Adaptation and Evaluation of Ware Potato Storage in Horo and Jardega Jarte Districts of Horo-Guduru Wollega Zone of Ethiopia

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Abstract- *Agricultural products become important for various purposes. To sustain an adequate supply on the market, handling method, storage and transporting technologies of agricultural produce are imperative. Especially for perishable commodity, great attention should be given. Horticultural product must be transferred from the field to the table in a state that is acceptable to end users. In Oromia as whole, substantial amount of horticultures are believed to go waste before it reaches for users due to lack of proper handling and appropriate storage. Until damage occurred, mostly effect of mishandling and storage is not realized. However, poor handling and storage can easily result in total loss of agricultural produce. Holetta ware potato storage was developed to prolong shelf life of potato in two Districts of Horo-Gudure Wollega Zone. In order to adapt and evaluate this ware potato storage, the study was conducted at Horo and Jardega Jarte districts in Gitilo Dale and Sombo Watu sites. From the result obtained, for Gitilo Dale site ware potato storage prolonged potato tuber for four and half months with 0.85% damage, 1.35% shrinkage and 8.32% sprouted. Average maximum and minimum storage temperatures are 21 and 10 ^{0}C respectively whereas maximum and minimum of relative humidity of storage are 70 and 34% consecutively. Whereas for Sombo Watu site within four and half months, the storage is characterized with 3.32% damage, 8.42% shrinked and 15.65% get sprouted. Average maximum and minimum storage temperatures are 26 and 17 ^{0}C respectively whereas maximum and minimum of relative humidity of storage are 63 and 20% consecutively. As per result observed from evaluation of storage, the storage is mainly recommended for Gitilo Dale site condition irrespective of potato variety.*

Index Terms- *Damage, Humidity, Potato, Shriveling, Sprout, Storage & Temperature*

I. Introduction

Potato (*Solanum Tuberosum L.*) is the fourth most important food crop in the world [1, 2] and grown in more than 125 countries and consumed almost daily by more than billion people. Several millions of people living in developing countries depend on potatoes for their survival. Ethiopia has highest potato producing potential than any country in Africa with 70% of 13.5 million hectors of arable land suitable to potato cultivation and production as well [3]. However, the potato is widely regarded as a secondary non-cereal crop in part because it has never reached the potential in supporting food security.

In Oromia, root crops covered more than 86 thousand hectares of land and yielded more than 5 million quintals of produce per year. Potatoes, onion and sweet potatoes constituted 62.56%, 13.94%, and 12.57% of the regional area under root crops, respectively. Particularly in East Wollega Zone, potatoes and sweet potatoes covered 77.98% and 9.89% of the area under root crops and 60.91% and 16.83% of the production, respectively [4].

Potato is one of the most productive food crops in terms of yields of edible energy and good quality protein per unit area and per unit of time fitting into intensive cropping systems [5]. Potato is one of precious gift and also very common in the dishes of most Ethiopians. This importance necessitated the growth and production of potato throughout the year often via the use of irrigation. Potato provides high nutrition and an adaptive to Ethiopia climate [6].

Contribution of potato tubers to the diet and income generation in the country is insignificant due to several factors. The reasons are low production and productivity, lack of adequate pest control, lack improve varieties, market, lack of attention to product quality and prevention of physical damage, as well as the lack of storage and packing facilities [3,7]. To reach the end users, there should be appropriate post-harvest handling mechanism. Methods and technologies of handling are imperative for various agricultural products.

Great attention should be given for ware storage especially for perishable commodities in order to transfer from the field to the table in a state of acceptable to users. Most of them begin deteriorate as soon as they are harvested, and most are particularly prone to handling damage at all times till consumed. Since they are susceptible to any action, proper handling and appropriate storage structure is paramount important to preserve their self-life.

In general speaking, handling damage is greatly underestimated, because usually mishandling do not appears until sometime damage occurred. Mechanical or physical damage of the products can be occurred through all stage of the chain from harvest to consumption with inclusiveness of handling and transportation from rural to urban markets. Poor handling and storage can easily result in a total loss.

Lack of proper storage systems are among the main factors contributing to the low yield of potato in the region, which is the case at the country level also [8]. Furthermore, market price of the product and marketing systems are also problematic [9]. Due to lack of an appropriate storage and handling equipment's, substantial amount of horticultural product is believed to go waste before it reaches for consumption or is sold at a thrown away price. According to Mulatu, 2005 [10] unavailability of proper potato seed storage forces the farmer to sell immediately during harvest with low price, whereas availability of proper storage facilities allow farmers to sell their potato tuber as a seed during planting or in the later season with higher price compared to the immediate sell.

Farmers stored potato either for ware or seed using various traditional mechanisms. These traditional storage facilities do not allow the farmer to store potato not more than three and half months without deterioration [9]. However farmer requires good storage either to use tubers of their own harvest as a seed source to postpone sales to get better market price and for household consumption in the later season. Low market demand for potato tuber production cost was among the main factor. According to Fuglie, 2007 [11] farmers in the Jeldu and Degem districts were already distinguished the seed and ware potato and they might look only for seed potato market, whereas according to Ayalew and Hirpa, 2014 [9] study farmers immediately sell the tuber as a ware due to fear of market unavailability for seed potato.

Postharvest losses can also be minimized by storing them at low temperature and high relative humidity environment [12]. The storage employs the cooling power of evaporation. Evaporative cooling occurs when dry warm air blown across a wet surface. Heat in the air is utilized to evaporate the water resulting in air temperature drop and a corresponding increase in relative humidity [13, 14]. According to Rusten 1985 [15], Evaporative cooling is generally more efficient where air temperature are high; relative humidity very low, water available and air movement is adequately available.

An evaporative cooling chamber is simple technology, easy to construct and low cost of its construction since it can be made from locally available materials. Low temperature storage system can effectively extend shelf life of fruit and vegetables in minimizing major postharvest losses by arresting metabolic breakdown and fungal deterioration. An evaporative cooling system has an efficiency of 50% significant effect on room temperature of non-air conditioned as well as shaded rooms [16]. It enables by letting availability of fruits and vegetables possible in most parts of the year effectively without additional inputs in to production. In addition to this, disposal problem faces in many town and city that consequent pollution will be reduced.

The purpose of this investigation was therefore; to adapt and evaluate effective storage that helped to prolong shell life of potato tuber and reduces loss occurs due to mishandling and storage problem and enable sustainable supplying to local market got ensured.

II. MATERIAL AND METHOD

SITE SELECTION

Potential potato producing districts were identified and selected according to recommendation established by Horo Guduru Zone Natural Resource and Agricultural Development office based on merit and accessibility to road. From Horo district, *Gitilo Dale* site was selected for conducting research. *Gitilo Dale* is located at altitude of 2770m above sea level, latitude $9^{0}32^{'}$N, longitude $37^{0}04^{'}$and characterized with wind speed of 0.02 to 0.04 m/s. From Jardega Jarte district, *Sombo Watu* was selected. *Sombo Watu site* is characterized with altitude of 2410m above sea level, latitude $9^{0}57^{'}$N, longitude $37^{0}05^{'}$E and has wind speed range of 0.01 to 0.02m/s.

MATERIAL

Important materials for construction of an appropriate evaporative cooling storage were identified and selected. Accordingly different sizes of wooden plank, straw, thatch, timber, mesh wire, mud and nails with different sizes were prepared and employed for construction of required size and shape of storage structure. Five storages were constructed and each ware potato storage has a capacity to store five quintals of potato tube. However Gudane, Jalane and Menagesha potato variety were available at *Gitilo Dale* site but Gudena variety was selected and used as treatment since it is predominately cultivated. Jalane potato variety was employed or used in *Sombu Watu*.

So far two meter width and three meter length ware potato storage were constructed for three & two farmers in Horro & Jardega Jarte districts respectively. The constructed potato storage structures were faced in windy direction of *Gitilo Dale and Sombo Watu* sites so as to enhance removal of warmed air due to respiration of potato tubers. The storages were constructed in sites where air is mostly blown for more than four months starting from September. The storage employs an evaporative cooling system which is an efficient & economical means for reducing the temperature and maintains required relative humidity in storage.

CONSTRUCTION OF STORAGE

Floor is basic component of potato storage structure and should be strong enough to support or carry the required load. Storage load mainly imposed from entire constructed body and loaded potato tubers. The floor carried the bed or maximum height of the piles of potatoes laid on six crates which has1.2m length and 0.6m width where potato tubers get over laid. Each crate has a capacity to store 80 kg of potato tubers. The constructed wall stands up to 1.5m above floor level to support bulk potatoes under normal condition. The wall in a bulk potato store, together with a layer of insulation, must resist all lateral forces. On these walls with preference to windy direction, ventilation window was suited for air entrance and exit for cooling system.

Four ventilation windows which have 35 by 40cm dimension were prepared in our workshop and constructed. Among these, two of them allow cool air in flow from environment in to the storage and the remaining two of them exit hot air from storage to the environment. The roof spans were 3 meter by 1.7meter and to provide a minimum overhang of 0.5m on inlet and out let elevations. The roof must prevent rain penetration and must not allow light to reach the potatoes. The actual opening part of the door requires no special structural attention. However, if it is intended to fully utilize the entire store volume, it is necessary to provide vertical timber boards across the door opening. Main treatments are amount of damage, sprouted, shrinkage, temperature, humidity and area of storage. Potato tubers were stored over floor that is exposed to sun light.

EVALUATION OF STORAGE

Four quintals of potato tubers were stored in all storages. Prior to harvesting potato tubers, potato stalks were removed in order to make better curing period. Before storing the potato, prerequisite data's particularly weight of potato, volume of potato, storage and ambient condition were collected & documented starting on loading day. Potato tubers were directly harvested from the farm and screening was made soon and separation of undamaged from damaged done earlier to storing them.

Since storage employs evaporative cooling heat trapped from warmer pad to lower, stored produces shelf life would be prolonged to better without significant decomposition & deterioration. Rate of evaporation is mainly affected with temperature, relative humidity, air movement and surface area of containers. In order to achieve best storage time or prolong shelf life, proper storage management should be practiced.

Proper storage practices include temperature control, relative humidity control and air circulation. Both storage air inlet & outlet ventilation windows were opened during night time at 13:00 to 00:00 and closed at day time 00:00 to 12:00 at local time. Storage losses are mainly caused by the processes like respiration, sprouting and evaporation of water from the tubers. Therefore parameters like damage, wilting & sprouting which determine storage performance were closely observed & data were being collected within five days interval from both sites.

III. RESULT AND DISCUSSION

Three storages were constructed in *Gitilo Dale* site of Horo district where as two of them were prepared in *Sombo Watu* site of Jardega Jarte district. Each ware potato storage has a capacity to store five quintals of potato tube. All storages were made to have good feature than any other and their inner surface became smooth so that physical injure of potato that was accountable for decomposition get removed. Before storing the potato, pre-requisite data's particularly on storage and surrounding condition were collected and recorded.

Since all data were collected at the same time with similar air condition, average based ambient condition was taken for all storages. Important datas' were begun to be collected proceeding storing date. Proper data was taken as follow, four quintals of potato tube were kept in each storage for case of *Gitilo Dale* site at the same day and important data's were registered. Whereas for case of *Sombo Watu*, five days later the remaining two storages were loaded and data collections were began.

In overall, proper storage practices include temperature, relative humidity, air circulation and maintenance of space between containers for adequate ventilation, and avoiding incompatible product mixes. 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. Temperature and relative humidity of surrounding environment and storage were collected at day and night of storage and for control within five days interval since both are important parameters for determining shelf life of stored commodities. The storage life of a product varies with species, variety and pre harvest conditions particularly quality and maturity.

As a whole, ambient temperature and humidity, temperature and humidity of storage, mass of damage, sprouted and shrinkage were among those important treatment collected to determine number of a day potato can be stored without inconsiderable losses occurred.

Gudane variety was collected using modern potato digger at Gitilo Dale site and stored starting from October 08, 2018 in three storages. Whereas at Sombo Watu site Jalane variety was digged and stored later than five days. In both sites, data were started to be collected on the storage began. Data were collected and interaction of these parameters was anticipated separately as follow for both districts.

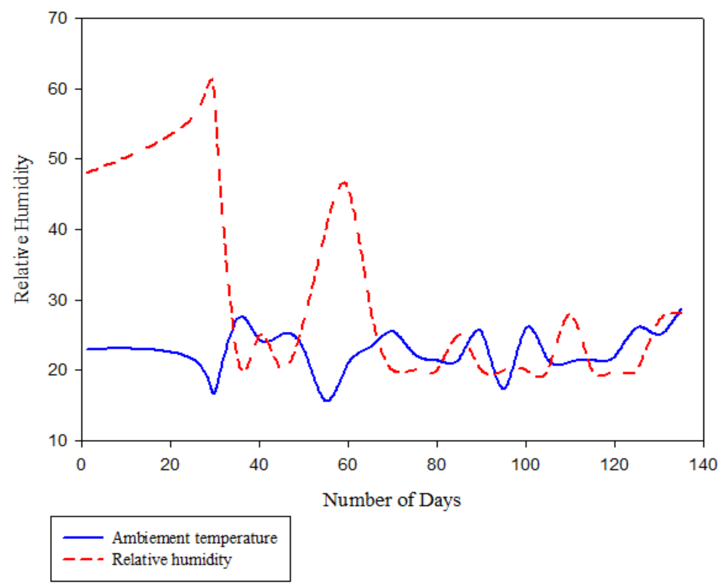

Figure 1 Ambient temperature and humidity variation during day time in case Gitilo Dale site

According to Basedya & Samuel, 2013 [17] under ambient temperatures from 25 to 35 $°_C$, respiration rate is higher and storage life become short. Deterioration of stored produce during storage mostly depends on temperature. Throughout the period between harvest and consumption, temperature control is one of the most important factors in maintaining product quality. Respiration and metabolic rates are directly related to room or air temperatures within a given range. The higher the rate of respiration, the faster the produce deteriorates. However average based maximum and minimum ambient temperature variation of Gitilo Dale at mid-day is 27.3 $°_C$ and 15.6 $°_C$ respectively which is still less than recommendation.

Relative humidity, air movement and surface area are other important parameters to be considered during handling product stored since they have much contribution to determine shelf life of product stored. Speed of air at *Gitilo Dale* is low and it's intensive movement is mostly occur between September to February. Here maximum and minimum relative humidity of potato stored during mid-day is 60% and 20%.

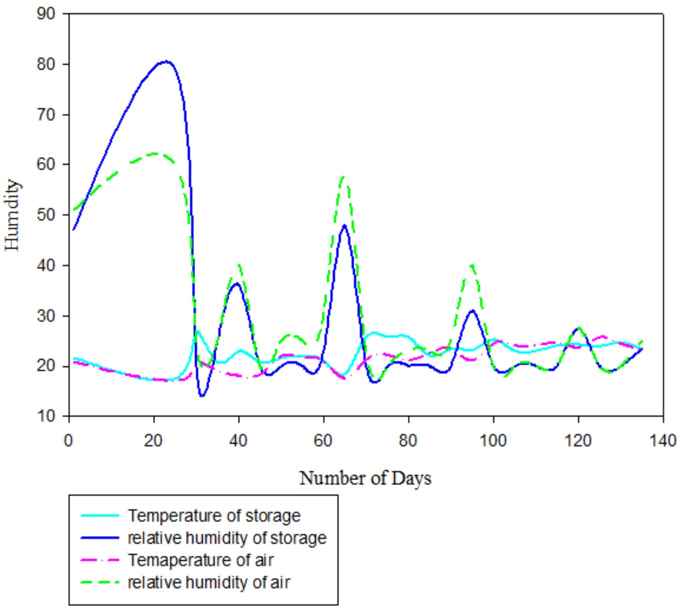

Figure 2 Night time ambient temperature and humidity as well as temperature and humidity as well as temperature and humidity at Gitlilo Dale Site

According to Odesola & Onyebuchi, 2009 [18] at high relative humidity, agricultural products maintain their weight, wilting and softening are reduced and rate of water evaporation is low and therefore cooling is low. Maintaining high humidity around harvested produce reduces water loss, which would result in decreased returns through poor quality which mean wilting, shrivelling and loss of saleable weight [17].

High humidity should be used with low temperature storage because high humidity and temperate in combination favours the growth of fungi and bacteria. In order to prolong shelf life, relative humidity and temperature should be maintained properly. According to heat transfer application temperature goes from higher to lower concentration until it reaches equilibrium condition. During day time since the storage is tight and no way for light and wind to enter, what products respired concentrated in storage. When ventilation windows which is directed to wind motion get opened during the night, cold wind wiped out the warms from the storage and storage get cooled.

Here maximum & minimum relative humidity of storage environment is 70 % & 34% whereas maximum & minimum temperature of the storage is during night is 21 & 10 °c respectively. Air movement here is better and dried air blown outside of the ware storage which carried off warmed air from inside of the storage.

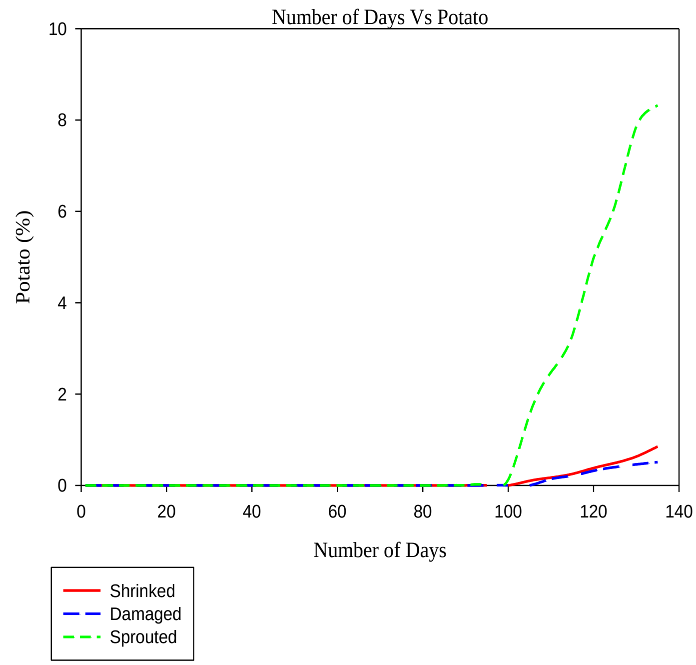

Figure 3 Amount potato damage, shrinked and sprouted during storage period at Gitilo Dale

Rate of evaporation is mainly dependent on movement of air and surface area over which tubers stored. As water evaporates from a surface it tends to raise the humidity of the air that is closest to the water surface. If humid air remains in place, the rate of evaporation will start to slow down as humidity rises. On the other hand, if the humid air and the water surface constantly been moved away and replaced with drier air, the rate of evaporation will either remain constant or increase. The greater the surface area from which water can evaporate, the greater the rate of evaporation [18].

As the period of storage increased, rate of decomposition, shriveliing and sprout increased too. However at hundred thirty five days: 8.32 %, 1.36 % & 0.85% became sprouted, shrinked & damaged respectively. Here all sprouted tubers were directly used for on field plantation for the next season where as some shrinked part were used for dish. Decomposition of the tubers may be caused mainly because of injury happened during transportation from field in to storage and respiration processes.

The storage is very tight and opaque for light to minimize degree of damage and welting and storage ventilation window should be opened as per programmed. But in reality due to mismanagement and dalliance, the windows were not opened on time and not closed before the time as per scheduled. Because of this mishandling considerable amount of potato tubers were decomposed, welted and sprouted before it researched expected time planned.

Here potato tubers were normally stored over local bed inside the house which exposed to solar radiation. At high relative humidity and temperature, respiration rate becomes high and the faster the produce deteriorates. The more water gets removed; greater weight losses and shrinkage become higher than usual.

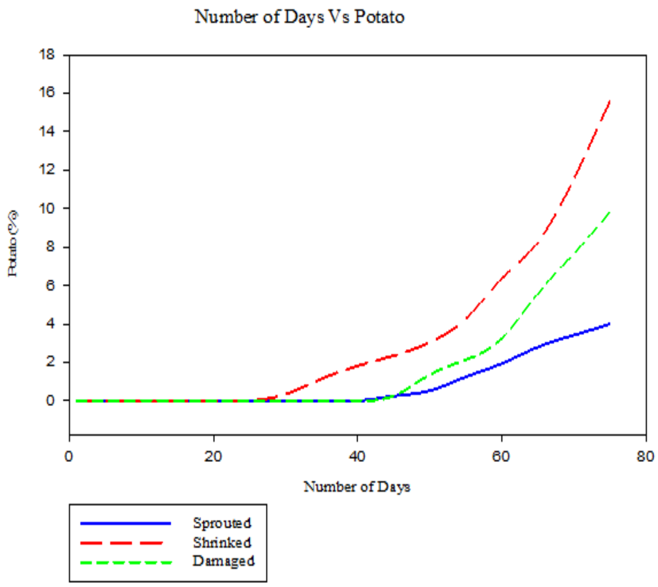

Figure 4 Amount of potato get damaged, shrinked and sprouted employing traditional mechanism

Since potato tuber respires, water gets losses quickly. Unless water vapor should be blown up with dry air coming outside through vent, wilting, shriveling & weight loss will be increased. Here there is no vent and means to remove humid air to get cooled environment and pad. Sample of 25kg potato tubers were used as control at seventy five days 54.65% wilted, 14.19% damaged and 30% sprouted.

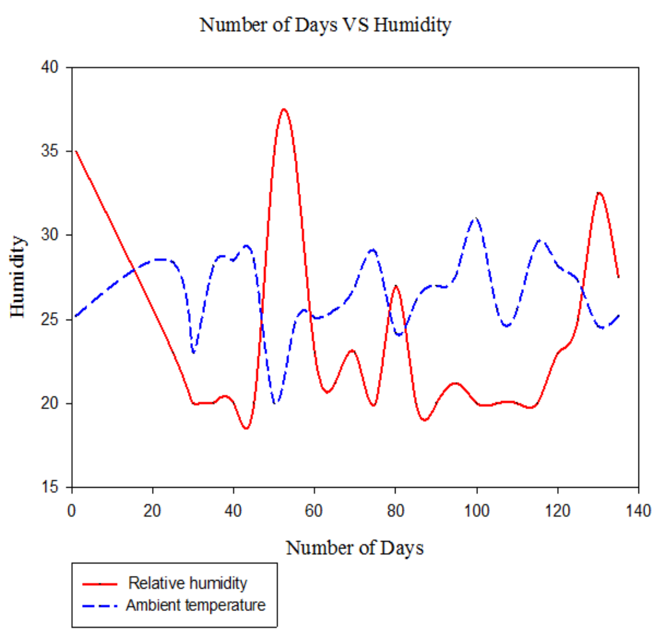

Figure 5 Ambient temperatures and Humidity variation during time in case Sombo Watu site

Under ambient temperatures from 25 to 35°C according to Basediya, 2013 respiration rate is higher and storage life is short. However in case of Sombo Watu site of Jardega Jarte average based maximum and minimum ambient temperature variation at mid-day were 31°c & 23°c respectively which is more or less in the specified range.

Since they have much contribution to determine shelf life of product stored, relative humidity, air movement and surface area are important parameters to be considered during handling product stored. Here maximum and minimum relative humidity of potato stored during mid-day is 36% and 20%. Here temperature is becoming higher as compare to Horo district site and relative humidity is become lower as compare to Horo district. Both parameters are directly and indirectly influencing storage performance in handling practices.

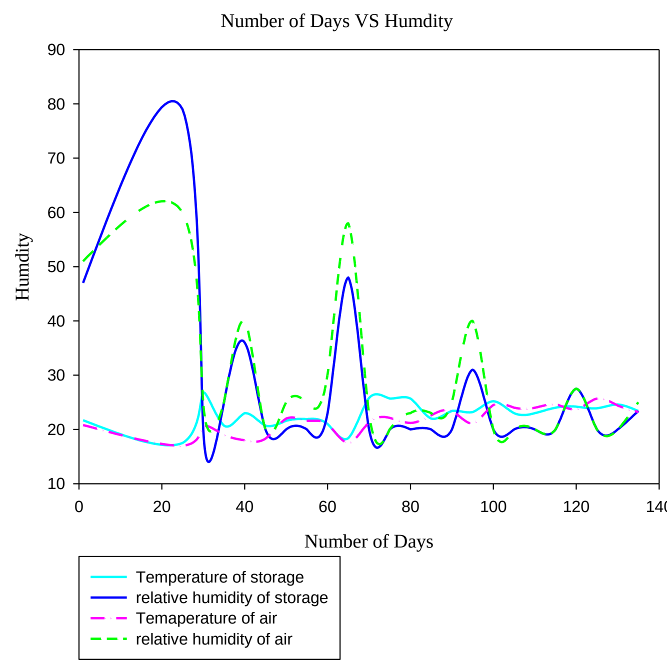

Figure 6 Night time ambient temperature and humidity as well as temperature and humidity as well as temperature and humidity at Sombo Watu

According to Odesola & Onyebuchi, 2009 [18] when the relative humidity is high, the rate of water evaporation is low and therefore cooling is also low. But relative humidity of the storage during night time is still higher than ambient when computed on average, maximum & minimum became 62% and 20% respectively.

However humidity & high temperate in combination favors the growth of fungi and bacteria. At night time higher temperature with warmed air presented in the storage but cold and dried air is blown in environment outside the storage. Since at every day at 1:00 local time, ventilation window get opened for recirculation of air the chamber. Cold dried drive out warmed air due to creation of bouncy force because ingredient of density difference air. Temperature of storage is higher than temperature of air in environment this implies that water vapor get respired during the day time get accumulated and become removed at night time. This causes temperature difference which bases cool environment for potato tubers.

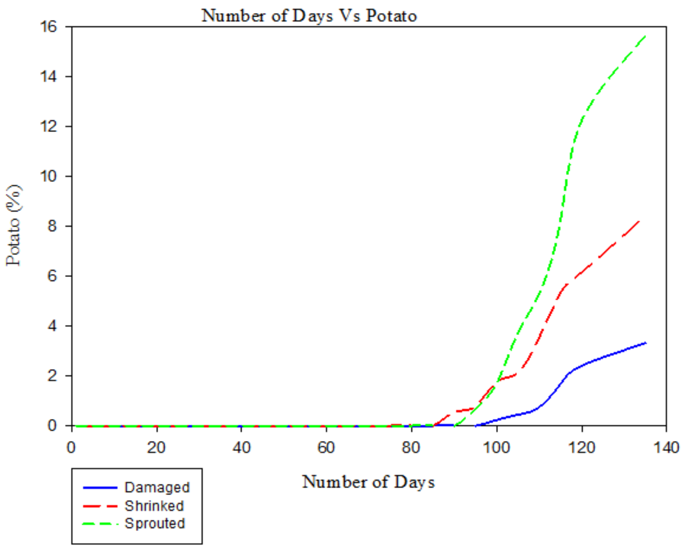

Figure 7Amount potato damage, shrinked & sprouted during storage period at Sombo Watu

Since ambient temperature and relative humidity of Sombo Watu is higher than Horo district, rate deterioration is increasing from time to time. As the period of storage increased, rate of decomposition, shriveling and sprout increased faster than that of Horo district. Since altitude is lower, air becomes warmer & wind speed is lesser. However at hundred thirty five days about 15.65%, 8.42% & 3.32% became sprouted, shrinked & damaged respectively.

Damage or decomposition mainly connected with injure caused during transporting from field in to storage and respiration processes. All damage and some sever shrinkage tubers are not useful. The remaining tubers can be used as food and seed. The sprouted potato totally used as seed for both off season and on season. Most of the time for off season case; it generates high income for farmers than on season.

IV. CONCLUSION AND RECOMMENDATION

From the experimental result obtained, we observed that various parameters are engaged to determine quality of storage of potato tubers. In addition to the maturity level and variety, damage, shrivelling and sprouting have great importance in order to decide shelf life of stored potato and their valuable. Thus, damages and sprout can be minimized by taking care during transportation from field to the storage and harvesting time. Harvesting period and activity also affects the storing time and the stalk of the potato should be removed twelve days before storage to strengthen skin of potato under the soil.

With proper storage practices, this ware storage has prolonged shelf life of potato for five months with little losses at holeta site. While the remaining factor keeps constant, at Gitilo Dale site, this storage enabled to preserve potato tubers for about four and half months with little damages which is 0.85%. Since altitude, weather condition and wind speed of Holetta and Horo district is diverse, result obtained at both sites are somewhat different. Whereas at Sombo Watu site within the same months potato get stored with losses of 3.5%. Therefore, temperature, relativity humidity and air speed are main influence factor for storing potato tubers.

Proper handling practices and managing time of operation are another important issue which affects storage produce life. Storage ventilation window operation time should be managed in order to have long storage time. Window should be opened at 13:00 and closed before 06:00 in order to block sunlight from entering the storage. If the light gets diffused in it speeds up sprouting faster and losses too. Main advantage of storage is prolonging shelf life of potato thereby sustainable availability of potato over the market and makes gain of additional money for farmers.

In general the structure of the storage required important care during construction totally the sun light should be blocked as much as possible from entering into the storage and time of ventilation have to be seriously applied unless there might be great losses or cause total damage on potato tubers.

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