African Journal of Biotechnology Vol. 7 (8), pp. 3092-3099, 3 September, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

*Full Length Research Paper*

# Storage temperature affects fruit quality attributes of Ber (*Ziziphus mauritiana* Lamk.) in Zimbabwe

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Accepted 18 July, 2008

**Fruit utilization is affected by quality attributes and shelf life. The quality of Jujube or Ber (*Ziziphus mauritiana* Lamk.) fruits after harvest depends on storage conditions used. In this study, different storage temperatures and durations were evaluated to determine the appropriate storage conditions of fresh fruits of *Z. mauritiana*. Three storage temperature levels, low (5°C), intermediate (15°C) and ambient (22°C) were evaluated at 3, 6, 9 and 12 weeks storage durations. Fruits stored at low temperature lost only 48% of their weight during the entire 12 week storage period while the fruits stored in the ambient and intermediate temperature ranges lost 70 and 75% of weight, respectively. At three weeks of storage, more than 40% of fruits had shrivelled under the ambient and intermediate storage temperatures compared to only 3% under the low storage temperature. It is concluded that cold storage condition can prolong the shelf life of *Z. mauritiana* fruits.**

**Key words:** Naturalised fruit, drying, storage condition, shelf life, fruit colour, vitamin C.

## INTRODUCTION

Indigenous fruits are essential for food security, health and nutrition, and economic welfare of rural communities in southern Africa (Akinnifesi et al., 2004; Saka et al., 2007). Mithofer et al. (2006) found in Zimbabwe that the probability of households falling below the poverty threshold is in the worst-case scenario at about 70% during the critical food insecure season when agricultural crops are planted if no indigenous fruits are available, and about 25% during maize harvesting time. However, if indigenous fruits are available, the probability of households falling below poverty level is reduced by about 30% during the critical period.

In Zimbabwe, the collection, processing, storage and marketing of indigenous fruits are the notable coping strategies adopted by rural communities to reduce hunger, improve nutrition and generate income (Mithofer et al., 2006). Many of the miombo indigenous fruits ripen and are often available during the dry season when food availability is low (Campbell, 1987; Akinnifesi et al., 2004, 2006). These indigenous fruits are an important source of income for poor people since entry barriers for collection and use are relatively low.

*Ziziphus mauritiana* (Lamk.) is a drought-tolerant fruit tree that originated in Central Asia (Morton, 1987), but has been widely naturalized in Zimbabwe, and it is now almost considered indigenous to Zimbabwe by local communities (Palgrave, 1990). The fruits are extensively collected, processed and marketed by the local population in Zimbabwe (Ramadhani, 2002), and offers great opportunity for income generation but farmers face the challenge of lack of storage and packaging facilities (Schomburg et al., 2001). Fresh fruits of *Z. mauritiana* deteriorate fast and cannot be kept for more than 10 days under ambient conditions without serious deterioration (Kadzere et al., 2004), even though some improved cultivars in India are known to store for up to 15 days without loss of organoleptic quality (Pareek, 2001).

The contribution of indigenous fruits is limited to areas where the trees grow naturally because of the absence of processing and preservation technologies and marketing

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opportunities (Tiisekwa et al., 2004). The fruits are high in vitamin A and C and other mineral nutrients (Vashishtha, 1998). Temperature and storage duration have been reported to affect the vitamin C content of fruits and vegetables (Lee and Kader, 2000; Kadzere et al., 2006b). Temperature management is one of the most important tools for extending the shelf life of fruits (Lee and Kader, 2000). Abbas (1997) reported that storing fresh fruits at 4 to 10°C increases the shelf life up to 33 days and 73% of farmers interviewed in Zimbabwe. Using cold storage to preserve fresh and dried fruits can ensure its availability throughout the year (Potter and Hotchkiss, 1998; Pareek, 2001).

In Zimbabwe cold storage is rarely used for extending shelf life of *Z. mauritiana* fruits due to lack of availability of the storage facilities where the fruits are found. As a result, *Z. mauritiana* fruit loss due to deterioration has been reported as one of the major constraints by “whole-salers” and “retailers” in Zimbabwe (Kadzere et al., 2001). This study was carried out to determine the effect of storage temperature and storage duration on the post harvest quality of the *Z. mauritiana* fruits in Zimbabwe.

## MATERIALS AND METHODS

The study was conducted in the post harvest laboratory at the Harare Research Station of the Department of Research and Extension (AREX) between August and October 2006. The fruits used in the experiment were collected from Muzarabani District and transported to Harare where there is access to cold storage facilities.

### Experimental procedure

The fruits were graded to remove unripe fruits (green in colour) and damaged fruits before they were subdivided into 36 sub-samples of one kg each. The 36 samples were randomly allocated to three storage temperature treatments (ambient, intermediate and low) and four storage durations (3, 6, 9 and 12 weeks). The ambient treatment in this study represented the laboratory room temperature condition with an average temperature of 22°C. The intermediate represented a controlled temperature with an average temperature of 15°C while the low treatment represented cold room conditions with a temperature of 5 °C.

The experiment was set up as a randomised complete block (RCBD) design with three replicates. At the beginning of the experiment, three replicates of 50 fruits each were randomly picked from each batch harvested from tree from same population and used to determine weight, colour, size, insect damage, and the remaining fruits were used to for nutrition analysis. All treatments were applied within 24 h of time between storage and harvesting.

### Physical characteristics and nutrient content of fruits

Fruits were weighed before and after each storage duration in the experiment. Fifty randomly picked fruits were used to determine colour using the Munsell colour chart, which describes colours on the terms of the hue, value and chroma (Kadzere et al., 2006) at each sampling date. At the end of each fruit storage duration, the number of fruits that were shrivelled, undesirable, darkened and damaged by insects was recorded. Undesirable fruits had turned black on the surface and could not be assigned a Munsell colour value. Fruits that had a hue of dark red, dark reddish brown and dusky red were recorded as darkened.

The content of vitamin C, reducing sugars and titratable acids of the fruits were determined at 0, 3, 6, and 12 weeks of storage. Vitamin C was determined using titrimetric method with 2,6-dichlorophenolindophenol described by Egan et al. (1987). Reducing sugars were determined using the Fehlings method (Egan et al., 1987) and titratable acidity was determined using the titrimetric method using sodium hydroxide.

### Data analysis

The post-harvest data was subjected to analysis of variance (ANOVA) using SAS version 9.1 (SAS Institute, Inc., Cary, NC, USA). The least significant difference (LSD) at $P = 0.05$ was used for means comparison. Normality test using the box Cox plot procedure showed that the data were not normally distributed. Square root transformations were carried out on proportions before they were subjected to analysis of variance.

## RESULTS

### Fruits weight loss in storage

There were no significant interactions ($P > 0.05$) between storage temperature and storage duration with respect to weight loss during drying. Low temperature storage significantly reduced ($P < 0.001$) weight loss in the *Z. mauritiana* fruits over the 12 week storage period (Figure 1). By the end of 12 weeks, fruits stored at 5°C had lost only 48% of their weight, while those in the ambient and intermediate had lost 70 and 75% of their initial weight respectively. There was no significant interaction between storage temperature and duration of storage with respect to weight loss during drying.

The fruits showed some shriveling during storage ($P < 0.001$) and this was influenced by the storage temperature conditions. As the storage duration increased an increase in the proportion of shriveled fruits under the three storage temperatures ($P < 0.001$) were observed (Figure 2). Lowest proportion of shriveled fruits was observed under cold storage, followed by intermediate and highest in ambient, and were significantly ($P < 0.001$) different at all storage durations (Figure 2). The proportion of shriveled fruits was highest in ambient temperature, increasing from 55% at 3 weeks to about 82% at 12 weeks. The proportion of shriveled fruits under cold storage was negligible (< 2%) at 3 weeks, about 15% at 6 weeks, 30% at 9 weeks and 38% at 12 weeks storage durations (Figure 2). For intermediate temperature (15°C), the proportion of shriveled fruits ranged from 40 to 64%.

Over the 12 week storage period, none of the fruits under cold storage become darkened (Figure 3). The percentage of undesirable fruits was influenced by the temperature conditions as well as the storage duration. The ambient storage temperature had the highest proportion of undesirable fruits, reaching the highest proportion

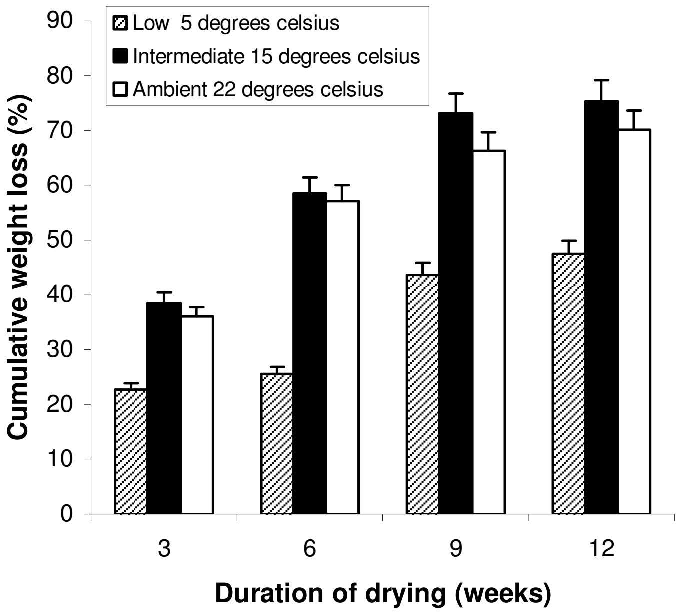



**Figure 1.** Effect of storage temperature on the cumulative weight loss (%) of *Z. mauritiana* fruits (vertical bars represent standard errors of means).

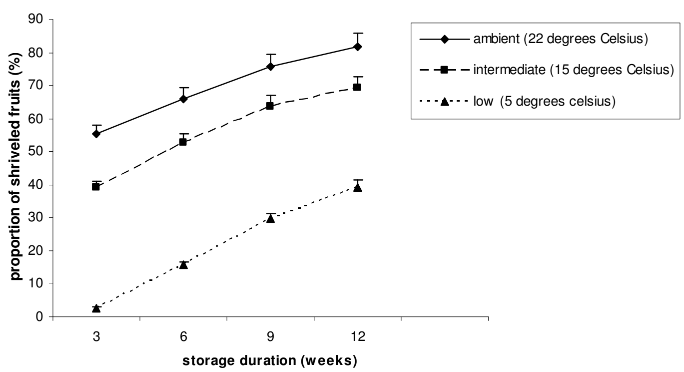



**Figure 2.** The proportion of shriveled fruits of *Z. mauritiana* stored various temperature conditions (vertical bars represent standard errors of means).

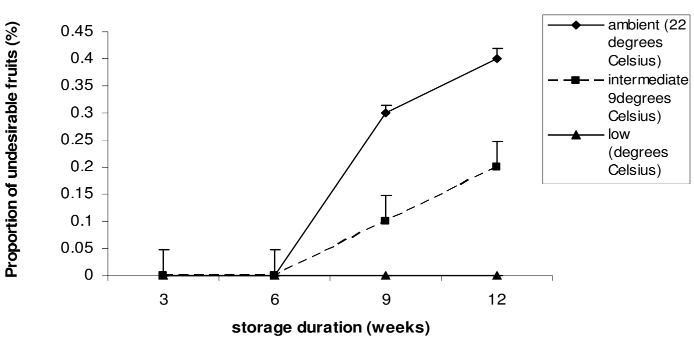



**Figure 3.** Effect of different storage temperature on the proportion of undesirable fruits of *Z. mauritiana* for a period of up to 12 weeks (vertical bars represent standard errors of means).

of 0.4% by week 12 of storage (Figure 3). In the low storage temperature, no undesirable fruits appeared even up to 12 weeks of storage (Figure 3) Storage duration had effect on the proportion of undesirable fruits in the intermediate and ambient storage conditions ($P < 0.001$).

## Colour attributes during storage

There was a significant interaction ($P < 0.001$) between storage temperature and duration of storage with respect to colour chroma and value. Fruits stored at 5°C maintained high color chroma while storing them at ambient temperature (22°C) and intermediate temperature (15°C) caused fruits to lose their chroma ($P < 0.001$) (Figure 4a). By week 12 fruits stored at ambient temperature had the lowest colour chroma (4.8) followed by intermediate (6.4) and low temperature (7.8) stored fruits. Fruits stored under low storage temperature maintained their initial color value until week 12 when the color value began to change (Figure 4b). The colour value of fruits stored in the ambient and intermediate storage temperature decreased ($P < 0.001$) as the storage duration increased.

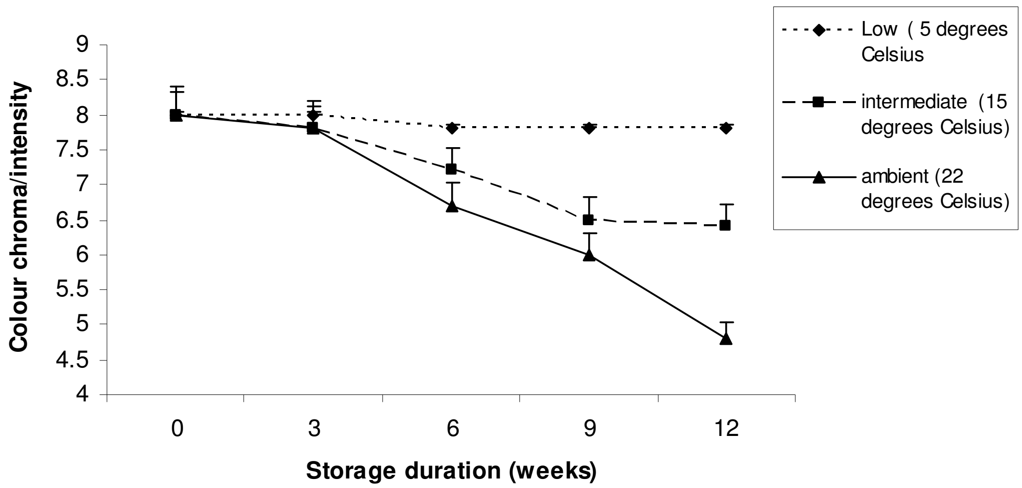
The highest percentage of darkened fruits was obtained in the ambient temperature and the lowest was recorded in the low temperature condition (Figure 5). At 3 weeks storage duration all storage methods produced less than 6% darkened fruits. Cold storage maintained darkened fruits at less than 20% within the 12 week period. The high temperature tends to encourage the browning of fruits. An increase in storage duration also increased the percentage of darkened fruits and the highest proportion (90%) was obtained after 12 weeks of storage under the ambient storage condition

## Nutrient content of the fruits

Generally, the vitamin C content of the fruits decreased ($P < 0.001$) during storage (Figure 6). The low storage temperature maintained a higher ($P < 0.05$) vitamin C content while fruits maintained at the intermediate (15°C) and ambient (22°C) storage temperature lost vitamin C rapidly during the storage over the 12 week duration. There was no interaction between storage temperature and duration of storage with respect to vitamin C concentration. Storage temperature and storage duration significantly affected ($P < 0.05$) the concentration of reducing sugars during the 12 week storage duration (Figure 7). The reducing sugar content was significantly highest at 9 months under low temperature condition. There was no interaction for ($P > 0.05$) between storage temperature and duration of storage for reducing sugars.

The titratable acidity decreased by 14, 60 and 48% in fruits stored at low, intermediate and ambient storage temperature respectively at 9 weeks of storage (Figure 7). Fruits stored under low temperature (5°C) maintained

(a)




(b)

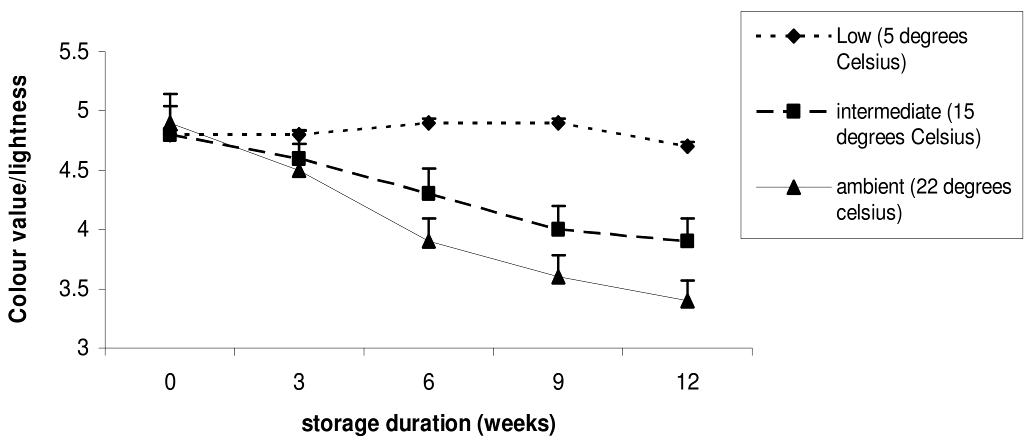



**Figure 4.** The effect of storage temperature on the colour attributes expressed as chroma (a) and value (b) of *Z. mauritiana* fruits (vertical bars represent standard errors of means).

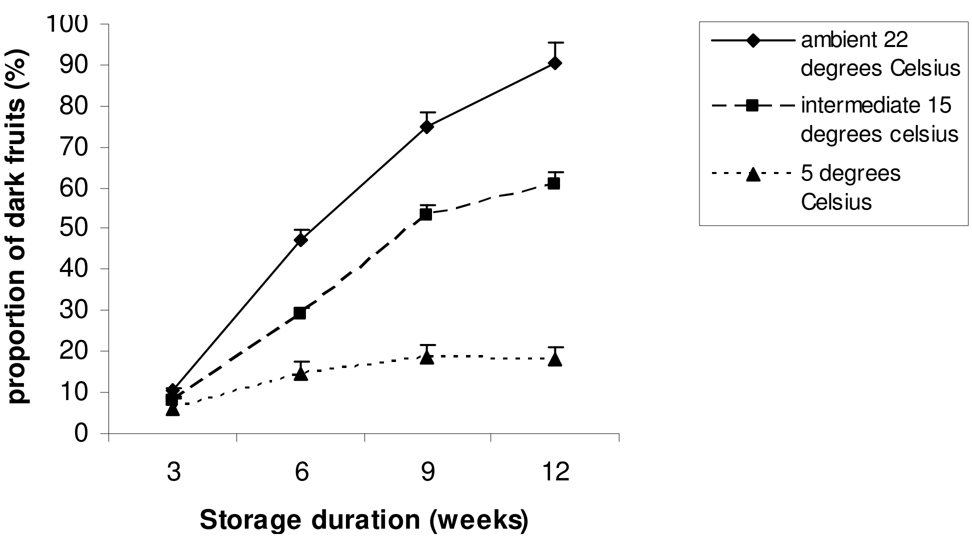



**Figure 5.** Percentage of darkened fruits of *Z. mauritiana* stored under various temperature conditions (vertical bars represent standard error of means).

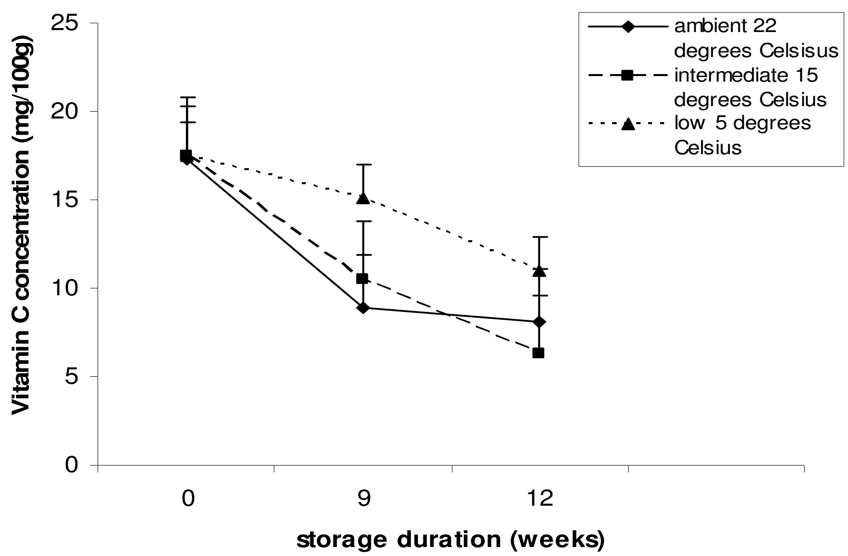



**Figure 6.** Vitamin C concentration of *Z. mauritiana* fruits stored various temperature conditions (vertical bars represent standard errors of means).

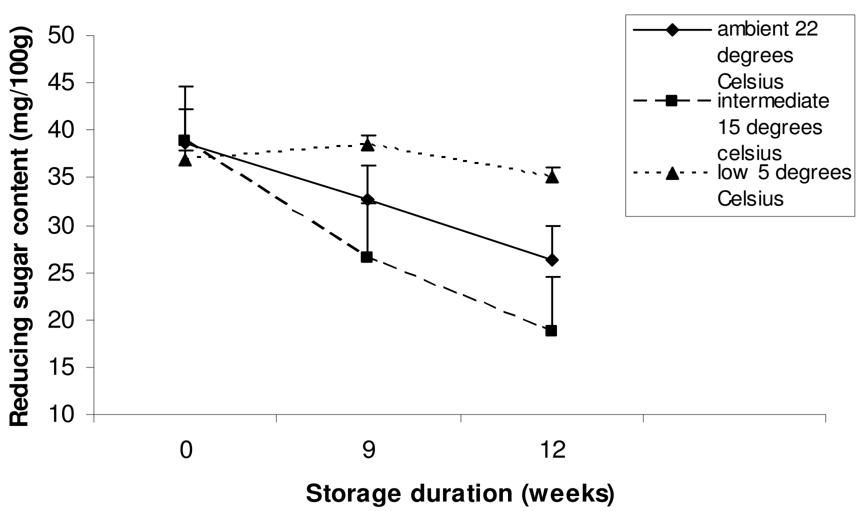



**Figure 7.** Concentration of reducing sugars of *Z. mauritiana* fruits stored under various temperature. (vertical bars represent standard errors of means).

a higher level of titratable acidity ($P$ = 0.001) during the whole 9 and 12 weeks storage duration (Figure 8). There was no interaction ($P$ > 0.05) between storage temperature and duration of storage with respect to titratable acidity. There was no significant difference in the titratable acidity under ambient and intermediate temperature conditions.

## DISCUSSION

During storage, fruits lose weight, shrivel and change colour, lose acidity and ascorbic acid but gain sweetness (Pareek, 2001). The study confirmed that fruits stored under the cold storage condition maintained lowest rate of weight loss than the fruits stored at medium and ambient temperatures. These also maintained acceptable organoleptic quality of fruits than ambient and intermediate temperatures. Low temperature reduces respiration and metabolic processes thereby slowing down the rate of fruit weight loss during storage (Wills et al., 1989). The result agrees with the report elsewhere (Pareek, 2001) that *Z. mauritiana* fruits can remain in good storage for 28 to 42 days in cold storage at 10°C.

During this period, the enzyme activity, sugar and carotenoid contents increased with corresponding decrease in

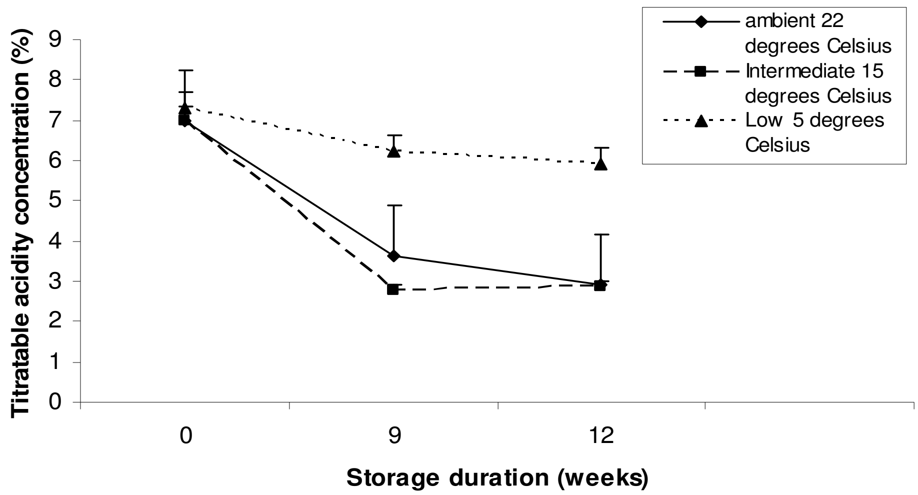



**Figure 8.** Concentration of titratable acidity of *Z. mauritiana* fruits stored under various temperature (vertical bars represent standard errors of means).

acidity, pectin and tanning content (Pareek, 2001). According to studies by Abbas and Fandi (2002), *Z. mauritiana* fruits exhibit climacteric behaviour. Climacteric fruits produce high levels of ethylene that accelerate the ripening and senescence processes. Storage of *Z. mauritiana* fruits at intermediate and ambient temperatures could have resulted in production of high levels of ethylene and increased respiration and subsequent weight reduction. Where fruit is sold on a weight basis, loss of water means economic loss and additionally, water loss reduces visual quality.

Fruits stored at low temperature had a low proportion of shrivelled fruits compared to intermediate and ambient temperature conditions. High temperatures have been shown to increase water loss from fruits resulting in fruit shriveling and loss of fresh appearance (Willis et al., 1989). Visual shriveling can occur when water loss reaches 3 to 5% of fruit's initial weight (Kader and Mitchell, 1989). Fruits of *Z. mauritiana* show some shriveling as they ripen and under dry conditions they lose moisture, shrivel and become spongy inside (Morton, 1987). *Z. mauritiana* fruits are believed to be climacteric and therefore produce ethylene during storage, which accelerates senescence and shrivelling of the fruits. Low temperatures reduce the sensitivity of fruits to ethylene and senescence is reduced (Willis et al., 1989). The ambient storage temperature had the highest proportion of undesirable fruits (blackened, rotten) and no undesirable fruits were recorded in the low storage temperature during the entire 12 week storage duration. High temperatures encourage spoilage and browning due to high microbial activity and oxidation.

Fruits stored at the low storage temperature maintained high chroma and value during storage. The optimal colour change from green to greenish to yellow and then brown (Kadzere et al., 2004). However, whether this browning is desired or at acceptable level warrants further sensory evaluations of the fruits in future studies. The increase in darkening with increasing temperature could be due to deterioration caused by natural senescence of fruits during storage. However, the possible effects of bacterial and fungal activity on the fruits and chemical reactions as possible causes of darkening need future research. A decrease in the chroma and value of fruits during storage indicates development of browning. The low storage temperature condition has a great potential in the post-harvest handling of *Z. mauritiana*. Ramadhani (2002) has recommended better cooperation between producers and marketing system by introducing storage facilities to foster steady market supplies and reduce fruit perishability. With the increased efforts towards domestication and production of *Z. mauritiana*, identification of appropriate storage temperature and duration in this study will be important to farmers and marketers interested in maximizing profits by reducing losses. The investment decision will depend on sound economic analysis.

The low storage temperature maintained a relatively high Vitamin C content than the fruits stored at intermediate and ambient storage temperature. This is consistent with results obtained by Lee and Kader (2000) in which fruit stored at 0, 10 and 20°C lost 5, 33 and 89% vitamin C respectively in a storage period of 2 days. According to research by Nunes et al. (1998) on strawberries, water loss by the fruits has a greater effect on vitamin C levels than temperature. In their work combining wrapping with storage, storing fruits at 1 or 10°C reduced vitamin C loss by 7.5-fold compared to unwrapped strawberries stored at 20°C. Low vitamin C content of the fruits stored at ambient and intermediate temperature could be due to the combined effect of temperature and water loss during storage. The content of reducing sugars decreased more rapidly in the ambient (22°C) and intermediate (15°C) storage temperature than in the low (5°C) storage. This could be attributed to higher respiratory activity occurring at the ambient and intermediate storage temperature than in the low temperature and the sugars being used up in the respiration process (Wills et al., 1989). The fruits in the intermediate and ambient temperature continued to ferment and sugars were reduced to simpler elements. Titratable acidity was reduced as the storage temperature was increased. Pailly et al. (2004) obtained similar results with grapefruit (*Citrus paradise*) where fruits stored at 6°C had higher titratable acidity than those stored at 10°C. The titratable acidity and Vitamin C behaved in the same manner and the reduction in Vitamin C could have resulted in subsequent reduction in titratable acidity because vitamin C is acidic and therefore contributes to the acidity on fruits.

## Conclusion

Fruits stored at low storage temperature gave better fruit colour, lost the least weight and maintained the best appearance than those stored at intermediate and ambient temperatures because it reduced weight loss by the fruits during storage. The proportion of shriveled fruits increased as the storage temperature was increased from 5 to 22°C. The low storage temperature maintained a low proportion of shriveled fruits during the entire storage duration. Fruits stored at low storage maintained high purity and lightness of colour and there was no development of darkening during the entire storage period. The results show that low storage temperature has potential for storage of *Z. mauritiana* fruits. Since the percentage reduction in Vitamin C, reducing sugars and titratable acidity are less in the low storage temperature condition; higher levels of nutrients are maintained in fruits during storage. The study provides foundation for minimizing post harvest losses by using appropriate storage methods. The extent to which variability in fruit quality at harvest influences subsequent post harvest shelf life warrants future research as well as organoleptic tests to determine the acceptance of the stored fruits by consumers.

## ACKNOWLEDGEMENTS

The first author would like to thank the Regional Universities Forum (RUFORUM) for their support during this study. This work was carried out as part of the agroforestry activities of the World Agroforestry Centre (ICRAF) under the Protracted Relief Programme (PRP) in Zimbabwe with funding from the United Kingdom Department for International Development (UK-DFID). The financial support by DFID in this work is appreciated. My sincere gratitude goes to Mr. O Chirimuzhengeni, Mr. C. Dube; Ms. M. Nyakuwa, Dr. Khosi Ramachela, Mr. L. Mundoza, Mr Maruseta, Musiyambiri, Dr. B. Mvumi and Mr. Nazare for their invaluable assistance in this work.

### REFERENCES

Abbas MF (1997). Jujube. In: Post-harvest physiology and storage of tropical and subtropical fruits. Mitra SK (ed.), CAB International, Wallingford, UK, pp. 405-415.

Abbas MF, Fandi BS (2002). Respiration rate, Ethylene Production and Biochemical Changes during Fruit Development and Maturation of Jujube (*Ziziphus mauritiana* Lamk) J. Sci. Food Agric. 82(13): 1472-1476.

Akinnifesi FK, Kwesiga F, Mhango J, Chilanga T, Mkonda A, Kadu CAC, Kadzere I, Mithofer D, Saka JDK, Sileshi G, Ramadhani T, Dhliwayo P (2006). Towards the development of miombo fruit trees as commercial tree crops in southern Africa. Forest, Trees Livelihood, 16: 103-121.

Akinnifesi FK, Kwesiga FR, Mhango J, Mkonda A, Chilanga T, Swai R (2004). Domesticating priority miombo indigenous fruit trees as a promising livelihood option for smallholder farmers in southern Africa. Acta Hort. 632: 15-30.

Campbell BM (1987). Use of Wild Fruits in Zimbabwe. J. Econ. Bot. 41: 375-385.

Egan H, Kirk RS, Sawyer R (1987). Pearson's chemical analysis of foods. Longman Scientific and Technical, London, UK.

Kader AA, Mitchell FG (1989). Post harvest physiology In: Peaches, Plums and Nectarines. Growing and handling of fresh market. LaRue JH, Johnson RS (eds.), University of California, pp.158-164.

Kadzere I, Hove L, Gatsi T, Masarirambi MT, Tapfumaneyi L, Maforimbo E, Magumise I (2004). Current status of post-harvest handling and traditional processing of indigenous fruits in Zimbabwe. In: Rao MR, Kwesiga (eds.), Proc Regional Agroforestry Conference on Agroforestry impacts on Livelihoods in Southern Africa: Putting Research into Practice. World Agroforestry Centre (ICRAF), Nairobi, Kenya, pp. 353-363.

Kadzere I, Hove L, Gatsi T, Masarirambi MT, Tapfumaneyi L, Maforimbo E, Magumise I, Sadi J, Makaya PR (2001). Post-harvest fruit handling practices and traditional processing of indigenous fruits in Zimbabwe. ICRAF Annual Report, Harare, Zimbabwe. pp. 24-39.

Kadzere I, Watkins CB, Merwin IA, Akinnifesi FK, Saka JDK (2006a). Postharvest damage and darkening in fresh fruit of *Uapaca kirkiana* (Muell. Arg.). Postharvest Biol. Technol. 39: 199-203.

Kadzere I, Watkins CB, Merwin IA, Akinnifesi FK, Saka JDK, Mhango J (2006b). Fruit Variability and Relationship between Color at Harvest and Subsequent Soluble Solids Concentrations and Color Development during Storage of *Uapaca kirkiana* (Muell. Arg.) from Natural Woodlands. HortScience 41(2): 352-356.

Lee SK, Kader AA (2000). Pre-harvest and post-harvest factors influencing Vitamin C content of horticultural crops. Postharvest Biol. Technol. 20: 207-220.

Mithofer D, Waibel H, Akinnifesi FK (2006). The role of food from natural resources in reducing vulnerability to poverty: a case study from Zimbabwe. Paper accepted for the 26th Conference of the International Association of Agricultural Economists (IAAE), August 12-18, 2006, Queensland, Australia.

Morton J (1987). Indian Jujube In: Fruits of Warm Climates. Miami, FL, pp. 272-275

Nunes MCN, Brecht JK, Morais AMB, Sargent SA (1998). Controlling temperature and water loss to maintain ascorbic acid levels in strawberries during post harvest handling. J. Food Sci. 63(6): 1033-1036.

Pailly O, Tison G, Amouroux A (2004). Harvest time and storage conditions of 'Star ruby' grape fruit (Citrus paradise Macf) for short distance summer consumption. Postharvest Biol. Tech. 34: 65-73

Palgrave K (1990). Trees of Southern Africa, Struik Publications, Cape Town, South Africa, pp. 549-552.

Pareek OP (2001). Fruit for the future 2: Ber. International Centre for Underutilised crops, University of Southampton, Southampton, UK, p. 290.

Potter NN, Hotchkiss JH (1998). Food Science. A Chapman Hall Food Science Book, Fifth Edition. Aspen Publishers, Inc. Gaithersburg, Maryland, USA.

Ramadhani T (2002). Marketing of indigenous fruits in Zimbabwe. PhD Thesis, Universitat Hannover, Hannover, Germany. Socioeconomic Studies in Rural Dev., 129: 212.

Saka JDK, Rapp I, Akinnifesi FK, Ndolo V, Mhango J (2007). A comparative study of the physicochemical and organoleptic characteristics of *Uapaca kirkiana*, *Strychnos cocculoides*, *Adansonia digitata* and *Mangifera indica* products. Int. J. Food Sci. Tech. 42: 836-841.

Schomburg A, Mhango J, Akinnifesi FK (2001). Marketing of Masuku (*Uapaca kirkiana*) and Masawo (*Ziziphus mauritiana*) fruits and their potential for processing by rural communities in Southern Malawi. Proc. 14th Southern Africa Regional and Planning Workshop. 3-7 September, Harare, Zimbabwe. SADC-ICRAF Agroforestry Regional Programme, pp. 169-176.

Tiisekwa BPM, Ndabikunze BK, Samson G, Juma M (2004). Suitability of some indigenous fruits for manufacturing juices and jams in Tanzania. *Proc. Regional* Agroforestry *Conf. on Agroforestry Impacts on* Livelihoods in Southern Africa: Putting Research into Practice,. Rao MR, Kwesiga FR (eds.), Pp. 331-335. World Agroforestry Centre (ICRAF), Nairobi, Kenya.

Vashishtha BB (1998). Jujube or Ber (*Ziziphus mauritiana* Lamk.) Cultivation in Africa. Paper presented at an international workshop on *Ziziphus Mauritania*, Harare, Zimbabwe, 13-16 July.

Wills RBH, McGlasson WB, Graham D, Lee TH, Hall EG (1989). Postharvest. An introduction to the physiology and handling of fruits and vegetables. Van Nostrands Reinhold, New York, pp. 17-52.