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Evaluation of the shelf-life extension and sensory properties of *mahewu*–A non-alcoholic fermented beverage by adding *Aloe vera (Aloe barbadensis)* powder

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Abstract

Purpose – The purpose of this paper is to determine the effect of adding Aloe vera powder (AVP) in the production of *mahewu* with the aim of determining its shelf-life and sensory qualities.

Design/methodology/approach – Mahewu was produced at home (Sample B) and in the laboratory (Sample C) using a standard home-made procedure with the addition of AVP. A control *mahewu* (Sample A) was produced without AVP. Shelf-life was determined by following the chemical, microbiological, physical properties at 36 ± 2 °C for 60 days and the sensory properties of the products were also evaluated.

Findings – Physicochemical analysis revealed decreases in pH ranging between 3.3 and 2.4 from day 15–60 days of storage in all three samples. There was a significant increase ($p < 0.05$) in titratable acidity (0.2–1.8%) of all *mahewu* samples during storage. Total soluble solids were different amongst the samples from day 15 to day 60. The colour of the products was significantly different ($p = 0.05$) with respect to L*, a* and b* throughout the storage period. Microbiological results revealed an increase in coliforms bacteria, lactic acid bacteria, and yeast during storage. Sensory analysis showed that the control *mahewu* was more preferred than AVP added *mahewu*.

Practical implications – The study may help small-scale brewers to increase the shelf-life of *mahewu*.

Originality/value – Results of this study showed that the addition of AVP extended shelf-life of *mahewu* up to 15 days at 36 ± 2 °C.

Keywords Maize, *Mahewu*, *Aloe vera*, Physicochemical, Sensory properties

Paper type Research paper

1. Introduction

Cereal beverages, such as *mahewu, pito* are very common in Africa since they are associated with values, such as social, religion and diet therapy (Nwachukwu *et al.*, 2010). Most of these

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cereal-based beverages and foods are produced by natural fermentation, and most of them are consumed as weaning foods and dietary staples for adults (Osungbaro and Taiwo, 2010). Cereal beverages constitute better nutrition, digestibility and some modification in the stability of foods in areas where they cannot afford refrigeration coupled with rising energy costs. Various researchers have reported the therapeutic values of cereal-based beverages and foods, and there is a need to develop new fermented food products that will target the black consumer market, which keeps on growing (McMaster *et al.*, 2005). The development of products could be done by improving or modifying the existing cereal beverages, such as *mahewu*. However, the challenges faced with these type of products is their rapid deterioration which renders the products to be unacceptable for consumption within two to four days of production, and this is due to over souring and off flavour caused by the ongoing activities of a microorganism after production (Konfo *et al.*, 2015; Kutyauripo *et al.*, 2009; Okafor, 1990).

Mahewu (*Amahewu*) is a popular non-alcoholic fermented beverage prepared using maize and is produced at household and industrial levels in the southern African region (Matsheka *et al.*, 2013). It contains little or no alcohol and has a pH between 2.74 and 3.5. The fermentation process of *mahewu* is naturally carried out between the temperature of 20–30 °C, and the dominant microorganisms belong to *Lactococcus lactis* subsp. *Lactis* (Blandino *et al.*, 2003; Steinkraus, 1996). The total market for *mahewu* in South Africa was estimated to be in the range of one hundred and forty-six (146) million litres in 1984 with about ninety-seven (97) million litres being packed and forty-nine (49) million litres transported in bulk. It is estimated that one black adult consumes around 12–14 L of commercial *mahewu* on a yearly basis (Steinkraus, 2004).

Aloe barbadensis Miller or *Aloe vera* is a perennial plant of the lily (*Liliaceae*) family, generally known as *Aloe vera* (Ramachandra and Rao, 2011; Bozzi *et al.*, 2007). Presently the most widely used part of the *Aloe vera* plant is the gel, whereas part of its peel is not yet utilised optimally (Narsih *et al.*, 2012). *Aloe vera* contains different types of active ingredients, but *aloin* is the one that is best known. *Aloin* is a yellow crystal with a bitter taste, and it is a C-glycoside derivative of an anthraquinone (Patel and Patel, 2013). The use of *Aloe vera* gel has gained interest in recent years, especially in the food industry where it is used as a source of functional food in products, such as beverages and ice creams (Ramachandra and Rao, 2011). Some of the examples of food applications of *Aloe vera* are diet drink with fiber (soluble), yoghurt, a soft drink containing electrolytes, healthy vegetable and tropical fruit juices, jelly desserts with chunks of aloe, etc. (Singh and Singh, 2009; Hamman, 2008; Eshun and He, 2004).

Different studies have tried to reduce and determine the spoilage of home-made *mahewu* and other non-alcoholic fermented beverages in South Africa, whereby different trials on cold storage of these products were conducted (Moodley *et al.*, 2019; Simatende *et al.*, 2019). However, the mass of the product has resulted in a failure to adopt cold storage since it will be difficult for home-made *mahewu* manufacturers to acquire big cold rooms due to financial constraints. Basic preservation methods, such as low-temperature storage, irradiation and heat treatment, i.e. canning, are greatly restricted in terms of their application in developing countries due to the cost of infrastructural requirements and installation (Kutyauripo *et al.*, 2009). The addition of *Aloe vera* powder (AVP) may result in *mahewu* product to have a longer shelf life because of its bacterial and antifungal effects. This could also improve the nutritional value of *mahewu* because the *Aloe vera* plant contains different types of beneficial nutrients, such as vitamins, minerals, amino acids, sugars, enzymes, fatty acids and saponins. A newly developed home-made *mahewu* with *Aloe vera* as a natural food supplement can also attract consumers who are health-conscious. The objective of this study was to determine the effect of adding AVP on the physicochemical, microbiological, shelf-life and sensory properties of *mahewu*. This was achieved by assessing the effect of AVP on the production process of *mahewu*.

2. Materials and methods

2.1 Production of mahewu *samples*

Maize meal and wheat cake flour were purchased from a local retailer, and AVP (250 g) was generously supplied by Khutsong Natural Herbs and Treatment Centre, Makwarela location, Thohoyandou, South Africa. Reagents from Merck South Africa were used to perform the experiment. *Mahewu* samples were prepared traditionally following the method of Chelule *et al.* (2010), whereby one part of the maize meal was added to 9 parts of boiling water. The suspension was cooked for 15 min at 90 °C with occasional stirring, allowed to cool to about 40 °C, and then transferred to a container for the fermentation process. Wheat flour (approximately 5% of the maize meal used) was also added during cooking since it serves as a source of inoculums. The porridge was cooled and allowed to ferment at a controlled temperature of 37 ± 5 °C for three (3) days. The porridge was re-cooked for five to ten min and ten (10) g of AVP was added before the product was packaged in 500 ml bottles. This was the basic method, which was used to prepare *mahewu* at home (B) *and* in the laboratory (C). A control *mahewu* was produced in the laboratory without adding AVP (A). The same processing conditions were followed to produce *mahewu* samples to avoid variations amongst the products.

2.2 Physicochemical analysis of mahewu *samples*

2.2.1 pH and total amount of acid. The pH of *mahewu* samples was measured in a 10% (w/v) dispersion of the samples in distilled water. The suspension was mixed, and pH reading was recorded using a Crison digital pH meter (Crison instrument, South Africa). The pH meter was calibrated with standard 4.00, 7.00, and 9.00 pH buffer. The total amount of acid present in each sample during 15-days intervals was determined by titration (AOAC, 1998) , whereby 2 g of sample was measured in triplicate into 250 ml flasks, 8 ml of distilled water and three drops of phenolphthalein indicator were added with thorough mixing. The mixture was titrated against 0.1 N NaOH to a pink colour. The amount of acid produced was calculated as percent lactic acid according to the formula:

$$\% \text{ lactic acid} = \frac{\text{ml of 0.1M NaOH} \times \text{normality of NaOH} \times \text{mol weight of acid}}{\text{ml of sample} \times 10} \quad (1)$$

2.2.2 Total soluble sugar. A refractometer was used to measure the total soluble sugar (TSS) of *mahewu*. Approximately five drops of mahewu sample were placed on the refractometer plate and covered with a plate, and the light turned on (on the centre side of the refractometer), the refractometer viewer, adjusted interface so that it lined up with the X-shape on the viewer screen. Readings for TSS were recorded (Martinez-Romero *et al.*, 2006).

2.2.3 Colour analysis. The HunterLab LabScan XE Spectrophotometer CIELAB colour scale with the parameters L*a*b* was used to determine the colour of *mahewu* samples. L* shows lightness, 0–100 with 0 indicates black and 100 indicates white. Coordinate a* corresponds to red (positive values) and green (negative values) while b* corresponds to yellow (positive values) and blue (negative values) (Anyasi *et al.*, 2017). The hue (H°), Chroma (C) and colour differences (ΔE) of *mahewu* samples were also recorded.

2.3 Microbiological analysis of mahewu *samples*

Samples (1 ml) of fermenting *mahewu* were collected aseptically from different plastic bottles at 15 days interval and homogenised in a mortar, which was previously cleaned with ethanol and passed over Bunsen flame. The homogenised samples were suspended in sterile 9 ml distilled water tubes and serially diluted (10-fold dilution). Dilutions (0.1 ml) of 10^{-3} 10^{-5} were inoculated on sterile disposable Petri dishes by pour plate method. The plates were

previously labeled appropriately based on the different media used; deMann Rogosa Sharpe (MRS) agar for lactic acid bacteria (LAB), potato dextrose agar (PDA) for yeast and mould and violet red bile agar (VRBA) for coliform bacteria. The plates were then incubated appropriately to allow the growth of organisms: MRS agar at 30 °C in an anaerobic jar for 72 h, PDA at 25 °C for 120 h and VRBA at 37 °C for 24 h. Counts of bacteria, yeasts and moulds were made on the respective media (Omemu *et al.*, 2018).

2.4 Estimation of shelf-life of mahewu *samples*

The effect of adding AVP in the production of *mahewu* was investigated using the method in section 2.2. Fermented *mahewu* from all the three samples was stored at 36 ± 5 °C for 60 days. From A, B and C, 10 ml of the sample was withdrawn at 15-days intervals starting at zero until 60 days for the purposes of chemical and microbiological analyses.

2.5 Sensory analysis of mahewu *samples*

Sensory evaluation was conducted using a 9 point hedonic scale (1 = dislike extremely to 9 = like extremely) in order to evaluate the consumer acceptance of mahewu samples. A total of 50 panelists from the university community, including students and staff, participated in the study, and thirty five were men and fifteen were women. Consumer panelists were selected based on their experience of *mahewu* consumption, having feel of the basic tastes, recognise smell and taste, interested in this study and willing to disclose their decisions. Ethical clearance to conduct the study was obtained from the University Research Ethics Committee. Consumers were asked to write their preference of the *mahewu* samples for the sensory attributes appearance, colour, taste, sourness and overall acceptance. All mahewu samples were stored at a refrigerated temperature of 4 °C for 60 days.

2.6 Statistical analysis

Data were analysed in triplicates using the Statistical Package for Social Science (SPSS) software Version 24 (IBM, New York, USA). Data were subjected to one-way analysis of variance (ANOVA). Results obtained were expressed as the mean values ± the SD of three replicates, and the mean comparison was made using Duncan's multiple range test. Statistical significance of the results was determined at a probability level of $p < 0.05$.

3. Results and discussion

3.1 Physicochemical properties of mahewu *samples*

Table 1 shows the changes in the physicochemical properties *of mahewu* samples during the storage period of 60 days. All three samples showed a decrease in pH values during the storage period ranging between pH 3.3 and pH 2.4 from day 15–60 days. The pH values of all the three samples kept on decreasing during the storage period. The decrease in pH values in all samples could have been caused by competition amongst the different microorganisms that were available in the fermented *mahewu* samples to such level whereby they prevented the fermentation process until one microorganism dominates and out-classes the other microorganisms by natural selection and succession process (Ramaite, 2004). This might have also resulted from the capability of these microorganisms to produce a high amount of organic acids and the capacity to survive in an acidic environment (Fowoyo and Ogunbanwo, 2010). The low pH values obtained during the storage period are necessary since most bacteria, including the pathogenic microorganisms, struggle to grow at low pH values, and this provides microbial safety, as well as extending the shelf life of *mahewu* samples (Halm *et al.*, 1993). Various researchers have studied the effect of pH on different characteristics and found that the pH of around 6.0 is important for the growth of most of the microorganisms and for food products (Akerberg *et al.*, 1998; Bernard Bibal *et al.*, 1988; Parente *et al.*, 1994).

Day	Sample	pH value	TA (% lactic acid)	°Brix
0	A	3.9 ± 0.01^{f}	0.2 ± 0.01^{a}	4.7 ± 0.12^{h}
	B	4.0 ± 0.04^{f}	0.5 ± 0.05^{b}	4.7 ± 0.19^{h}
	C	4.0 ± 0.04^{f}	0.6 ± 0.05^{b}	5.4 ± 0.52^{i}
15	A	3.3 ± 0.01^{d}	0.8 ± 0.05^{c}	4.7 ± 0.04^{h}
	B	3.6 ± 0.09^{e}	0.8 ± 0.04^{c}	2.6 ± 0.03^{c}
	C	3.6 ± 0.00^{e}	0.8 ± 0.08^{c}	3.5 ± 0.04^{f}
30	A	3.0 ± 0.03^{c}	1.0 ± 0.06^{d}	4.7 ± 0.03^{h}
	B	3.4 ± 0.06^{d}	1.2 ± 0.05^{d}	3.2 ± 0.04^{e}
	C	3.2 ± 0.08^{d}	1.1 ± 0.04^{d}	2.4 ± 0.49^{b}
45	A	2.7 ± 0.17^{b}	1.3 ± 0.08^{e}	4.3 ± 0.13^{g}
	B	3.4 ± 0.29^{d}	1.3 ± 0.05^{e}	3.0 ± 0.20^{d}
	C	3.1 ± 0.01^{c}	1.4 ± 0.08^{e}	2.2 ± 0.21^{a}
60	A	2.4 ± 0.05^{a}	1.8 ± 0.07^{f}	4.2 ± 0.55^{g}
	B	2.9 ± 0.08^{b}	1.8 ± 0.06^{f}	3.0 ± 0.19^{d}
	C	2.8 ± 0.60^{b}	1.7 ± 0.05^{f}	2.0 ± 0.13^{a}

Note(s): Mean ± Standard deviation (SD). Mean values in the same column with different superscripts are significantly different from each other ($p < 0.05$). Sample A = Control *mahewu*, sample B = Home-made *mahewu and sample C = Laboratory-made mahewu*

Table 1. Physicochemical properties of *mahewu* samples

Titratable acidity (TA) increased significantly ($p \leq 0.05$) during the storage period of *mahewu* samples, and it ranged between 0.2 and 1.8% lactic acid (v/v). TA is used as a guide to determine how acidic the product will taste. There was a general increase observed in TA for all samples during day 15 (0.8), and it continued to increase until day 60 (1.8). The total acidity in the control sample increased rapidly until 60 days of storage. There was a much slower increase of acidity in the other two samples from day 15 to 30, rapidly rising only after day 45 and 60 of storage. The results show that there was no significant difference ($p < 0.05$) in TA during the storage periods (15, 30, 45 and 60 days) amongst the three samples. This implies that the addition of AVP did not have any effect on the acidity of the two samples. The early increase in TA might have resulted from acid production by the fermentative microorganisms such that sugars were broken down by lactic acid bacteria to produce, among other secondary fermentation products, lactic acid, hence, the sour taste which makes *mahewu* famous among the black population of South Africa (Adesokan *et al.*, 2011). The organic acids, such as lactic, acetic, propionic and butyric acids that are released as secondary products of lactic acid fermentation have the ability to reduce the pH values to 3 to 4 with a TA of about 0.6% as lactic acid (Sanni, 1993; Holzapfel, 1989). The early increase in TA is significant to avoid the multiplication of harmful microorganisms that result in bad fermentation. The results are consistent with those reported previously by other researchers working with *mahewu* and similar products (Adesokan *et al.*, 2008; Gotcheva *et al.*, 2001). There was a significant difference ($p < 0.05$) amongst the samples from day 15 to day 60 with respect to TSS. A general decrease in TSS was recorded in all three samples during day 45 and 60, while sample B had an increase in TSS on day 30 (3.2). Sample A had the highest decrease in total solids over 45 days of storage (4.3) from 4.7 on day 30. The highest decrease in the TSS of the control samples on day 45 was presumably due to a high bacterial count in the control sample, which meant rapid utilisation of accessible solids (Kutyauripo *et al.*, 2009). Moreover, fermentation of sugars might have caused lactic acid bacteria to multiply as acidity increased (Jay *et al.*, 2005). The amount of sugar utilisation in the control sample was, therefore, higher when compared to the other two samples. Moreover, microorganisms were unable to utilise all available dissolved solids as exhibited by leveling off of the solids during day 60 in all *mahewu* samples. The increase in fermentation process might have caused the levelling off of solids since it prevents metabolic activity (Zvauya *et al.*, 1997).

3.2 Principal component analysis (PCA): pH, TA (% lactic acid) and TSS of mahewu *samples*

The principal component analysis for the physicochemical properties of three *mahewu* samples was investigated by looking at the pH, TA and TSS (Figure 1). The main sample differences and similarities, and attributes relationships were explained by the first and second PC. Principal Component (PC) 1 is characterised mainly by Brix and pH. Principal component (PC) 2 is characterised by lactic acid. There was a correlation amongst sample C (day 0) and Sample A (days 15 and 30) with regard to the TSS. These results mean that samples C and A had high values of Brix during the above-mentioned storage days. There was a correlation amongst samples B (day 0 and 15), A (day 0) and C (day 15). These results show that these samples had high pH values in the above-mentioned storage days. Figure 1 shows a correlation between samples B (days 30, 45 and 60) and C (days 30, 45 and 60). This implies that these two samples had high TA during the above-mentioned storage days. There was a negative correlation between TA and pH, while there was a positive correlation between Brix and pH. The negative correlation between pH and TA is expected since it is known that the increase in TA results in the decrease of pH in fermenting cereal grains (Efiuvwevwere and Akona, 1995; Hounhouigan *et al.*, 1994). The negative correlation between the two parameters that occurred during storage days is characteristic of fermenting cereal grains (Onofiok and Nnanyelugo, 1998).

3.3 Colour properties of mahewu *samples*

The colour properties of the three *mahewu* samples were investigated by looking at three parameters: L*, a* and b* (Table 2). The L* (lightness) values of three *mahewu* samples were significantly different on day 0, where sample A had the highest L* value (61.1), followed by sample C (57.3) and sample B (55.7). There was a significant difference amongst the samples on days 45 and 60. Generally, all the three samples had high values of lightness ranging from Hunter L 55.7 on day 0 to 69.9 on day 60. The increase in the lightness could

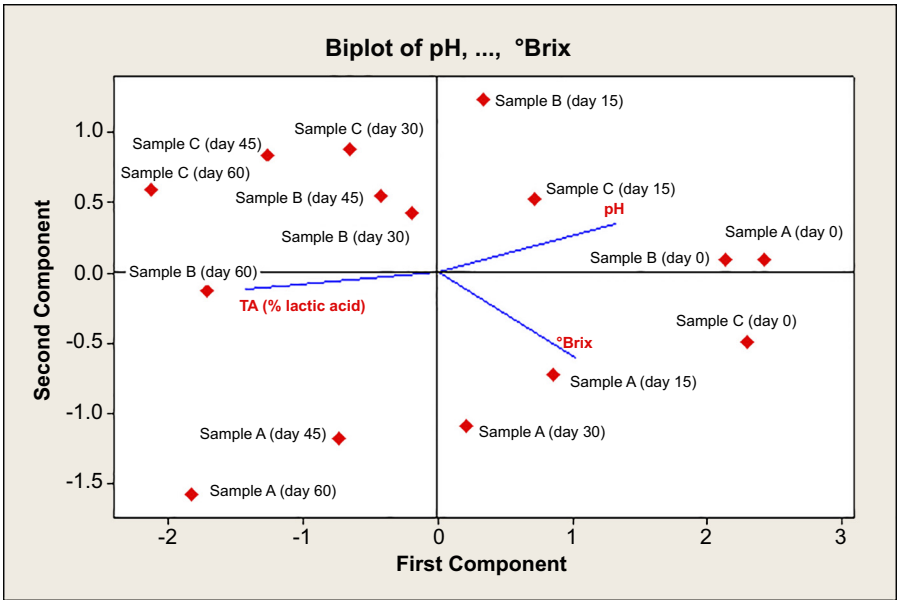

Figure 1.
Principal component analysis Bi-plot indicating physicochemical properties of different *mahewu* samples

Table 2.
Colour properties of *mahewu* samples

Samples	L*	a*	b*	Chroma	Hue	ΔE
Day 0						
A	61.14 ± 0.55^{c}	5.72 ± 1.02^{bcd}	14.20 ± 0.81^{a}	15.32 ± 1.14^{ab}	68.19 ± 2.33^{cdef}	–
B	57.26 ± 0.31^{b}	4.74 ± 0.61^{ab}	14.45 ± 0.23^{ab}	15.21 ± 0.21^{a}	71.85 ± 2.33^{fg}	–
C	54.91 ± 1.48^{a}	7.79 ± 1.80^{fghi}	14.31 ± 0.23^{a}	16.35 ± 0.74^{bcd}	61.60 ± 5.77^{a}	–
Day 15						
A	65.09 ± 0.78^{d}	3.48 ± 0.09^{a}	15.11 ± 0.23^{bc}	15.50 ± 0.24^{abc}	77.04 ± 0.14^{h}	4.88 ± 0.64^{a}
B	68.37 ± 0.29^{gh}	5.43 ± 0.86^{bc}	17.42 ± 0.52^{g}	18.25 ± 0.76^{e}	72.74 ± 2.06^{g}	11.60 ± 0.28^{de}
C	66.84 ± 0.39^{ef}	5.86 ± 0.30^{bcd}	17.34 ± 0.22^{fg}	18.30 ± 0.18^{e}	71.32 ± 1.04^{efg}	12.58 ± 1.67^{efg}
Day 30						
A	65.93 ± 0.91^{de}	5.91 ± 0.46^{bcd}	15.45 ± 0.29^{cd}	16.55 ± 0.43^{cd}	69.08 ± 1.16^{defg}	5.04 ± 0.32^{a}
B	67.57 ± 0.62^{fg}	6.44 ± 0.42^{cdef}	16.10 ± 0.59^{de}	17.34 ± 0.69^{de}	68.23 ± 0.65^{cdef}	10.62 ± 0.71^{cd}
C	67.45 ± 0.59^{fg}	6.97 ± 0.07^{defg}	16.67 ± 0.18^{ef}	18.07 ± 0.18^{e}	67.31 ± 0.21^{cde}	12.88 ± 0.88^{efg}
Day 45						
A	67.91 ± 0.18^{fgh}	7.09 ± 1.03^{defgh}	18.84 ± 0.80^{i}	20.14 ± 1.11^{f}	69.44 ± 1.94^{defg}	8.32 ± 0.52^{b}
B	69.75 ± 0.21^{i}	8.52 ± 0.39^{hi}	18.15 ± 0.33^{hi}	20.05 ± 0.42^{f}	64.87 ± 0.84^{abc}	13.59 ± 0.12^{g}
C	65.99 ± 0.56^{de}	9.22 ± 1.40^{i}	17.39 ± 0.13^{g}	19.70 ± 0.78^{f}	62.14 ± 3.38^{ab}	11.75 ± 0.78^{de}
Day 60						
A	68.98 ± 0.67^{hi}	7.37 ± 0.53^{efgh}	18.74 ± 0.27^{i}	20.14 ± 0.43^{f}	68.56 ± 1.18^{cdef}	9.22 ± 1.21^{bc}
B	69.97 ± 0.05^{i}	8.13 ± 0.08^{ghi}	18.02 ± 0.03^{gh}	19.76 ± 0.00^{f}	65.72 ± 0.24^{bcd}	13.65 ± 0.19^{g}
C	67.83 ± 0.64^{fgh}	8.95 ± 0.19^{i}	17.77 ± 0.16^{gh}	19.89 ± 0.22^{f}	63.28 ± 0.28^{ab}	13.50 ± 2.07^{fg}

Note(s): Mean ± SD. Mean values in the same column with different superscripts are significantly different from each other ($p < 0.05$). L* = lightness; a* = redness; b* = yellowness. Sample A = Control *mahewu*, sample B = Home-made *mahewu* and sample C = Laboratory-made *mahewu*

be due to the fermentation process during the storage period. Fermentation reduces bulk since it has the ability to reduce the viscosity of the cereal gruel, making it lighter. Starch granules are hydrolysed by the microbial activities during cereal fermentation, which results in cereal gruel becoming lighter (Onofiok and Nnanyelugo, 1998). In terms of the a* values (redness), there was no significant difference between samples B and C from day 15 to day 60 of storage, while sample A was significantly different from the two samples during the same storage days. This result shows that the addition of AVP had an effect on the redness of the B and C because they were significantly different ($p < 0.05$) from A, which is a control although all samples had positive a* values, which indicate the presence of the red colour in all *mahewu* samples. The positive b* values indicate the yellowness, while the negative values mean that the sample is blue. There was no significant difference in the b* values of samples B and C during day 15, while sample B was significantly different from A and C from day 30 until day 60 of storage ($p < 0.05$). The high values of redness and yellowness in B and C on days 30 and 45, respectively, may be due to *aloin* in the AVP. *Aloin* is a yellow-brown compound estimated at levels from 0.1 to 0.66 % of dry leaf present in cells adjacent to the rind of the leaf gel (Patel and Patel, 2013). Chroma* (colour intensity) values of *mahewu* samples ranged from 15.32 to 16.35 during day zero and from 19.76 to 20.14 during day 60. There was no significant difference ($p < 0.05$) amongst all *mahewu* samples on days 45 and 60, although there was an increase in Chroma values when compared with day zero. Chroma normally increases with increasing pigment concentration and decreases as the sample becomes darker.

The higher the Chroma values, the higher the colour intensity of mahewu samples as perceived by humans. The Hue values did not show any significant difference ($p < 0.05$) throughout the storage period, and the values ranged from 61.60 to 68.19 (day 0) to 63.28 to 68.56 (day 60). The control and sample C had a slight increase in Hue values during the storage period, while sample B had a decrease in Hue values from day 30–60. The ΔE showed significantly ($p < 0.05$) difference and increased with storage periods with the exception of sample B, which had a slight decrease at day 30 (10.62) as compared to 11.60 during day 15. The ΔE values ranged from 4.88 to 12.58 (day 0) and 9.22 to 13.65 (day 60). The increase in Chroma and ΔE usually occurs when yeast converts sugars present in the gruel into carbon dioxide and ethanol, producing the leavening action, which contributes to increase in yellowness and redness of the gruel (Serap *et al.*, 2017).

3.4 Microbiological properties of mahewu *samples*

There was a significant increase ($p < 0.05$) in numbers of coliform bacteria, lactic acid bacteria (LAB), yeast and moulds during the storage period of 60 days (Table 3). Sample B had the highest coliform counts from day 0 when compared to samples A and C, which had no coliform detected on day 0; however, all samples recorded the highest number of coliforms count on day 45 and 60 because the coliforms were too numerous to count. Coliforms were used as an indicator organism for basic hygiene during the processing of *mahewu,* as well as handling of packaging materials. Sample B (home-made *mahewu*) recorded a high count of coliforms from day 0, indicating that basic hygienic was not practised during the processing period. The presence of coliforms in B during day 0 might be due to dirty equipment or poor hygienic handling and cross contamination during processing. Microorganisms could have originated mainly from the maize meal, utensils and tap water used during the mixing process (Kutyauripo *et al.*, 2009). However, the high number of coliform counts in all the three samples during day 45 and 60 of storage could be due to contamination of product and packaging materials during the storage period. The highest LAB counts were obtained after 15 days in all samples; that is, LAB counts increased from 3.0086 in day 0–7.9395 log10 cfu/ml, 3.2434 to 7.8062 log10 cfu/ml and 3.2542 to 7.7559 log10 cfu/ml for all *mahewu* samples.

Day	Sample	Coliforms	LAB	Mould	Yeast
0	A	ND	3.0086	2.4771	4.8513
	B	2.9823	3.2434	1.4322	2.7075
	C	ND	3.2542	2.4771	2.3222
15	A	1.0000	7.9395	1.3222	7.0414
	B	5.0086	7.8062	1.0000	4.9912
	C	1.1304	7.7559	1.0000	4.5315
30	A	4.7482	>3.4771	>3.4771	9.1761
	B	>2.1761	>3.4771	>3.4771	9.1139
	C	5.9731	>3.4771	>3.4771	7.8633
45	A	>2.1761	>3.4771	>3.4771	>3.4771
	B	>2.1761	>3.4771	>3.4771	>3.4771
	C	>2.1761	>3.4771	>3.4771	>3.4771
60	A	>2.1761	>3.4771	>3.4771	>3.4771
	B	>2.1761	>3.4771	>3.4771	>3.4771
	C	>2.1761	>3.4771	>3.4771	>3.4771

Note(s): Average bacterial counts log10 (cfu/ml); ND = Not Detected; Sample A = Control, sample B = Home-made and sample C = Laboratory-made *mahewu*. LAB = Lactic acid bacteria

Table 3. Microbiological content of *mahewu* samples

The LAB counts continued to increase on days 30, 45 and 60 in all three samples. The results of this study showed that as fermentation progressed, the LAB increased and this resulted in quick fermentation of *mahewu* samples. The low pH of *mahewu* contributed to the increase in lactic acid during fermentation allowing the growth of LAB, which resulted in competing microorganisms being inhibited. Moreover, the antibiotics substances produced by LAB also play a role during the inhibition process (Kalui *et al.*, 2009; Reid, 2008; Vasiljevic and Shah, 2008). The increased counts of LAB during the storage period of *mahewu* samples might also be due to the ability of the LAB isolates to predominate and suppress the growth of other undesirable microorganisms. The result of this study is in line with the report by Oyeyiola (1990). The decrease in pH and increase in LAB counts followed the same trend as reported for other naturally fermented foods.

There was a decrease in mould growth in all the three samples on day 15. Sample A had a decrease of 1.3222 from 2.4771 log10 cfu/ml on day 0, whilst samples B and C had a decrease of 1.0000 from 1.4322 to 2.4771 log10 cfu/ml, respectively and this could be due to the observed decrease in pH (Table 3). The acid produced by bacteria has been shown to inhibit the growth of moulds (El-Gendy and Marth, 1980). Jespersen *et al.* (1994) reported that 5.0000 log10 cfu/g of mould count, found in raw maize, is reduced to less than 2.0000 log10 cfu/g within 24 h of fermentation. Moulds in cereals appear not to play any noteworthy role during the fermentation process, but they are present as contaminants. The yeast counts increased in all the three samples during the storage period. The increase in the yeast numbers during the storage period was due to the decrease in the pH of the products, which created conditions favourable for the growth of yeast (Serna-Saldivar and Rooney, 1995). The highest numbers of yeasts were recorded on day 15 for sample A (7.0414 from 4.8513 log10 cfu/ml in day 0) while B and C recorded high numbers of yeasts in day 30 9.1139 and 7.8633 log10 cfu/ml respectively. The yeasts were too numerous to count in day 45 and 60 of storage. Various yeast species, such as *Saccharomyces* and *Candida,* have been found in unsolicited lactic acid fermenting cereals (Serna-Saldivar and Rooney, 1995).

3.5 Extension of shelf life of mahewu *samples*

Growth of mould and yeast was used as an indicator of spoilage and consumer acceptance of *mahewu* samples. The most important microorganisms that can cause the spoilage of

mahewu are yeasts belonging to the *Pichia* spp. *Acetobacter liquefaciens* have been found to be another major spoilage microorganism. It converts lactic acid into acetic acid leading to off-odours and also causes discolouration of the product (Holzapfel, 1989). The acceptability of *mahewu* samples decreased after 15 days in the control and after 30 days in *Mahewu* B and C (Table 3). According to the National Department of Health, Guideline for microbial standards, (South Africa, 1972), fermented food products (including *mahewu*) should not exceed a coliform count of log10 < 2.3010 cfu/ml and log10 < 4.0000 cfu/ml for yeasts and moulds. The control sample (A) had a high yeast count (log10 7.0414 cfu/ml) on day 15 meaning the product was no longer acceptable for human consumption while samples B (log10 9.1139) and C (log10 7.8633) had high counts on day 30 meaning that the two products were out of detection limit until day 60 of storage. The control (A) deteriorated faster than samples B and C. The results of this study show that the addition of AVP extends the shelf-life of home-made *mahewu* up to 15 days at 36 ± 5 °C. This is because AVP greatly reduces the organic acids produced in the samples and thereby resulting in the reduction of over-souring of the products during the specified period. Good hygiene should be followed during the home preparation of *mahewu* to prevent the growth of coliforms as was evident in this study.

3.6 Sensory properties of mahewu *samples*

The control *mahewu* (A) was significantly different from B (home-made *mahewu* and C (laboratory-made *mahewu*) in terms of appearance, colour, taste, sourness and overall acceptability in day 0 and 60. Sample A was the most preferred in terms of the above mentioned quality attributes. This implies that the addition of AVP had an effect on the organoleptic characteristics of two *mahewu* (B and C). The two new products (B and C) had a 39% (mean score 3.5) and 41% (mean score 3.7) overall acceptability rating compared to 60% (mean score 5.5) acceptability in the control sample (Table 4). The unacceptable taste, sourness and overall acceptability recorded in samples B and C warrant rejection of the new *mahewu* products. The comments made by most of the panel members indicated that *Mahewu* B and C had a bitter taste and this is the characteristics of *Aloe vera* plant. The bitterness was caused by aloin (glycoside group) compounds, which are found in most parts of the skin of *Aloe vera* plants (Bozzi *et al.*, 2007). It is used in alcoholic beverages due to its bitter principle (Patel *et al.*, 2012). Various researchers have reported the availability of *aloin* in *Aloe vera* plants. Adushan (2008) reported that aloin also can act as antioxidant compounds but can have a negative health effect if consumed in a higher amount. Ramachandra and Rao (2011) found that heating at 30–80 °C decreases the aloin compound since the parenchyma tissue found on the extracted material is destroyed by heat. Moreover, thermal processing at 50–80 °C also decreases aloin from 10.6 ppm to 1.7 ppm since *aloin* is heat sensitive (Gulia *et al.*, 2009). A method for reducing aloin should be

Samples	Appearance	Colour	Taste	Sourness	Overall acceptability
Day 0					
Sample A	7.3 ± 1.6^{c}	7.2 ± 1.6^{c}	6.0 ± 1.6^{b}	6.0 ± 1.9^{c}	5.5 ± 2.3^{c}
Sample B	5.7 ± 2.1^{a}	5.9 ± 1.7^{a}	3.3 ± 2.1^{a}	3.3 ± 2.2^{a}	3.5 ± 2.3^{a}
Sample C	6.0 ± 2.2^{b}	6.3 ± 1.6^{b}	$3.2 \pm 1.6^{\mathbf{a}}$	3.7 ± 2.3^{b}	3.7 ± 2.3^{b}
Day 60					
Sample A	7.2 ± 1.6^{c}	7.1 ± 1.5^{c}	6.0 ± 1.6^{b}	6.1 ± 1.8^{c}	5.6 ± 2.4^{c}
Sample B	5.6 ± 2.1^{a}	5.8 ± 1.6^{a}	3.2 ± 2.2^{a}	3.4 ± 2.3^{a}	3.5 ± 2.3^{a}
Sample C	6.1 ± 2.2^{b}	6.2 ± 1.6^{b}	3.2 ± 1.6^{a}	$3.6 \pm 2.3^{\mathbf{b}}$	3.7 ± 2.3^{b}

Table 4.
Mean scores for sensory acceptability of *mahewu* samples

Note(s): Mean ± SD. Mean values in the same column with different superscripts are significantly different from each other ($p < 0.05$). *Mahewu* A = Control, B = Home-made and C = Laboratory-made *mahewu*

investigated during the production of AVP. This will help to reduce the bitterness of the product and make the product acceptable in the market.

4. Conclusions

The results of this study showed that the addition of AVP had an effect on the shelf-life of home-made *mahewu*. It increased the shelf-life of home-made *mahewu,* which is normally less than four days to fifteen days. Spoilage of *Mahewu* B (home-made) and C (laboratory-made *mahewu*, AVP added) products as evidenced by high counts of moulds and yeasts and appearance of ropiness was observed at 30 days, and this may be due to the proliferation of yeast in the products. The addition of AVP did not have any effects on pH, TA, TSS and colour (L* and a*) during 60 days of storage. The challenge is the acceptability of the AVP added products since the sensory results showed that most of the panelists did not like the taste and sourness of *Mahewu* B and C. Moreover, there is a need to carry out further studies with different concentrations of AVP if the addition of AVP is to be adopted as a way of producing home-made *mahewu* with extended shelf life.

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