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Shelf Life Determination of Mango Juice Produce by Small-Scale Processing Techniques in Eastern Hararghe Zone

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Abstract
A perishable agricultural commodity like potatoes requires great attention to sustain its supply on the market. Because of the lack of appropriate handling and storage, huge amount of potato goes to waste before it reaches to the consumer. Therefore these loss can be minimized by storing them at low temperature under high humidity environment like pit storage. The determination of the physical and chemical properties of potato in the long-term storage and their variations is one of the significant specifications in terms of keeping shelf life of the product with acceptable quality. This paper include the study of physical properties such as sprouting, color change, and rotten were identified by countering, while the chemical properties such as carbohydrate, moisture contents, protein contents, Vitamin, Minerals, Total Soluble Solid and PH were collected and tested in laboratory before and storage period. The chemical properties of some potato tubers increased while decreased at some of them were increased. The changes at the rates of loss of 3.2, 2.2, and 3.6% in terms of weight loss, 3.14, 2.03, and 2.78% in terms of sprouting, 1.25, 1.58 and 1.84% color change, 4.02, 5 and 4.8% protein contents, 83, 84.4 and 84.3% Moisture contents, 7.19, 4.45 and 5.73% total carbohydrate FARC, Kombolcha and Haramaya respectively. All data were collected for five months of storage times with its schedules. The results of studies presented that the physical and chemical changes that occurred in the tubers were depending on the tuber's geometrical size and under storage environment of minimum and maximum temperature and relative humidity of (19 and 29 ℃), 34 and 59%) respectively.

Keywords: Handling and storage, physical and chemical properties, weight loss

Introduction

The potato is the most important food crop in the world after wheat, rice and maize and its ranks 4th (Eltawil *et al*, 2006) [4]. Potato (*Solanum tuberosum* L.) is the most important food crop in the world after wheat, rice and maize as well as ranks 4th in the world with respect to food production (M. Eltawil *et al*, 2006) [4]. It is a semi-perishable commodity. According to CSA, 2016 G.C. of Ethiopia showed that potential production of the East Hararghe zone were 194,247.72 quintals, and the numbers of holders were 34,732.00, among potential producers worade Haramaya, Kombolcha, and Dadar where most potato producing area during Meher and Balg season. Potatoes production area main practices by peasant farmer and both home and market supply. Though the land in the zone has high production potential both for rain-fed and irrigated potato cultivation, lack of prolong conditions with improved storages is among the major factors limiting the production and productivity of farmers in all potato growing areas.

The purpose of the storage is to maintain tubers in their most edible and marketable condition and to provide a uniform flow of tubers to market and processing plants throughout the year. Storage losses are often specified as weight losses and losses in the quality of potatoes, although the two cannot always be distinguished. Storage losses are mainly caused by the processes like respiration, sprouting, evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tuber, and damage by extreme temperatures. These processes are influenced by storage conditions. All the losses mentioned above depend on the storage conditions and therefore can be limited by maintaining favorable conditions in the store. However, the storability of potatoes is already determined before the beginning of storage, by such factors as cultivar, growing techniques, type of soil, weather conditions during growth, diseases before harvesting, and maturity of potatoes at the time of harvesting, damage to tubers during lifting, transport, and filling of the store. Good storage should prevent excessive loss of moisture, the development of rots, and excessive sprout growth. It should also prevent the accumulation of high concentration sugars in potatoes, which results in dark-colored processed products. Temperature, humidity and air movement are the most important factors during storage (Tanabe, S. and Kimura K., 1994) [18].

However, all the product in the area is supplied and saturates the market during on season exceeding the demand. As a result of the selling price in the local market falls extremely, mostly to the extent that it cannot cover the production cost invested by farmers which opens the opportunity for the exporters and the middlemen (brokers) to determine the fate of the producers. As the farmers have no alternative the dealers reduce the price to the level they want on one hand while producers also force the farmers to add an extra sack size called "gonfa" up to 150 kg to be taken as one quintal (100 kg). The farmers have to accept whatever the buyers decide as they lose the whole of their product for the reason they have no means of maintaining the product once they have harvested. They give their product without receiving cash as they are fooled by the traders. (Zonal Major Post-harvest constraints/problems/ identified which need an immediate response) Even if the above-ground warehouse was attempted in the study area, it was not affordable as compared with that of farmer production capacity and area of the farm. Therefore to cover these gaps the study aimed to adapt an underground pit for potato storage which can be used by entire producers due to its simplicity and economically feasible.

Materials and Methods

Experimental sites: The storage was adapted from Jimma Agricultural Engineering Research Centers then constructed and evaluated on selected farmer's land. The study was conducted at selected East Hararghe zone of Haramaya, Kombolcha, and on the station. For laboratory purposes, the experiment was conducted at Haramaya University both in the food chemistry and animal nutrition laboratory.

Materials: The raw materials used to construct the Storage were wood strip, Input Pipe (to connect to the basal vent), Exit (exhaust) Pipe, Elbow joint (s) and glue, Poles or other timber, Brushwood, and Shovel.

Storage preparation: Pit preparation procedures included digging the pit, installing vertical ventilation ducts, cover the pit, and bed of pit with triangular floor.

Digging the pit: Digging a rectangular pit 2 meters long, 1.4 m wide, and 1.6 m deep. Depth and width can be adjusted, however: Deeper pits impede air flow and can lead to rotten produce. They are also less practical to dig and unsafe. Pit width should not exceed 2.5 m wide (1 m on either side of the vent), as this is the maximum floor area that one triangular floor vent can aerate. The walls should be allowed to dry prior to filling as the walls absorb quite a lot of moisture and also help to regulate the humidity. Digging the pit one month before covering is best. Constructing the horizontal ventilation ducts. Using any thin material (for example, willow or poplar tree branches), construct an equilateral triangle of 40 cm sides in a cross-section made up of units approximately 2 m long for easy handling. Slats 2 cm wide run vertically with 2-3 cm gaps between the slats. Installing horizontal ventilation ducts.

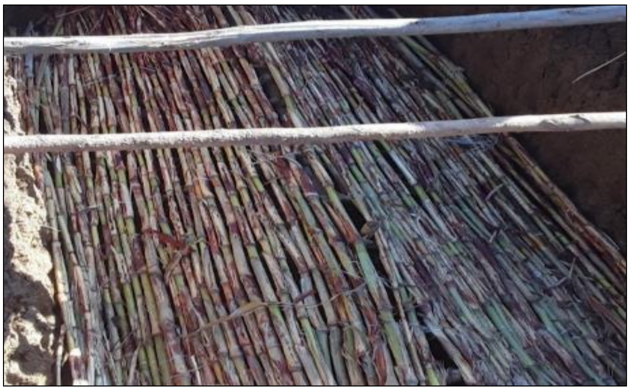

Fig 1: Triangular shelf

Installing vertical ventilation ducts: Vertical ventilation ducts can be made of plastic pipe 10-15 cm in diameter, and long enough that they extended approximately 30 cm above the surface of the soil as the pit was covered. An elbow joint was attached with glue at the top or the top was bent horizontally to assist air movement through the stack. Input vertical duct was connected to one end of the horizontal vent that was sitting at the bottom of the pit. This ensures proper movement of cool, dry air through the base of the potato stack. The shorter exhaust vent should stick out from the opposite end of the stack to vent warm air and gases. The top of the input pipe should face the wind and the exhaust pipe should face the opposite direction, this helps push air through the storage pit.

Fig 2: Installed ventilation ducts from PVC

Cover the pit: The pit will cover with cemented wall to provide strength. Then the poles will cover with flat boards, followed by a layer of brushwood to prevent soil from falling through. Brushwood will be covered with soil to ensure good insulation. Less soil cover can increase the chances the crop will freeze. An opening approximately 45-60 cm square (large enough for a basket to pass through) to allow access to the storage to empty the pit will leave. The opening will cover with boards and the same amount of soil as the rest of the pit. The creation of a roof for the pit is necessary so that there is a space between the potato stack and the roof. This traps the warm, moist air that is rapidly expelled when the exhaust vent is opened, causing air to be drawn in and pass through the stack.

Sample preparation

Gudanne variety was selected and collected from FARC station at their maturity stage**.** To avoid the possibility of damage bruises and signs of infection were discarded from the sample before storing, the sample was graded based on their geometrical diameter as; Large, Medium, and Small diameter.

Fig 3: Large, medium, and small geometrical diameter

Collected Data

Data were collected over a month across locations throughout storing period.

Moisture content (%)	Temperature (°C)
Spoilage (No)	Relative humidity (%) and other physical and chemical change
Sprouting (No)	

Temperature and relative humidity

The storage air temperature and relative humidity were recorded two times weekly three times in days at 4-hrs intervals during the day-time using a digital electronic Thermo- hygrometer model ETHG 913 R placed inside and outside storage. The average both temperature and relatives humidity difference between the inside storage and outside was calculated by using the following.

Temperature

Since the study area was not able to give the temperature (cold) that was favorable for storing the product. Storage temperature was maintained at the needed condition as much as possible by the naturally ventilated method using a purposely installed vent system.

$$\Delta T\ (°C) = \frac{\mathrm{Tout} - \mathrm{Tin}}{n}$$

Where,

ΔT = average residual temperature between the air in the storage and ambient air Tin = inside storage temperature

Tout = outside storage temperature n= number of records

Relative humidity

Since the study area was not able to give the humidity (moist environment) favorable for storing the product. It’s necessarily needed to maintain as much as possible by the natural ventilated method using a purposely installed vent system.

$$\mathrm{RH}\ (\%) = \frac{Rin - Rout}{n} * 100$$

Where,

RH=average residual relative humidity between inside and outside of storage

Rin = inside storage relative Rout = outside storage relative

n= number of record

Fig 4: Thermo-hygrometer during recording temperature and humidity

Weight loss of potatoes (%)

Weight losses were taken from the sum of sprouted, rotten, color changed, and moisture loss of cured samples. The measurement was done by digital electronic balance having the precision of 0.01gm, in the monthly interval and the difference between initial weight and final weight gave the total weight loss percentages.

Where: Wi = initial weight

$$\mathrm{W}\ (\%) = \frac{\mathrm{Wi} - \mathrm{Wf}}{\mathrm{Wi}} * 100$$

The number of Potatoes sprouted

The sprouted of potato was determined by counting the number of sprouted potatoes through the storage period. The sprouted potatoes were discarded after each count to avoid double counting.

Number of rotten potatoes (%)

The incidence of rotting was determined by counting the number of rotten potatoes that were discarded after each observing to avoid double counting. During storage incidences of insects were noticed in the first year at all locations, leads all the stored products being damaged, due to this second year the storage site and season were changed and the good result were obtained at all location.

Moisture loss (%)

Moisture content has a direct economic importance and a significant influence on the shelf life of potato tubers

(Capriles, V.D. and Arêas, J.A.G., 2014) [2]. Potato tubers generally contains 63–80% moisture resulting in an ambient relative humidity. On the other hand, the moisture content of potato tubers variation leads to shrinking when lost and deterioration at above internal saturation state.

Chemicals composition of potatoes

The results of moisture, ash, fiber, carbohydrates, and some minerals contents were comparable to the results achieved, as well as by Sawicka and Michałek (2005) [11]. The chemical combustion of stored potato was tested in t h e laboratory throughout storing period. The tubers contain 35% moisture, 25% vitamin C, 16% dietary fiber, 12.5% Carbohydrates 10% calcium, and others. The composition of potato tubers, however, varies considerably according to the class of potato, its variety of origin, and the proportion of outer parts removed by a particular milling process.

Fig 5: The photo was taken during laboratory analysis

Mineral Analysis

Minerals including Na, K, Mg, and Ca were determined by the method described by Sun *et al*. (2011). A total of 100 g of sample was mixed with 8 mL 65% (v/v) HNO_3 for 1 h and then 30% (v/v) H_2O_2 was added. This mixture was digested using a microwave digestion system (MARS 5, CEM Company, NC, and USA). The completely digested sample was diluted with Milli-Q water (Bedford, MA, USA) to make the total volume up to 100 mL and kept at 4 °C for further analysis. The sample was carried out by Inductively Coupled Plasma Mass Spectrometry (ICP-MS, 7700X; Agilent, CA, USA).

Experimental design and data analysis

The experiment was arranged in Factorial Design. With two factors, each at 3 levels (3 potato tuber sizes and 3 storage locations). Statistical analyses were performed on response variables collected over the storage periods using ANOVA (Analysis of Variance) Genstat 18th edition.

Results and Discussion

Temperature and relative humidity of the surrounding environment and storage as well as the mass of damage and number of losses were collected and recorded. Since these, all parameters are important treatment that determine number day potato get stored with considerable losses occurring.

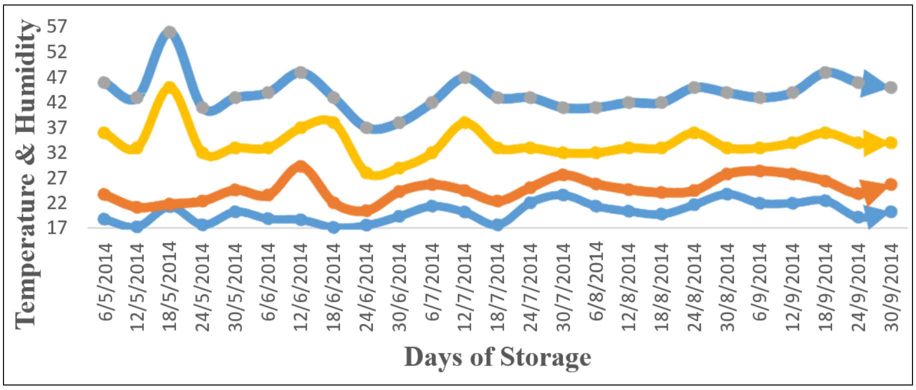

Fig 6: Temperature and relative humidity distribution

As shown in the graph above the temperature and relative humidity of the environment fluctuated frequently, but the internal atmosphere was stayed constant, this was due to that internal conditions were kept in equilibrium by the artificially installed ventilation system, and due it was the ground which was cooler than the above-ground atmosphere. Accordingly, the internal and external average temperatures were recorded as 20 and 25 °C. According to

Saltveint, 2005 & Irtwange, 2006 respiration is mostly affected by temperature, atmospheric composition, physical stress, and stages of development. Ambient temperature can directly affect or influence respiration and metabolic rates. The respiration rate of an agricultural product becomes higher and the shelf life of stored commodities gets shorter under ambient temperatures ranging from 25 to 35 °C (Basediya & Samuel, 2013) [7]. If the temperature of the surrounding area goes beyond the range, deterioration of potatoes began unless relative humidity gets maintained. Thus temperature control is one of the most important factors in maintaining product quality, throughout the period between harvest and consumption. The result obtained agrees with these findings since the temperature was kept below the recommended values.

$$\Delta T(°C) = \frac{Tout - Tin}{n} = \frac{25 - 20}{25} = 0.18\ °C$$

$$RH(\%) = \frac{Rin - Rout}{n} * 100 = \frac{43.8 - 34}{25} * 100 = 40\ \%$$

Table 1: Mean values of physiological Losses of stored potatoes for three locations

variety	Location	Sprouted (%)	Color change (%)	Rotten (%)	Moisture loss (%)
Gudanne	FARC	3.14a	1.25a	1.39a	3.2 a
	Kombolcha	2.03a	1.58a	1.76a	2.2 a
	Haramaya	2.78b	1.84a	2.04a	3.6b

Where, CV-Coefficient of Variation
LSD-Least Significant Difference

In a column means having similar letters are statistically similar and those having dissimilar letters differ significantly at 0.05 level of probability. Accordingly, color change and rotten were not significant across the location due to the management taken across the location was similarly controlled.

Dormancy and sprouting behavior

The sprouting behavior results are indicated in Table 2. The first three months there was a notice of sprouting, after this, there was an increase in the rate of sprouting with storage time. Gudanne variety had the shortest dormancy periods, but the due to good handling of the storage condition the shelf life of the variety were was extended from 21 (twenty-one) days to five months of storage time with minimum total losses of 3.14, 2.03, and 2.78 %, at FARC, Kombolcha, and Haramaya respectively. The difference in the rate of sprouting among the location throughout the storage time is likely to be due to the difference in location temperature and others.

Moisture loss

From lowest to highest moisture of the sample was recorded as 3.2, 2.2, and 3.6 % FARC, Kombolcha, and Haramaya. Even if handling management was taken it was difficult to control all moisture loss. The gradual increase in weight loss is due to respiration which converts the valuable starch in the presence of oxygen to carbon dioxide, water, and Weight loss is primarily attributed to the water loss that occurs through the outer skin tissues during the processes of respiration. The gradual loss in weight is also likely to be due to transpiration with water loss through the tuber skin pores with the help of evaporation (Mathur and Singh, 2008).

Weight of potatoes after total loss (%)

Weight losses were taken from the sum of sprouted, rotten, color changed, and moisture loss of cured samples.

$$W(\%) = \frac{Wi - Wf}{Wi} * 100 = \frac{90 - 8.98}{90} * 100 = 90\ \%\ \text{at the FARC location}$$

$$W(\%) = \frac{Wi - Wf}{Wi} * 100 = \frac{90 - 7.57}{90} * 100 = 92\ \%\ \text{at Kombolcha location}$$

$$W(\%) = \frac{Wi - Wf}{Wi} * 100 = \frac{90 - 7.57}{90} * 100 = 88.6\ \%\ \text{at Haramaya location}$$

Table 2: Effect of tuber size on chemical composition loss (mg/100g) during storage under ambient conditions (Laboratory result)

Parameters		Locations with treatment								
		FARC			Kombolcha			Haramaya		
		Large	medium	small	Large	medium	small	Large	medium	small
		Sample mg/100g			Sample mg/100g			Sample mg/100g		
Vitamin c		2.52	2.16	2.88	3.24	3.24	3.24	2.88	2.16	2.52
Mineral	P	304.18	368.22	350.9	279.5	286.94	316.5	321.4	346.05	385.5
	Mg	4.37	3.7	4.19	3.8	3.8	3.71	3.12	3.52	3.7
	Ca	86.44	88.96	112.1	98.54	85.44	89.47	81.41	83.92	86
Sample		Sample in (%)			Sample in (%)			Sample in (%)		
Moisture. C		85.43	83.54	80.06	84.2	84.12	85	83.39	87.39	82.22
Protein		2.2	5.1	4.7	5.0	4.7	5.4	4.3	4.8	5.4
Ash		4.49	3.59	3.84	3.9	3.48	3.4	3.49	3.39	3
Fiber		1.76	1.50	1.29	1.13	1.36	1.76	0.84	1.13	1.31
Fat		0.39	0.21	0.31	1.13	1.42	0.50	0.95	0.39	0.88
CH_2O		5.76	6.09	9.73	4.595	4.845	3.915	7.02	2.88	7.3
TSS (% brix)		6	6	7.5	6	6	6.5	6	6	6.5
PH		6.19	6.3	6.07	5.97	6.29	5.95	6.36	6	6.12

Total soluble solid (TSS) (% Brix)

TSS (total soluble solids) of harvested potato tubers was measured by using a Hand Sugar Refractometer "ERMA" Japan, Range: 0-32% according to AOAC (1990) through a drop of potato juice and recorded as percentage (%) Brix from an immediate reading of the device. The difference was recorded among the three locations with respect to geometrical diameter and the total soluble solid (TSS) percentage (Table 3). Maximum TSS (7.5%) was recorded in 'large diameter at FARC' followed by 'large diameter at Kombolcha (6.50%). The TSS was the least (5.0%) in 'small diameter' at Haramaya. TSS (total soluble solids) increased with increasing the ambient storage time, up to 5 (five months) days of storage.

Protein content (%)

The laboratory result for the protein content of three geometrical diameters is shown in (Table 3). The highest value for protein content was found in 'small' (5.4%) at Kombolcha followed by 'small at Haramaya' (5.3%). The minimum value for protein was observed in varieties 'Large' (2.2%) followed by 'Large' (4.3%), the difference in protein content was due to the storage environment and tuber sizes, that small diameters have a small surface area that exposed to the storage temperature to loss the moisture content which has a direct relation with the nutritional values of the potatoes tubers.

Ash content (%)

The results regarding the ash content of different potato sizes were given in (Table 3). The highest ash content was found as 4.49% in large diameter of tuber and the least ash content (2.93%) was found in small diameter. 4-6%. Variation in ash was a varietal character as mentioned by earlier researchers (Abbas *et al*., 2011) [1].

Moisture content (%)

The loss of moisture can be attributed to the water lost during transpiration and evaporation while the increase in moisture content is a result of water liberated as a product of respiration. The highest moisture content was recorded in Large at 87.39% and medium at 85.43%. The lowest moisture content was recorded in small at 80.06%.

Total carbohydrates (%)

There was also a noticeable increase in total sugars at the end of the storage period. Tubers had total carbohydrates ranging from 2.88-9.73%. The highest level of total sugars was recorded in small diameter tubers lowest total carbohydrates was recorded in medium tuber due to the area coverage of potato size.

Vitamin C

Vitamin C is the most predominant vitamin in potatoes (Table 3). In general, during the storage time vitamin C content was recorded as 2.16, and 3.24 minimum and maximum respectively. Lower contents of vitamin C have been reported for the variety "Liseta" (2.8mg/100g) (Tudela, Espín, and Gil, 2002), and up to 46 mg/100 g in a Korean cultivar (Han *et al*., 2004).

Minerals

From the laboratory result of Table 3 the potassium, magnesium, and calcium values ranged from (279.5-385.5), (3.12-4.37) and (81.41-112.1) mg respectively. Potassium, Calcium, and magnesium are the minerals typically present at high levels in potato tubers. Potassium is the most abundant mineral in potatoes, reported to represent between 35-45% of the total mineral content (Rodríguez Galdón *et al*., 2012) [5] reported potassium levels ranging between 328 and 451 mg/100g Magnesium levels range between 7.7 and 31.5 mg/100 g of potatoes.

PH

There was a general decrease in pH within the storage time, the pH range of the tubers was found to be between 5.95 and 6.36. This finding is in agree with the findings of Nourian *et al*. (2002) [14] who reported the pH of raw potatoes to be usually around 6.0.).

Conclusion and Recommendation

The following conclusion can be drawn from this study, the total weight before storage was 90 kg at each location from this physiological weight loss including Sprouted, Color changed, Rotten, and Others loss. At the end of the storage times of five months, the left weight of the product was recorded as 81.9, 83.2, and 80.8 kg for the FARC compound, Kombolcha, and Haramaya respectively. As well as chemical composition such as CH2O, moisture contents, protein contents, minerals, and TSS (% brix) almost agreed with their respective findings. It is obvious that the Gudanne variety had the shortest dormancy periods of around 21 days as Haramaya food science reported. The attempt was fruitful in that pit storage could extend the shelf life of the variety up to five months therefore by keeping all the procedure and handling management these storage type is preferable to above-ground storage.

From discussed results and respective findings, potato tubers are living, respiring, biologically active organisms that require optimal storage conditions to maintain the quality that is present at harvest. Successful storage requires that growers have an understanding of the factors that affect tuber health and quality. During this period high respiration rates high moisture loss and high heat production occurs. To minimize the amount of weight loss or shrinkage during early storage, proper wound healing must occur. Basic structural requirements for potato storage include wall strength to resist the pressure of the potatoes, insulation to reduce or prevent the insulation, and structural framework and reduce moisture loss from the storage. Ideal conditions are ventilated, cool temperatures, high humidity, and no light.

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