua Apong* is associated with the ethnic culture of the people of Arunachal Pradesh. The technology of these two fermented beverages may be utilized to

start-up a cottage or small scale industry with assured higher yield, improved product and better livelihood.

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