



Development of Cassava *mahewu* in Powder of Instantaneous Reconstitution

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Abstract: *Mahewu* is a traditional cool non-alcoholic fermented beverage known among African countries; generally made from cereals but also it can be made from tubers. The raw material (cereals and tubers) is spontaneously fermented at room temperature by acid lactic bacteria, the fermentation process is considered to increase the nutritional content of *mahewu*. The beverage is most known in the liquid form, that takes up more volume and less shelf life. The presentation of *mahewu* in powder it will allow minor volume and increase the shelf life. The objective of the present study was to develop cassava *mahewu* in powder form in order to stabilize a protocol of rehydration and investigate its instantaneous behavior. The standard cassava *mahewu* was prepared using fermentation techniques and thereafter 30 g and 40 g were firstly frozen for 24 h/-18°C followed by freeze drying at -20°C for a period of 24 h to obtain the powder form of cassava *mahewu*. The pH and acidity levels were controlled throughout the preparation processes and the total solids content of the solution was adjusted to 15.9 ± 0.1 °Brix, in order to freeze dry with a quantity of known soluble solids. The moisture content, water activity (w_a), tests of instantaneousness (wettability and dispensability) of the powdered cassava *mahewu* and the sensorial properties of the reconstituted powder after rehydration with water at 25°C to replace 60%, 80% and 100% of water lost during the freeze-drying were evaluated using standard methods. The results showed a reduction of the pH (6.11 to 4.56) and an increased in acidity (0.06 g/100g to 0.25 g/100g of lactic acid) of the standard cassava *mahewu* at beginning ($t = 0$ h) and at end of fermentation ($t = 24$ h) respectively. Both samples of 30 g and 40 g indicated a water activity of 0.39 and 0.42, moisture content of 6.50 and 8.57% and instantaneousness of 3 s and 3.33s respectively. The results showed an optimal behavior of instantaneousness of 3 s indicating an easy penetration of liquid (water) on the powdered cassava *mahewu*. According to the sensorial analysis, the reconstituted cassava *mahewu* rehydrated with 100% of water lost during the freeze drying was more appreciated and preferred compared with 80% and 60%.

Keywords: Cassava *mahewu*, Freeze Drying, Instantaneousness, Powder, Rehydration

1. Introduction

Mahewu is a non-alcoholic fermented beverage known and produced in larger scale in Southern African region. It is consumed as food and cool drink in this region and also normally used as weaning food for children between 4 to 8 months [1, 2]. In general, *mahewu* is rich in nutrients resulting from the process of fermentation, which influence

positively the digestion and absorption of nutrients in the human body [3]. The fermentation process leading to the formation of *mahewu* is due to the action of *Lactic acid bacteria* (LAB), which offer extension of shelf-life, increases the nutritional value and improve the organoleptic characteristics (such as taste, aroma and texture) of the *mahewu* [4, 5]. Moreover, fermented products including *mahewu* have been reported to have health benefits such as

prevention of diarrhea infections in children, improvement of immune system and prevention of cancer diseases [6].

In Africa *mahewu* is traditionally made mainly from cereals such as maize, rice and millet as well as tubers namely sweet-potatoes [7] and cassava [8]. The *mahewu* from maize is the most popular, which in Mozambique has been produced in commercial scale and called “super *mahewu*” [9]. Among the African countries, Zimbabwe is known as the most producer of maize *mahewu* followed by South Africa and Botswana [10]. Recently in Mozambique cassava *mahewu* has produced and it is considered an alternative to other *mahewu* produced from other carbohydrate extracts [8].

Mahewu is well known in the liquid form presentation, though maize *mahewu* in powder for instantaneous reconstitution has been produced at commercial scale in Zimbabwe using spray dry or drum dry techniques [11]. However, in Mozambique research about the development of

mahewu from maize or from cassava in powder has not yet been developed. In this context, the intent of the present study was to develop cassava *mahewu* in powder form using freeze drying process and instantaneously reconstitute it as the liquid cassava *mahewu* being developed by Salvador *et al.*, [8]. The success of the present purpose will allow the extension of shelf-life of cassava *mahewu* by decreasing the metabolism of LAB and practically stops the fermentation process. According to Hofuendahl and Hahn-Haherdal [12], the optimal temperature for the LAB activity for *mahewu* fermentation varies from 20 to 45°C.

2. Materials and Methods

2.1. Experimental Design

The present study followed three principal experimental steps shown on the Figure 1.

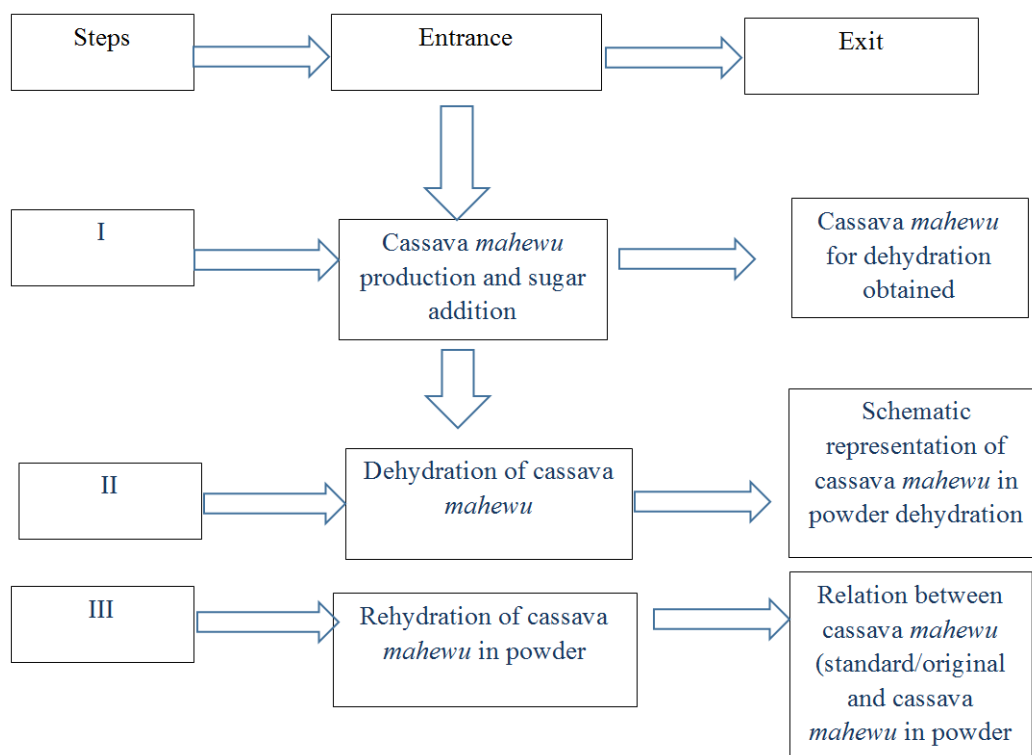


Figure 1. Schematic representation of the study, Adapted from Salvador *et al.*, [8].

2.2. Cassava Mahewu (Standard/Original) Preparation

Cassava *mahewu* was prepared according to the method developed by Salvador *et al.*, [8] Figure 2. The cassava flour for *mahewu* preparation was acquired from Zama-Zama farmer association at Inhambane Province, Mozambique. During the *mahewu* preparation, samples of 10 mL were taken and thoroughly homogenized for pH measurement at the beginning ($t = 0$ h) and at the end of fermentation ($t = 24$

h) using the method described by Brasil [13]. Other 10 mL of samples also were taken at the beginning and at the end of fermentation for titratable acidity where 2 to 3 drops of phenolphthalein indicator were dropped then titrated with 0.1 N of sodium hydroxide solution under constant agitation [13]. The balance was reached by the change of color to pink after 30 seconds as result of the presence of the indicator. The titratable acidity was express as percentage of lactic acid according to the formula below.

$$\% \text{ Lactic acid} = \frac{\text{Volume of NaOH 0.1 N (mL)} * f * M * 0.9}{\text{Weigth sample (g)}}$$

The soluble solids were measured at 20°C using a Digital Abbe WAY-S refractometer (Cometa Selecta group, Barcelona Spain) at the beginning and at the end of fermentation, where 10 g of cassava *mahewu* standard/original samples properly homogenized was placed to the prism. The result was express

in °Brix [14], one Brix (1°Brix) correspond to 1 g of sugar per 100 g of solution or 1% of sugar. The water activity of cassava *mahewu* at the end of fermentation was read directly at 20°C using Aqua Lab water activity meter S 3TE (Pullman, Washington, USA) [15].

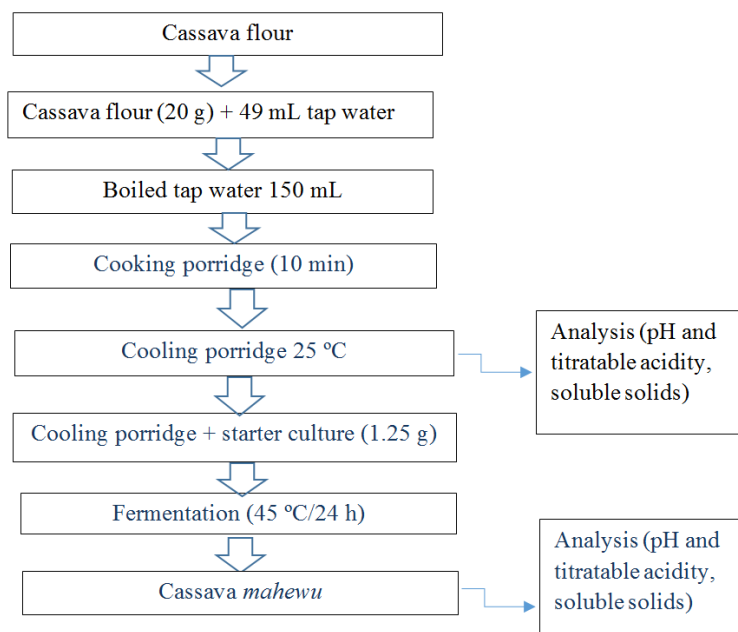


Figure 2. Schematic representation of cassava mahewu preparation [8].

2.3. Preparation of Cassava Mahewu in Powder Form

Cassava *mahewu* prepared on 2.2 was sweetened by adding sugar then subjected to freeze drying process in order to obtain the cassava *mahewu* in powder form according to Gonçalves [16]. The 30 g and 40 g of cassava *mahewu* previously prepared were placed in disposable glasses, frozen at -20°C during 24 h, then transferred to flask of 300 mL, the flasks were taken to freeze drying machine at approximately -20°C for a period of 24 h for dehydration to obtain cassava *mahewu* in powder as illustrated on the scheme Figure 3.

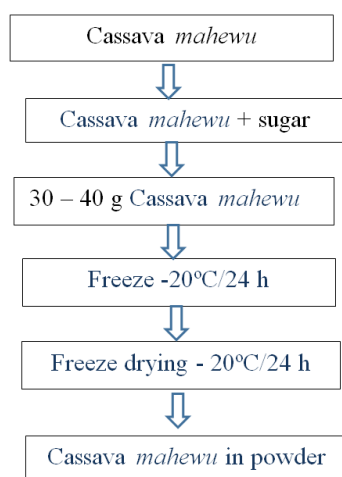


Figure 3. Flow chart of cassava mahewu in powder preparation.

2.3.1. Parameters Analyzed in the Cassava Mahewu in Powder

To the cassava *mahewu* in powder obtained, the following parameters were analyzed: moisture content, water activity, instantaneousness properties and sensorial analysis.

Determination of Moisture Content and Water Activity

The moisture content was determined according to *Normas Analíticas do Instituto Adolfo Lutz* [15]; where 10 g of cassava *mahewu* in powder was placed to oven at 105°C to dry directly; the value of moisture content was found when the weight was constant. The water activity was determined as described previously on the liquid cassava *mahewu* (2.2).

Evaluation of the Instantaneous Behavior of Powdered Cassava mahewu

The instantaneousness of cassava *mahewu* in powder was divided in two parameters: wettability and dispensability. To determine the wettability, 2 g of cassava *mahewu* in powder was weighed in a beaker with 400 mL of distilled water at 25°C and the period of time taken was measured using digital timer and the time was reached when all particles were visibly wet [17]. In the dispensability determination, 26 g of cassava *mahewu* in powder was placed in the beaker with 200 mL of distilled at 25°C then thoroughly mixed for 15 seconds. For the evaluation of performance of powder suspension after mixing, the following criteria were used: i) Poor – when the majority of powder is in suspension; ii) regular – minor part of powder in suspension; iii) good – some particles of powder in suspension and iv) optimal for

the absence of particle of powder in suspension [17].

Evaluation of the Sensorial Properties of Powdered Cassava mahewu

The sensorial analysis was made to evaluate the acceptability and the intention purchasing of the cassava *mahewu* in powder. This was performed by the workers of *Sumol + Compal* enterprise constituted by 30 testers of different ages and social classes [18]. The acceptability test was made obeying a hedonic scale of 1 to 9 points, where the extremes positive and negative were 9 equals to like it a lot and 1 equal to dislike it a lot and 5 was the middle and equal to did not like or dislike. The acceptability evaluation was followed by the test of the intention of purchasing, evaluated based on 4 parameters namely: would certainly buy; probably buy; probably not buy and certainly not buy.

2.3.2. Cassava mahewu in Powder Rehydration (Reconstitution)

The rehydration of cassava *mahewu* in powder where made by replacing 60%, 80% and 100% of water removed during the freeze drying. After rehydration of cassava *mahewu* in powder (reconstituted), the sensorial analysis was performed based on multiple comparison in order to evaluate the level of difference between cassava *mahewu* in liquid form (original/standard) and cassava *mahewu* in powder (reconstituted) with 60%, 80% and 100% of water removed on dehydration. For the evaluation, a portion of 16 mL of each sample of rehydrated cassava *mahewu* was served to the testers in codified transparent plastic glasses together with the control sample also codified; and mineral water was used to clean the plate between served samples. Fifteen (15) trained testers of different ages and social classes constituted by workers of the enterprise *Sumol + Compal* participated in the evaluation; all participants were informed about the objective of the study in order to decide their participation or not and informed consent was signed. Before the evaluation the participants were oriented and the test obeyed a scale from 1 to 5 points as follow: none-difference (1), minor difference (2), moderate difference (3), very different (4) and extreme difference (5). After the identification of level of difference between the rehydrated cassava *mahewu* in powder and the control, the sample which was more approximated to the control was applied the hedonic scale of 1 to 9 points; where the extremes positive and negative were 9 equals to like it a lot and 1 equal to dislike it a lot and 5 was the middle and equal to did not like or dislike in order to evaluate the acceptability of cassava *mahewu* in powder reconstituted. The acceptability of cassava *mahewu* in powder was calculated based on the index of acceptability (IA) [19] $IA (\%) = (A/B) \times 100$; where A = to the average of the results of the acceptability test and B = major score obtained on the acceptability test for each parameter.

2.4. Data Analysis

The data was analyzed using the analysis of variance (ANOVA) to calculate the significant differences between treatments. The separation of means was activated using the

Tukey test with level of significance of 95%. The tests were applied to see the difference between different parameters (pH, acidity and soluble solids) during fermentation of cassava *mahewu*, variation of water activity, moisture content and wettability.

3. Results and Discussion

3.1. Variation of pH, Titratable Acidity, Soluble Solids of Cassava mahewu Standard/Original in Function of Fermentation Time

During the fermentation process there was decreases on pH and soluble solids and increasing of acidity. There was significant difference ($p < 0.05$) in pH and titratable acidity at the beginning ($t = 0$ h) and at the end of fermentation ($t = 24$ h); and no significant difference was observed in soluble solids ($p > 0.05$), Table 1. The results of the present study were similar with the observations of Salvador *et al.* [8]. This observation is attributable to the proliferation of microbial population during the fermentation time. The decreases of pH on cassava *mahewu* can provide security against pathogenic bacteria and also extend the shelf-life of the product. Annan *et al.* [20] reported the importance of acidity developed in fermented products to avoid bacteria growth and prevention for diarrhoea infections. The soluble solids were decreased due to the use of carbohydrates as energy source by the fermentative bacteria [21].

Table 1. Variation of pH, titratable acidity, soluble solids of cassava *mahewu* (standard/original) in function of fermentation time.

Parameters	Time (h) 0	Time (h) 24
pH	6,11 a ¹ ± 0.01	4,56 a ² ± 0.02
Titratable acidity (%)	0,06 b ¹ ± 0.01	0,26 b ² ± 0.01
Soluble solids (°Brix)	10,1 c ¹ ± 0.03	9,8 c ¹ ± 0.02

Pairs of means with same letters and different numbers are statistically significant at Turkey test 0.05 level of significance.

3.2. Variation of Water Activity and Moisture Content on Cassava mahewu (Standard/Original) and Cassava mahewu in Powder

Table 2 shows the variation of moisture content and water activity of cassava *mahewu* and cassava *mahewu* in powder after freeze drying. Logically, the decrease of moisture content and water activity on cassava *mahewu* in powder when compared to cassava *mahewu* standard can be seen.

Table 2. Variation of moisture content and water activity of standard cassava *mahewu* with powdered cassava *mahewu*.

Treatment	W _A	Moisture content (%)
Cassava <i>mahewu</i>	0.93 a ¹	—
Cassava <i>mahewu</i> powder 40 g	0.42 a ²	8.57 b ¹
Cassava <i>mahewu</i> powder 30 g	0.39 a ³	6.50 b ²

Pairs of means with same letters and different numbers are statistically significant at Turkey test 0.05 level of significance.

The results in Table 2 are in agreement with the requirement for powder products showing the efficacy of freeze-drying process on dehydration of cassava *mahewu* in powder. The

water activity of cassava *mahewu* in powder was below 0.6 which according to Chisté *et al.* [22] is the minimal limit for the development of microorganisms. This makes the cassava *mahewu* in powder suitable for consumption and storage with good characteristics. The moisture content of cassava *mahewu* in powder was different from the dehydrated powder [13], but within the requirements. The difference on the moisture content can be explained by the difference in the quantity of samples freeze dried.

3.3. Instantaneous Behavior of Cassava mahewu in Powder

The instantaneousness properties (wettability and dispensability) of cassava *mahewu* in powder shows no significant difference between cassava *mahewu* freeze-dried at 30 g and 40 g respectively. The values show optimal behaviors of wettability and dispensability for cassava *mahewu* in powder which can be seen on Table 3. The cassava *mahewu* in powder presented lower period of wettability (3 s) indicating the ease penetration of liquid on the cassava *mahewu* in powder. The cassava *mahewu* in powder is poor in fat taking into account the content of fat in cassava estimated in 0.1% [23]; this fact made the cassava *mahewu* in powder more hydrophilic thus influencing the wettability and dispensability [24]. When compared to

products with higher contents of fat such as milk powder which was reported to have period of wettability and dispensability grander than 60 s and others [25, 26].

Table 3. Instantaneous behavior of cassava mahewu in powder.

Treatment (g)	Wettability (s)	Dispensability
Cassava mahewu powder 40	3.33 a ¹	Optimal
Cassava mahewu powder 30	3.00 a ¹	Optimal

3.4. Rehydration of Cassava mahewu in Powder

From 30 g of cassava *mahewu* 6 g of cassava *mahewu* in powder was obtained, meaning that 24 g corresponded to the water content withdrawn during dehydration by freeze drying process. Figures 4 and 5 presents the differences between cassava *mahewu* in powder rehydrated at 100% (replacement of 100% of water withdrawn) with cassava *mahewu* (standard/original) and the general classification of the cassava *mahewu* in powder rehydrated. It can be seen (Figure 4) that 80% of taster's responded that there is no difference between cassava *mahewu* in powder rehydrated at 100% and cassava *mahewu* (standard/original); however, 20% says that there is slight difference. The Figure 5 shows the acceptance of rehydrated cassava *mahewu* in 100%, the categories with highest percentage were liked it (46.7%) and liked it a lot (26.7%).

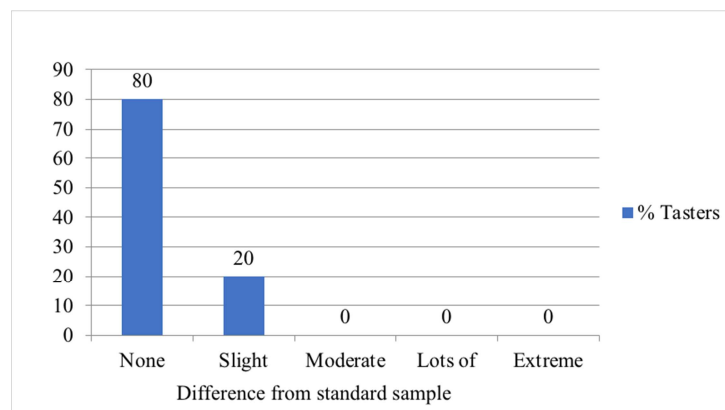


Figure 4. Evaluation of cassava mahewu in powder.

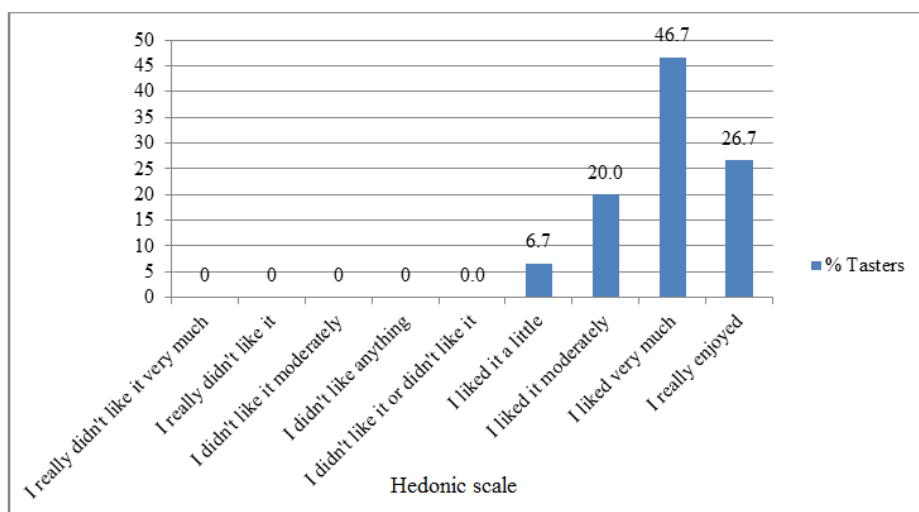


Figure 5. General classification of cassava mahewu powder rehydrated at 100%.

For the cassava *mahewu* in powder rehydrated at 80%, the tasters (20%) found huge difference between the rehydrated cassava *mahewu* in powder at 80% and cassava *mahewu* (standard/original) and 53.3% of tasters responded to have moderated differences (Figure 6).

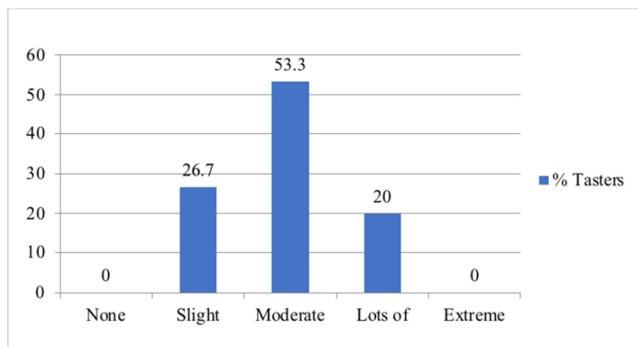


Figure 6. Evaluation of cassava *mahewu* powder rehydrated at 80%.

About 33.3% of taster responded to have extreme difference between cassava *mahewu* rehydrated at 60% and cassava *mahewu* (standard/original) and 60.0% of taster responded to have considerable difference Figure 7.

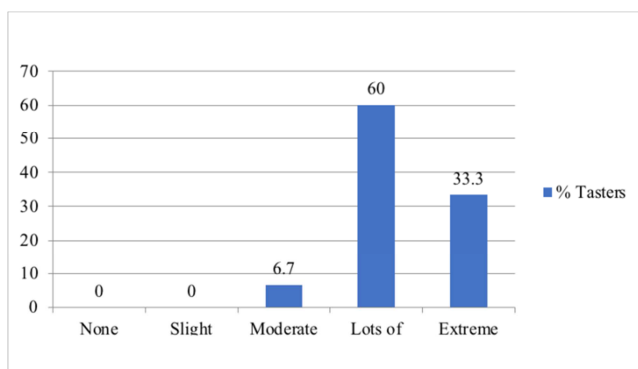


Figure 7. Evaluation of cassava *mahewu* powder rehydrated at 60%.

Among the different proportion (100%, 80% and 60%) of rehydration cassava *mahewu* in powder, the rehydration at 100% was closer to the cassava *mahewu* standard/original when compared to the rehydration at 80% and 60%. It can be noted that during the rehydration of cassava *mahewu* in powder, when less amount of water was added the result was different to the characteristic of the cassava *mahewu* standard/original making the cassava *mahewu* more consistent/dense due to less water, distorting their characteristics in relation to the cassava *mahewu* standard/original. In general, the heaviness of these two proportions (80% and 60%) justified the negative evaluation by the tasters. The findings of the present study are similar of the study developed by El-Bachá & Kim [27] who reported that the samples hydrated at 100% as closer to the standard. The results of this study are also supported by Ratti [28] who reported that the freeze-dried products are easily rehydrated. The factor of the cassava *mahewu* in powder rehydration at 100% being closer to the standard/original indicates that the

freeze drying was well succeeded, as was able to remove water, maintained the pores to the cassava *mahewu* in powder in order to receive again water during the rehydration.

3.5. Evaluation of Acceptability and Purchase Intention

The attributes of acceptability of cassava *mahewu* in powdered form was fundamentally concentrated in more than 95% of punctuation of hedonic scale liked from slightly to really enjoyed, the best values were liked a lot (33.7%) and really enjoyed (46.7%). For the color attribute, the acceptability index was 90% and for the texture, the obtained an acceptability index was 86.7% and 100% of punctuation in the hedonic scale of liked starts slightly to very much. The aroma attribute received 96.7% of the punctuation in the hedonic scale liked started from slightly to really enjoyed, where liked a lot got 23.3% and really enjoyed 46.7% with the index of acceptability evaluated in 88.9%. The attribute flavor obtained 96.3% of acceptability index, concentrated 100% on the hedonic scale liked started from slightly to really enjoyed where liked a lot was 16.7% and really enjoyed 76.7%. The cassava *mahewu* in powder was accepted with index of acceptability varied from 86.7 to 96.7 for all attributes evaluated (color, flavor, aroma and texture) which are superior to the minimal acceptability index estimated in 70% [29].

The global impression of cassava *mahewu* in powder got an acceptability index equal to 89.5%, indicated that it was well accepted taking into account the results of evaluation where 100% of hedonic scale fallen in liked varied from slightly liked (40%) to really enjoyed (33%). All taster says that they would purchase the cassava *mahewu* in powder, being 83.3% affirmed that surely purchase and 16.7% probably purchase; these statements coming to substantiate the possibility of marking cassava *mahewu* in powder as the results of the present study differed to Souza & Rodrigues [30] who considered their product as marking with 66% of surely purchase.

3.6. Freeze Drying Standardization of Cassava *mahewu* in Powder

Table 4. Cassava *mahewu* powder standardization.

Nº	Parameters	Values
1	Cassava <i>mahewu</i> standard/original (g)	30
2	Soluble solids of cassava <i>mahewu</i> standard/original (°Brix)	15.9 ± 0.1
3	Freezing temperature (°C)	-20
4	Period of freezing (h)	24
5	Temperature of freeze drying (°C)	-20
6	Period of freeze drying (h)	24
7	Rehydration (%)	100 of remove water
8	Instantaneousness (s)	3

Table 4 shown the parameters which could be used to prepare cassava *mahewu* in powdered form, that can be rehydrated to replace 100% of water lose during the freeze-drying process. The standardization of cassava *mahewu* in powder proposed in the present study allows the extension of

the shelf life and better storage of cassava *mahewu*.

4. Conclusions

There was no significant difference between cassava *mahewu* in powder rehydrated at 100% and cassava *mahewu* standard/original. The cassava *mahewu* in powder developed in the present study showed good acceptability and could be considered instantaneous and easily reconstituted. A protocol for cassava *mahewu* in powder which could be used to prepare cassava *mahewu* in minor volumes with higher shelf life was developed in the present study. The powder of cassava *mahewu* could be considered a convenient product as can be consumed at any place and time due to its instantaneously and portability. The development of cassava *mahewu* in powder form using other technologies (such as spray dryer) is recommended.

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