# Seed Quality Affects Postharvest Characteristics of Tomato Fruits (*Solanum lycopersicum*)

***H. M. Bortey, E. Adu-Kwarteng, and A. Aidoo Snr**
CSIR - Crops Research Institute, Fumesua, Kumasi

***Corresponding Author: hmireku@gmail.com**

***Abstract***
*The use of quality tomato seeds does not only ensure good germination, optimum crop establishment and yield but also guarantee good postharvest characteristics such as fruit uniformity and enhanced shelf life. The present study sought to establish the relationship between poor seed quality and some postharvest fruit quality characteristics such as fruit shapes and fruit shelf life. The percentage mean occurrence of varied fruit shapes harvested from the same farmer's field ranged from 2.4% to 47.6% in the Forest zone and from 3.3 to 21.6% in the Forest-Transition zone of Ghana. Generally, four to nine different fruit shape categories were identified across farmers' fields in both the Forest and Forest-Transition zones. The percentage weight loss after 15 days of storage under ambient condition for the flattened fruit shape was as high as 90% while the oblong shape fruit recorded 56% within the same duration. Smallholder tomato farmers are encouraged to use high quality seeds for uniform fruit*

***Key words: tomato, seed quality, postharvest, water retention***

# La Qualité des Semences Affecte les Caractéristiques Post-Récolte des Tomates (*Solanum lycopersicum)*

***Résumé***
*L'utilisation de semences de tomates de qualité garantit non seulement une bonne germination, une culture et un rendement optimaux, mais également de bonnes caractéristiques après la récolte, telles que l'uniformité des fruits et une durée de conservation accrue. La présente étude visait à établir la relation entre la mauvaise qualité des semences et certaines caractéristiques de la qualité des fruits après la récolte, telles que la forme et la durée de conservation des fruits. Le pourcentage moyen d'occurrences de diverses formes de fruits récoltées dans le champ du même agriculteur allait de 2,4% à 47,6% dans la zone forestière et de 3,3 à 21,6% dans la zone de transition forestière au Ghana. En générale, quatre à neuf catégories de formes de fruits différentes ont été identifiées dans les champs des agriculteurs, tant dans les zones forestières que dans les zones forestières en transition. Le pourcentage de perte de poids après 15 jours de stockage dans des conditions ambiantes pour la forme du fruit aplati atteignait 90%, tandis que le fruit de forme oblongue enregistrait 56% au cours de la même durée. Les petits producteurs de tomates sont encouragés à utiliser des semences de haute qualité pour obtenir des fruits uniformes.*

***Mots clés: tomate, qualité de la graine, post-récolte, rétention d'eau***

## Introduction

The tomato sector in Ghana over the years has not been able to attain its full potential, particularly in terms of yields comparable to other countries. Although average yield reported are varied, it ranges from 6.7 t/ha (Asuming-Boateng and Asuming-Boakye, 2008), 7.5 t/ha (ISODEC, 2004) to 10.6 t/ha (Robinson and Kolavalli, 2010a). Wolf (1999) however, had earlier reported a national average of 13 t/ha in late 1990s. The cause for such low yield levels could be several; however, the quality of seeds used by these farmers play a critical role. Farmers' choice of varieties influences and is influenced by access to seeds and growing technologies among other factors (Robinson and Kolavalli, 2010a).

Smallholder farmers in Ghana generally rely on their own saved seeds for tomato production (Orchard and Suglo 1999; Horna et al., 2006; Robinson and Kolavalli, 2010a; Bortey et al., 2011). According to Orchard and Suglo (1999), farmers in Ghana have historically appeared reluctant to purchase seeds. Although the authors acknowledge this phenomenon is changing, seed recycling or use of own-saved seeds account for up to 85–90 percent of seed supply in the past (Orchard and Suglo 1999; Horna *et al*. 2006). Recent surveys suggest that only 33 percent of farmers were exclusively using their own seed (extracted from tomatoes, washed, and dried), with another 20 percent using both recycled seed and purchased seed, or seed from other farmers; with the remaining 47 percent purchasing all their required tomato seed (Monney *et al.* 2009). Bortey *et al.,* (2011) also reported for tomato farmers, 52% used their own saved seed while the remaining are either obtained from the local market, neighbours or agro dealer stores. This phenomenon is similar for other vegetable, cereal and legume crops (Maredia *et al.,* 1999; Asare-Bediako *et al.,* 2007; Louwaars and De Boef, 2012).

Seed costs vary considerably according to variety. Farmers can recycle their own seed; that is extracting from local varieties at very little cost. They however, risk reduced yields from inbreeding and disease transmission, especially of fungal diseases. Further, due to the exchange of seeds with neighbours or purchased from local markets, seeds are highly mixed. The resultant fruits harvested from growing such mixed seeds are non-uniform in terms of shape, sizes and may also possess varied shelf life, which affect market value and postharvest losses.

The present study sought to establish the level of tomato seed mixtures within the same harvested lot among small holder farmers in two major tomato growing areas and the relationship between poor seed quality and some postharvest fruit quality characteristics (eg. fruit shape, shelf life). Regarding the shelf life of the tomato, the study looked at the ability of the different fruit shapes to retain moisture. The new insight generated from this study will guide small holder tomato farmers the need to use improved seeds.

## Materials and Methods

### *Study Area and Sampling technique*

The field survey to obtain tomato fruit samples was conducted in two major tomato growing areas in Ghana; Agogo area in the Forest zone in the Ashanti region and Akomadan area, which falls within the Forest-Transition agro ecological zone in the Brong Ahafo region. The study area was purposively sampled to cover areas the Korea-Africa Food and Agriculture Cooperative Initiative (KAFACI) Horticulture Postharvest Project was implemented.

A total of eight (8) tomato farmers both study areas were randomly selected with the assistance of the Agriculture Extension

Agents (AEAs). Five (5) farmers were selected from the Forest zone (Agogo area) while three (3) were from the Forest-Transition zone (Akomadan area). The researcher together with the farmers harvested the fruits from the farmers' fields. Fruits were randomly harvested as farmers ordinarily do. After harvesting, fruits were kept in an aerated plastic basket according to each farmer's field, labelled and conveyed to research station for fruit characteristics identification and storage studies.

***Laboratory Studies***

A total of 200 tomato fruits were harvested and brought from each of the farmers' fields to the research station. Out of this, a total of 50 apparently cleaned fruits with no bruises or defects each were randomly selected and scored to determine the level of distinctness in fruit shapes within a lot, harvested from a single source (field). The UPOV Text guideline for Tomato (TG/44/11 Rev.) was used for scoring fruit characteristics mainly fruit shape in longitudinal section, ribbing at peduncle end, depression at peduncle end, fruit shape at blossom end and locule number. The text guideline descriptions particularly for the fruit shape characteristics was more expanded and served the purpose of this study compared to the Bioversity tomato descriptor. According to the text guidelines for testing varieties for differences, a number of factors should be considered; in particular, the type of expression of the characteristics being examined; whether it is expressed in qualitative, quantitative or pseudo-qualitative manner. In the present study, both quantitative characters as well as pseudo-qualitative characters were examined. In all, four quantitative characteristics were examined; namely ribbing at peduncle end of fruit, depression at peduncle end of fruit, fruit shape at blossom end and number of locules. The pseudo-quality characteristic examined was fruit shape in longitudinal section.

To determine the shelf life of each fruit shape category, 10 fresh tomato fruits were selected due to insufficient fruits. Initial weights were recorded and subsequent weights were recorded at five days interval for 15 days. Fruits were stored at an average temperature of 27.3°C, minimum of 26.5°C and maximum of 30.5°C under ambient condition. The corresponding relative humidity was recorded for minimum, maximum and average was 75, 90 and 83.8% respectively. Rotten fruits were taken from the lot during the storage period and factored in the weight calculations.

Five (5) fruits per each fruit shape category were cut in transverse section and the number of locules was counted and the average recorded.

**Data analysis**

The differences among varieties in reference to fruit shapes to establish the level of mixture was obtained by scoring according to the text guidelines stated above. The scores were then expressed as a percentage of the total fruits scored. Descriptive analysis was used and presented in the form of column charts, Line charts. Pictorials were also used to present data on seed/fruit mixtures and locule numbers. Means were separated using error bars at 5% significant level.

**Results and Discussions**

From Figure 1 and 2, the level of seed mixtures among farmers harvest lot was significant. As revealed, the level of seed mixtures was related to different fruit shapes found within the same lot of farmers' harvest. The percentage mean occurrence of varied fruit shapes harvested from the same farmer's field ranged from 2.4% to 47.6% in the Forest zone (Figure 1). The major occurring fruit shape type was the Oblate, followed by the Circular and the Flattened. Fruit shapes identified within the same farmers' lot in the

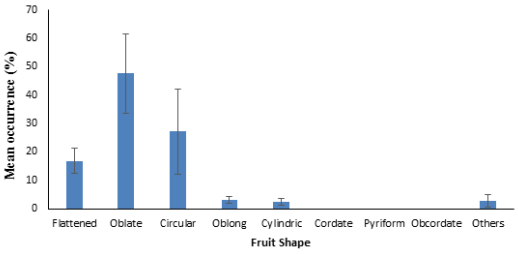


Figure 1: Mean occurrence (%) of different fruit shapes from tomato farms sampled in the Forest zone; Error bars = standard deviations for 5 farms

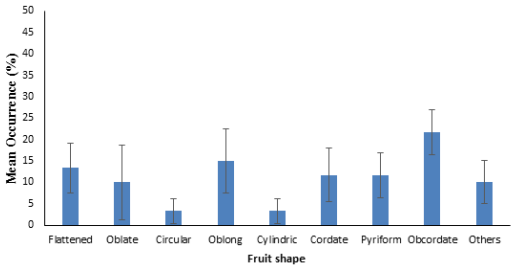


Figure 2: Mean occurrence (%) of different fruit shapes from tomato farms sampled in the Forest-Transition zone; Error bars = standard deviations for 3 farms

Forest-Transition zone covered a wider range. The percentage mean occurrence ranged from 3.3 to 21.6% (Figure 2). In the Forest-Transition zone, the major occurring fruit shape category was the obcordate (21.6%), followed by Oblong (15%) and Flattened (13%). Generally, four to nine different fruit shape categories were identified across farmers' fields in both the Forest and Forest-Transition Zones. Plate 1a, 1b and 1c show the diverse fruit shapes identified in farmers' field in the Forest-Transition zone, and Plate 1d depicts fruit shapes identified from fields in the Forest zone. There were fruit shapes that were unique to both agro-ecological zones. The Forest-Transition zone

(Akomadan) area had fruit shapes like oblong, cordate, ovate, obovate, pyriform and obcordate while the flattened, oblate and circular fruit shapes were the popular types mostly cultivated in the Forest zone.

The level of seed mixtures according to the fruit shape at blossom-end further depicted the differences among the various identified fruit categories. As shown in Fig. 3, majority of fruit shapes identified within the Forest zone (F1 –F5) had Flat and Indented to Flat shape at the blossom-end while fruits from the Forest-Transition zone (F6-F8) had most of its fruit shape at the blossom end being pointed, indented and Indented to Flat.

The bases for relating the level of seed mixtures (pertaining to fruit shape and size) to reveal the level of distinctness in fruit of tomato among farmers, stems from several studies establishing the genetic bases for such linkage (Lippman and Tanksley, 2001; van der Knaap and Tanksley, 2003). It has been established that tomato fruit size and shape are largely quantitatively inherited (Tanksley, 2004) and approximately 30

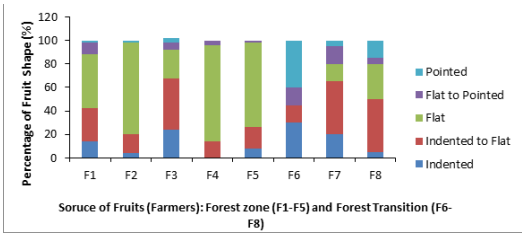


Figure 3: The level of seed mixtures identified within the same farmers' lot based on fruit shape at blossom-end.

quantitative trait loci (QTLs) accounts for most of the variations in both tomato fruit shape and size.

From this study, the level of seed genetic impurity as related to the diverse fruit shapes identified within the same harvest from one field depicts the prevailing practice in the seed system in Ghana, particularly the vegetable seed system. An earlier study by Bortey *et al.,* (2011) revealed that about 52% of tomato farmers save their own seed for replanting the subsequent years, however, the remaining 48% are shared among farmers who obtain seeds from the local market (28%), agro-store (15%), neighbours/friends (4%) and NGOs (1%). Further investigation revealed, almost all these seeds obtained from the above mentioned sources are farmer-saved seeds which have been sold or exchanged for income (Bortey et al. 2011). Other studies have reported the use of own-washed tomato seeds recycled seeds to be 33% and 20% respectively (Monney *et al.* 2009). This could explain why the level of seed mixtures observed cut across all tomato farms in the two study areas. As reported, majority (80%) of smallholder farmers in Africa continue to rely on the informal sources such as own saved seed, farmer-to-farmer exchange, local grain market for seeds. In the case of vegetable seeds in Ghana, this is more prevalent due to lack of reliable seed system (Maredia et al., 1999; Asare-Bediako *et al.,* 2007; Louwaars and De Boef, 2012).

**Number of locule among tomato fruits**

Another characteristic used in identifying the level of mixture as related to fruit shape is the number of locule. Plates 2 and 3 show pictorial representation of the number of locules identified in fruits from the same farmer's field. Locule numbers among fruits from farmers' fields in the Forest zone ranged from 6.8 to 8.6 while those from the Forest-

Transition zone ranged from an average of 3.2 to 3.8. The locule numbers found in fruits in the Forest-Transition zones were few, average of 3.2 while those identified from fruits in the Forest zone were more average 8.6. The fruits with less number of locules were correspondingly smaller compared to those that had more number of locules.

Plate 2: More Locule numbers (5-9)

Plate 3: Fewer Locule numbers (2-3)

The number of locules generally found in tomato fruits (*Solanum lycopersicum*.) ranges from two to ten or more as corroborated by other findings (Munos et al. 2011). This observation could be the reason fruits obtained from the Forest zone were relatively bigger than those from the Forest-Transition zone. Locule number has been linked to fruit size of tomato via changes in the number of carpels in the flower (Tanksley, 2004). Cong *et al.,* (2002) and Munos (2011) have also reported that the locule number affect both the final size and shape of tomato fruit. As observed, the fruits with less number of locules were of smaller size compared to those with more number of locules.

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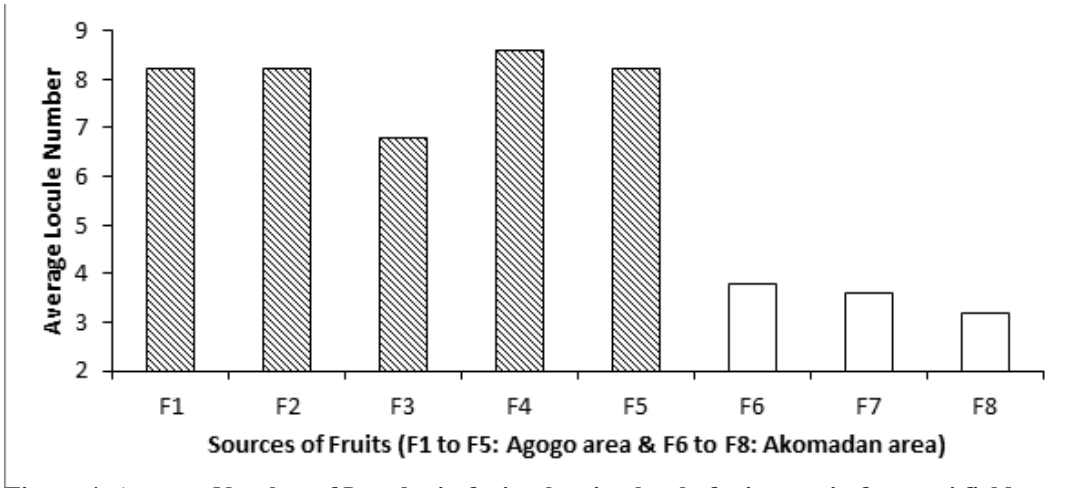


**Figure 4: Average Number of Locules in fruits showing level of mixtures in farmers' fields**

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**Seed mixture effect on postharvest characteristics**

The study revealed that approximately eight to ten distinct genotypes of tomatoes based on fruit shape and other qualitative and pseudo-qualitative characteristics were identified in farmers' fields in the study areas. The next step of the study sought to evaluate how the distinct identified fruit shape or type category performs in terms of shelf life. This was assessed using the fruit's ability to retain moisture over time while in storage under ambient condition. The minimum, maximum and average temperatures of 26.5°C, 30.5°C and 27.3°C respectively and a minimum of 75%, 90% maximum and 83.8% relative humidity were recorded during the storage duration.

**Relationship between shelf life and fruit shape, Forest and Forest-Transition Zones**

The shelf life of the major identified fruit shapes was studied. Generally, fruits of the flattened shape stored poorly among the other fruit shape categories from the Forest (Fig. 5 and 6). The rate of weight loss was higher for the flattened-shape fruit compared to oblong and circular fruit shapes. The % weight loss after 10 days of storage was 33.9% reaching as high as 90% at day 15. Among the three major identified fruit shapes in the Forest zone, the oblong fruit shape (56%) lost less fluid, followed by circular fruit shape (68%).

Correspondingly, the percentage weight retention was highest (44%) in oblong fruit shapes with the least percentage weight retention (10%) observed in the flattened fruit shapes at the end of day 15 of storage. Similarly, the % weight loss among fruit

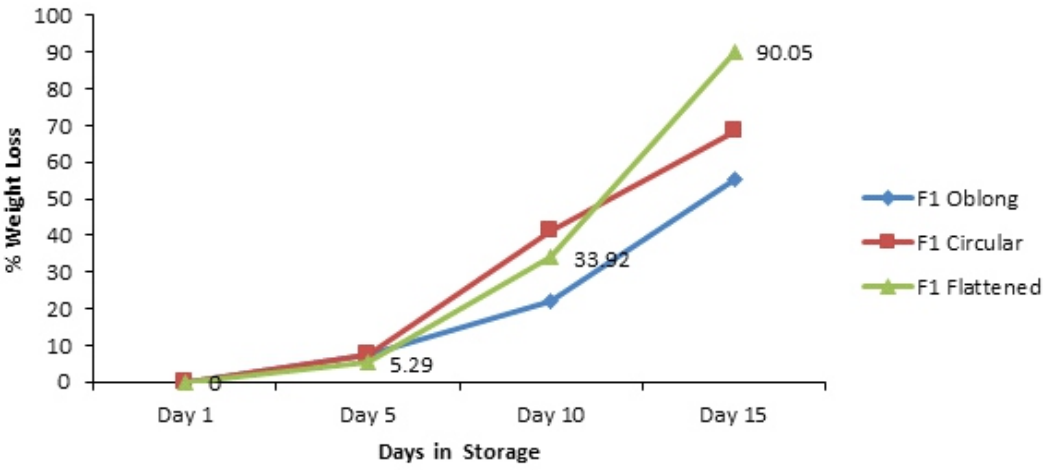


Figure 5: % Weight loss over time among different fruit shapes in the Forest zones

shapes differed in samples from the Forest-Transition zones. The highest weight loss (about 100%) was observed in the cordate shaped fruits followed by the Flattened fruit shape (66%) with the least been the Ovate shaped fruits recording 34% at day 15 of storage. Corresponding percentage weight retention was observed for the same fruit shape category. The ovate shaped fruits were able to retain more weight (65%) after 15 days of storage while cordate shape fruits retained the least % weight 20.5, followed by flattened shape (33.5%).

Fruit texture comprising mainly sensory attributes such as flesh firmness, mealiness,

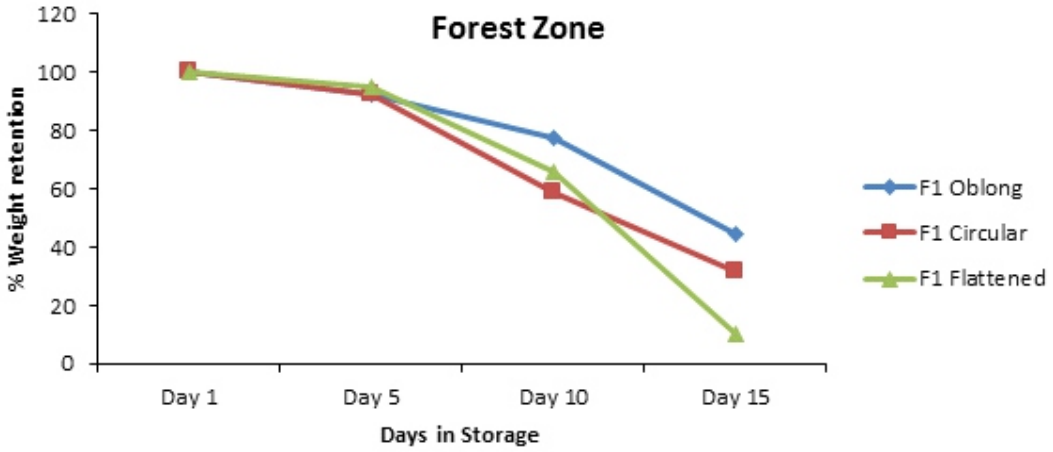


Figure 6: % Weight retention over time among different fruit shapes in the Forest zones

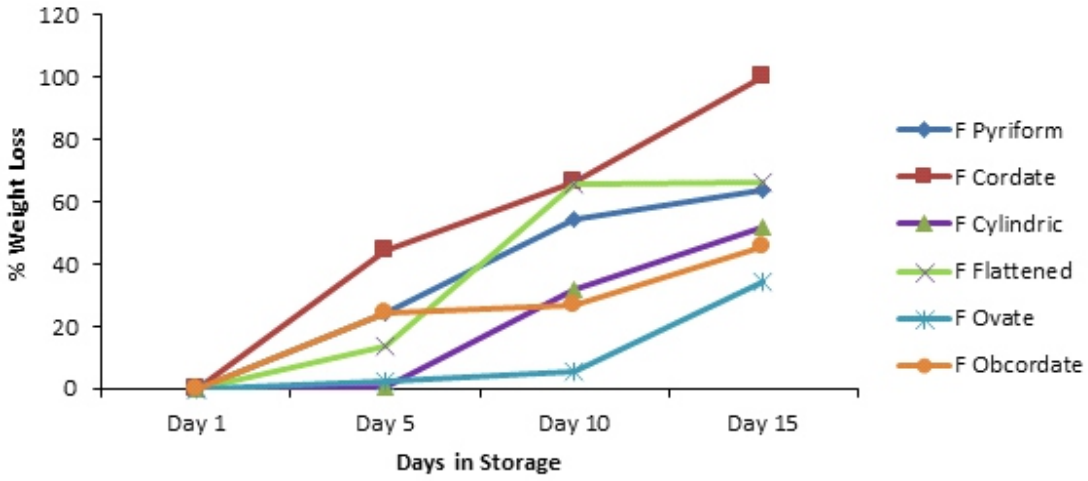


Figure 7: % Weight Loss over time among different fruit shapes in the Forest-Transition zoneszones

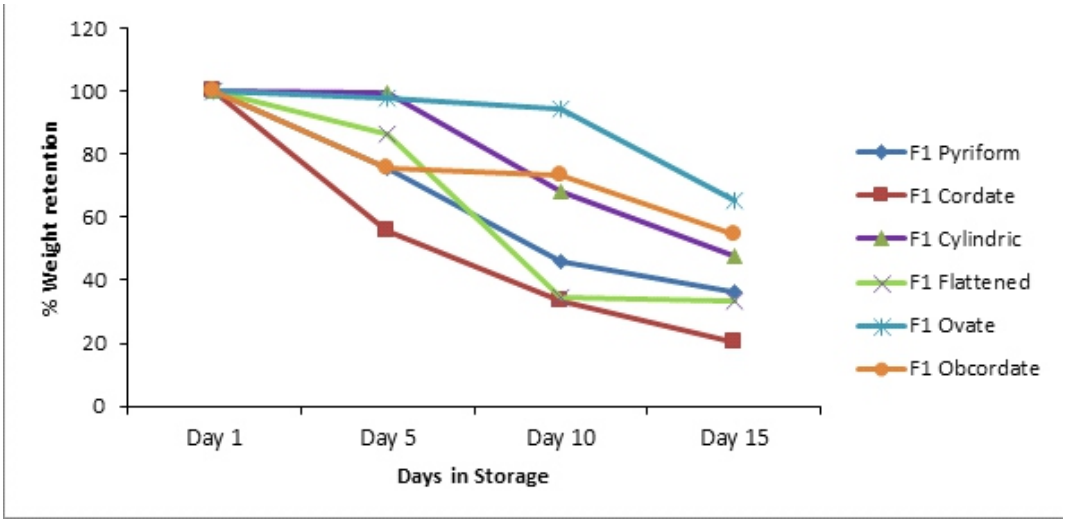


Figure 8: % Weight Retention over time among different fruit shapes in the Forest-Transition zonesruit shapes in the Forest zones

meltiness, juiciness and crispness (Redgwell and Fischer, 2002) is one of the most critical components for the consumer's perception of tomato fruit quality (Causse *et a*l., 2003). Majority of these changes occur during fruit repining, related to softening which affects postharvest performance. The softening of the fruit relates to the loss of water or weight over time. Water losses occur as a result of the relative humidity gradient between the internal atmospheres of the fruit and the surrounding atmosphere (Siddiq, 2012). When observed visually, the flattened and cordate fruit shape have a thin skin (epidermis) compared to the oblong and circular and other fruit shapes identified. Fruit shape (genotypes) that store well up to 20 days with good appearance were the pyriform, oblong, obcordate, which has low rate of weight loss. These types possessed thick fruit skin and firm when felt in the palm.

Water loss in fruits such as tomatoes is partially restrained by the fruit skin, which functions as a barrier against water vapour and other gases (Siddiq, 2012). Thus, the observed rate of water loss could be attributed to the different skin thickness for the different fruit shape categories. Water loss results in weight loss, shrivelling (Holcroft, 2015; Ahmad and Siddiqui, 2015) as observed in these study with a faster rate of weight decline. Since the practice of farmers and traders of tomato is to pack all harvested fruits which possess different levels of firmness/texture, shape and water retention ability into the same wooden crate, those with tougher skins and big are likely to exert pressure on those with thin skin. Eventually, there will be considerable damage to skin, either by cracking, bruising or softening (Kitinoja, 2002; Ray and Ravi, 2005). Consequently, there are often huge losses observed during transportation to market centres. Water loss is known to have an immediate economic effect in that it reduces saleable weight (Holcroft, 2015). Market appeal is also low due to non-uniform appearance of fruits. Farmers are encouraged to use seeds of high quality to produce fruits of uniform size and shape that possess similar shelf life characteristics.

## Conclusion

The level of seed mixtures is influenced by the current practice by small holder farmers through seed exchange and seed saving. This has several implications; introduction of pest and diseases to new fields, lower yields of crops after several years of recycling among others. Further, non-uniform harvested fruits may possess different abilities of fruit texture, shelf life, pathogen resistance which may negatively affect postharvest loss.

The study has been able to confirm that tomato seeds planted by small holder farmers in the study area are of poor quality in terms of physical and genetic purity. Tomato farmers plant highly mixed seeds due to the practice of seed saving and exchange and fruits harvested are highly mixed; non-uniform fruits with different shapes which possess varied shelf life abilities. Further, the study discovered that the various identified fruit shapes have varied ability to retain moisture, which has influence on their shelf life under ambient condition.

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