American Journal of Food Science and Technology, 2018, Vol. 6, No. 4, 161-166
Available online at http://pubs.sciepub.com/ajfst/6/4/5

DOI:10.12691/ajfst-6-4-5

Changes in Sensory and Quality Characteristics of *S. Aethiopicum* (Shum) and *A. Lividus* (Linn) Leafy Vegetables along the Supply Chain

Apolot Mary Gorret[1], Joshua Ssozi[1], Agnes Namutebi[1], Michael Masanza[2], Kizito Elizabeth[2], Deborah Rees[3], Acham Hedwig[1,*]

[1]Department of Food Technology and Nutrition, Makerere University, Kampala-Uganda
[2]Department of Agricultural and Biological Sciences, Uganda Christian University (UCU), Mukono, Uganda
[3]Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Chatham, Kent ME4 4TB, UK
*Corresponding author: hacham@caes.mak.ac.ug

Abstract Changes in sensory attributes of vegetables over time under different conditions have been reported, however, little has been done regarding profiling and assessing changes in sensory attributes of raw leafy vegetables particularly *Solanum aethiopicum* (S.) and *Amaranthus lividus* (L.). This study therefore fills an important knowledge gap of profiling sensory attributes and assessing changes in color, texture and appearance of *S.aethiopicum* and *A.lividus* leafy vegetables over time after harvest. A complete randomized design in a 3 ×3 factorial arrangement (each vegetable sample was subjected to three treatments (Time of the day) and three replicates) and data was collected by use of quantitative descriptive sensory analysis. Descriptive data was entered into Microsoft excel spread sheets, averages computed and graphs generated. The data was further subjected to ANOVA and a least significant difference test was used to compare means of samples for all attributes at 95% confidence interval. Correlation analysis using Statistical Package for Social Scientients' (SPSS version 16.0) was also performed to assess relationship between sensory attributes. Descriptive sensory analysis results showed that all 9:00hrs samples were rated highly for each attribute compared to the 12:00hrs and 15:00hrs samples. ANOVA results for *S. aethiopicum* showed statistical significant ($p<0.05$) difference for all the attributes except for light green color of leaf stalk ($p<0.05$) whereas that for *A. lividus* showed significant differences for moist appearance, well spread appearance, smoothness and overall quality. Correlation results showed significant positive relationship ($p<0.05$) among attributes. This study observed that sensory attributes of leafy vegetables change with time after harvest andtraders are therefore encouraged to adopt local cooling systems to help preserve the sensory attributes of vegetables.

Keywords: *sensory attributes, profiling, time after harvest, deterioration*

Cite This Article: Apolot Mary Gorret, Joshua Ssozi, Agnes Namutebi, Michael Masanza, Kizito Elizabeth, Deborah Rees, and Acham Hedwig, "Changes in Sensory and Quality Characteristics of *S. Aethiopicum* (Shum) and *A. Lividus* (Linn) Leafy Vegetables along the Supply Chain." *American Journal of Food Science and Technology*, vol. 6, no. 4 (2018): 161-166. doi: 10.12691/ajfst-6-4-5.

1. Introduction

Sensory quality of fresh produce is a very important attribute that is always required by consumers [1]. Attributes such as freshness, brightness, colour, absence of defect and cleanliness are essential for product acceptance by the consumer [1,2] and may influence sensory shelf life of vegetables.

Mechanical damage, temperature, enzymatic senescence processes and browning of fresh vegetables negatively affect their sensory properties and finally result in the rejection of affected products by consumers [2]. Cutting method of leaves during food preparation has also been reported to cause changes in the sensory quality of vegetables [3]. However, various mechanisms have been explored in maintaining sensory attributes. The applications of natural preservatives, plus optimal storage conditions, the use of packaging material have been reported to maintain sensory attributes in vegetables for some time. [2,4,5]. Refrigeration at household and supermarkets is practiced; moreover, local cooling techniques such as charcoal cooler have also been invented. Despite the available mechanisms of maintaining sensory attributes, farmers and traders in Uganda have not widely explored them especially for leafy vegetables. This is attributed to the expensive equipment and high maintenance costs, unavailability of the required equipment and tools in the local markets, lack of sanitary and packaging facilities and poor marketing systems. Moreover, they lack knowledge and appreciation for the need to maintain quality of vegetables [6].

From literature, little has been done regarding profiling and assessing sensory attributes of raw leafy vegetables particularly *S. aethiopicum* and *A. lividus*. However, changes in sensory attributes of vegetables over time under different conditions have been reported [2,7,8]. This study fills an important knowledge gap of profiling sensory attributes and assessing changes in color, texture and appearance of *S. aethiopicum* and *A. lividus* leafy vegetables over time after harvest.

2. Materials and Methods

2.1. Experimental Design

Two leafy vegetable types; *S.aethiopicum* (Shum) and *A.lividus* (Linn) were purposively selected because they are the most commonly cultivated and marketed vegetables in Central Uganda. They are grown for their ready market, palatability and high nutritive value [9] and yet little about their sensory properties is known.

Vegetable samples were picked from the markets at 9:00hr,12:00hr and 15:00hr after ascertaining that they were from the same farm; this was done through farm visits during harvesting and following up the truck during transportation up to the market. The samples that were picked were then wrapped in a black polythene bag and placed in a cool ice box and transported to the laboratory at the Department of Food Technology and Nutrition for sensory evaluation. Sensory evaluation was done as the vegetable samples came in at the respective hours.

2.2. Data Collection

Quantitative descriptive sensory analysis was used to profile and investigate changes in sensory attributes of vegetables with time after harvest (9:00hrs/morning, 12:00hrs/noon and 15:00hrs/evening). *S. aethiopicum* and *A. lividus* vegetable samples were picked from the markets at these respective times of the day after ascertaining that they were from the same source (farm).The samples that were picked were wrapped in a black polythene bag and then placed in a cool box and transported for further laboratory analysis at the Department of Food Technology and Nutrition.

2.2.1. Training of Panelists

Seven (3 females and 4 males) trained and experienced panelists were selected to participate in the development of sensory profiles for assessment of changes for the two types of leafy vegetables. They were chosen based on their ability to provide similar responses on similar vegetable samples on repeated occasions, interest in the study and availability for the duration of the study. Panelists were exposed to a two- day training session of one hour so as to develop a clear definition for each attribute of importance in the respective vegetables. Each panelist received a representative specimen and with training, they were able to increase their sensitivity and ability to discriminate between the sensory attributes of the leafy vegetables. Descriptors and definitions of the characteristics of the vegetables were collectively agreed on and developed by the panelists.

2.2.2. Scaling and Scoring

A 5 point category scale ranging from 1 to 5 was used to measure the intensity of each sensory attribute (appearance, color and texture) for the two vegetables; where 1 denoted the least intense and unacceptable condition (Highly unacceptable) and 5 denoted the most intense and acceptable condition (Highly acceptable). The overall quality was also rated using the same scale. A 5 point scale was chosen and modified from the 'just about right scale' as suggested that this kind of scale generates both intensity and acceptability at the same time [10]. [7] also used the same denotation on the category scale except that they used a 9 point scale.

Attributes described were appearance, colour and texture using descriptors generated during the training; appearance had three descriptors (moist, well spread leaves and whole leaves) for both *S. aethiopicum* and *A. lividus* leafy vegetables, colour also had three descriptors (Dark green top face, pale green bottom face and light green/purplish stalks) for *S. aethiopicum*. Colour was described differently for *A. lividus* (green with purple patches on top face of the leaf, purple with green patches bottom face of the leafy and purple leaf stalk). Texture had two descriptors for *S. aethiopicum* (rough leaf surface and firm/stiff leaves) and three for *A. lividus* (smooth top face of the leaf, rough bottom face of the leaf and firm/stiff leaves).

2.2.3. Sample Preparation and Serving

On arrival from the market, the roots and soil were removed and a portion of approximately 300g of raw vegetable sample was served on plastic trays and coded with a three digit figure. One type of vegetable was served at a time. A score sheet for evaluation accompanied the sample. All samples were evaluated by a trained panel according to methods by [10]. Samples were evaluated under a well-balanced light and each panelist sat in an individual booth.

2.3. Statistical Analysis

A complete randomized design in which each vegetable sample was subjected to three treatments (hour of the day) and three replicates was used resulting in a total of 18 vegetable samples for both *S. aethiopicum* and *A. lividus.*

The results were subjected to descriptive analysis, and when it was confirmed that the data followed a normal distribution, one-way analysis of variance was performed and mean comparison between the treatments was by least significant difference test (LSD) with confidence level of 95% using Statistical Package for Social Scientists software (SPSS version 16.0) . Correlation matrices of the sensory attributes and overall quality data were also performed using Pearson's correlation coefficients.

3. Results and Discussion

3.1. Sensory Profiles

Sensory profiles of eight (8) and nine (9) descriptors were developed for *S. aethiopicum* and *A. lividus;*

respectively using quantitative descriptive sensory analysis (Table 1 & Table 2). The final list of descriptors developed by the panelists encompassed; appearance, color and texture. Attributes and definitions for *S. aethiopicum* indicated three attributes for appearance, three for color and two for texture (Table 1). Attributes and definitions for *A. lividus* indicated three attributes for appearance, three for color and three for texture (Table 2), with definitions for each attribute and overall quality for both types of vegetables.

Table 1. Sensory profile for *S. aethiopicum* (Nakati)

Attribute	Definition
Appearance	
Moist	Presence of shinny water on leaf surface
Well spread leaves	Not falling/folded
Whole leaves	Not broken leaves
Color	
Dark green top face	Dark green color
Pale green bottom face	Pale green color
Light green/purplish stalks	Purplish color mixed with some light green color
Texture	
Rough	Rough leaves on touching
Firm stiff leaves	Firm leaf on the stalk
Overall quality	Overall impression covering all attributes

Table 2. Sensory profile for *A. lividus* (Bugga)

Attribute	Definition
Appearance	
Moist	Presence of shinny water layer
Well spread leaves	Not falling/folded
Whole leaves	Not broken leaves
Color	
Green- purple top face	Green color with purple patches
Purple- green bottom face	Purple color with some light green patches
Purple leaf stalks	Purplish color of leaf stalks
Texture	
Smooth top face	Smooth leaf top on touching
Rough bottom face	Rough leaf bottom on touching
Firm leaves	Firm leaf on stalk
Overall quality	Overall impression covering all attributes

3.2. Influence of Time after Harvest on Sensory Attributes of *S. aethiopicum* and *A. lividus* Leafy Vegetables.

Descriptive Sensory Analysis was carried at 9:00hrs, 12:00hrs and 15:00hrs. Results show all 9:00hrs samples being rated highly for each attribute compared to the 12:00hrs and15:00hrs samples for both types of vegetables (Figure 1 & Figure 2).

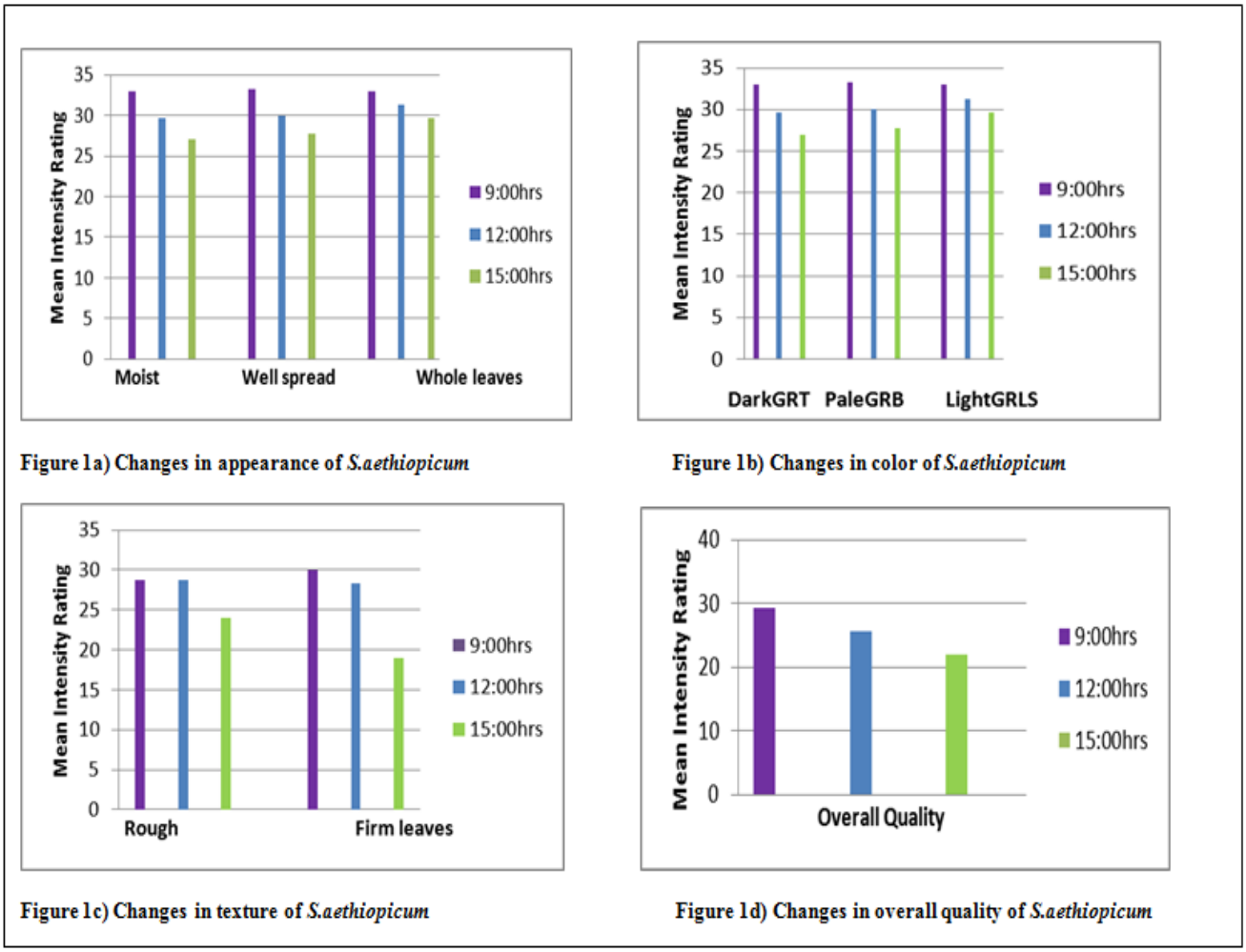

Figure 1a) Changes in appearance of *S.aethiopicum*

Figure 1b) Changes in color of *S.aethiopicum*

Figure 1c) Changes in texture of *S.aethiopicum*

Figure 1d) Changes in overall quality of *S.aethiopicum*

Figure 1. Descriptive sensory changes in *S. aethiopicum* leafy vegetable

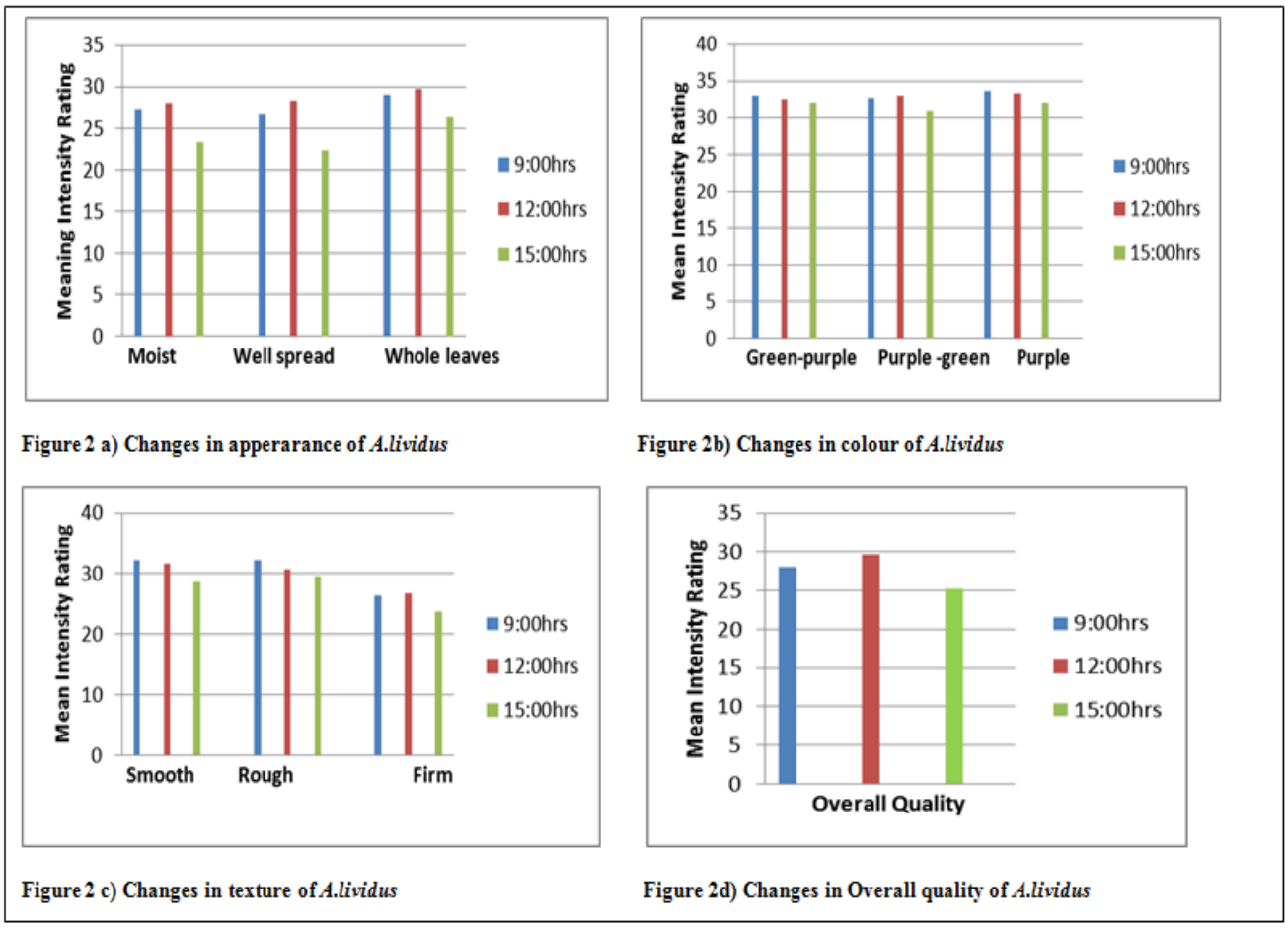

Figure 2. Descriptive sensory changes of *A. lividus* leafy vegetable

Changes in sensory attributes over time after harvest were observed and all 9:00hrs samples were rated highly for each attribute compared to the 12:00hrs and 15:00hrs samples .This implies that during morning hours (up to 9:00hrs), changes due to environmental and postharvest practices are minimal due to the little heat from the sun and therefore this can be a recommended time for purchase of leafy vegetables. Literature on this kind of study is limited, however, some studies have looked at changes in sensory attributes of non-leafy vegetables such as carrots and other products such as wine, cheese, honey over a storage period [11,12,13,14]. Those that have looked at leafy vegetables like lettuce, Chicory have subjected them to conditions like cooking methods and storage period [2-7]. This particular study has looked sensory changes in one day of sale. This is because vegetables are expected to be consumed when still fresh and most of the traders sell their vegetables in one day.

Appearance characteristics for *S. aethiopicum* were rated highest at 9:00hrs. However as time increased, more negative change was observed. From Figure1a, an observable decrease in appearance between 9:00hrs, 12:00hrs and 15:00hrs were observed. Despite the higher rating of other attributes for *A. lividus* at 9:00hrs, appearance characteristics were rated highest at 12:00hrs. As expected, change in appearance characteristics were observed at 15:00hrs. The observed changes in appearance attributes can be attributed to the high temperatures that cause loss of moisture making the leaves appear wilted and folded. Wilted appearance is not a desired sensory attribute and this can cause rejection of the vegetable by the consumer since appearance is one of the important quality attributes [1]. The loss of moistness is associated with loss in moisture content which later leads to loss of vigor [2].

Color for both types of vegetables rated highly for all the times (9:00hrs, 12:00hrs and 15:00hrs) as compared to other sensory attributes. This implies that color deteriorates but at a slow rate over time. It can be assumed that processes such as oxidation and enzymatic browning that are responsible for color change have no significant effect on vegetables within a day of harvest. Also cool temperatures during rainy days are assumed to maintain an attractive color on the vegetables. This could be another reason for the high color intensity rating by the panelists.

There was an observed deterioration in texture characteristics for both vegetables. However, deterioration was greater in *S. aethiopicum* as compared to *A. lividus*. The low intensity ratings of texture could be attributed to the improper handling of the vegetables from farm and in the market. Roughness and firm leaves described the texture of the vegetables and the later scored the least intensity. This implies that the rough handling, improper transport means and high temperatures of the day caused the leaves to lose their firmness and hence the poor texture observed. The loss in firmness can also be attributed to dehydration [3]. A decrease in firmness during day 1 of cold storage of fresh Broccoli was also reported [15].

Overall samples were evaluated as of acceptable quality though *A. lividus* samples were more acceptable than those of *S. aethiopicum*. Generally, 9:00hrs samples were

rated highest while evening samples rated lowest in overall quality. This shows evidence that the sensory quality of vegetables without refrigeration deteriorates in one day. Leafy vegetables should therefore be consumed on the day of harvest if no other means of preservation are available.

ANOVA results showed significant ($p<0.05$) differences in all attributes of *S. aethiopicum* over time after harvest except for light green color of the leaf stalks. For *A. lividus*, significant ($p<0.05$) differences were observed for moist appearance, well spread appearance, smoothness and overall quality. These results are related to the descriptive analysis results above where there is an observed variation the sensory attributes particularly for *S. aethiopicum* over time after harvest. These findings are related to those by [2,12] who reported significant ($p<0.05$) differences in the intensity ratings of all attributes such as color and freshness (appearance) during storage. Significant ($p<0.05$) mean differences were also observed in *S. aethiopicum* for moist appearance and firmness and none for *A. lividus* between 9:00hrs and 12:00hrs. Between 12:00hrs and 15:00hrs, significant ($p<0.05$) mean differences were observed in well spread appearance and texture characteristics for *S. aethiopicum*. For *A. lividus*, significant ($p<0.05$) mean differences were observed in moist appearance, well spread appearance, smooth leaf texture and overall quality. From this observation, appearance and texture characteristics for both types of vegetables deteriorated more than other attributes and these highly impact on acceptability of the respective vegetables in the market. From the statistical analysis, it appears that *S. aethiopicum* is more prone to degradation compared to *A. lividus*. This observation can be attributed to characteristics of leafy structure specific to each type of vegetable [2].

Sensory attributes for both types of vegetables had a positive significant ($p<0.05$) relationship($r=0.5$ & above) among each other. These findings relate to that of [16] where attributes like texture, aroma, and flavor and after taste had significant correlation coefficients. Stronger positive correlations of 0.8 were observed for more attributes of *S. aethiopicum* compared to that *A. lividus*. More related to these findings are those reported by [17] where positive correlations between aftertaste and texture descriptors in fresh orange juice were observed. Furthermore the strong positive correlations were observed between color characteristic for both vegetables. Color is an important attribute in the choice of any product in the market. The loss or change in color for example yellowing of vegetables may mean spoilage. There was a strong relationship between firm texture and well spread appearance in *S. aethiopicum* vegetable ($p=0.00$, $r=0.812$) and not in *A.lividus*. The loss of moisture causes loss in vigor which then affects the firmness and the well spread appearance of the leaves. Strong positive correlations among sensory attributes were also observed in bread [18]. For vegetables, overall quality and well spread appearance ($p=0.00$, $r=0.843$; $p=0.000$, $r=0.832$) respectively had a strong relationship. This implies that appearance has a great impact on the acceptable quality of these vegetables. Loss in appearance characteristics means loss in quality and acceptability as well. It is therefore important to preserve these appearance characteristics. Traders in the market sprinkle water on the vegetables from time to time in an attempt to preserve these characteristics. However, the best option would be keeping temperatures low for example by refrigeration/cooling system which is sustainable.

4. Conclusion

From the findings, it can be concluded that sensory attributes of leafy vegetables deteriorate with time after harvest especially when there is no cooling system in place. Due to the lack of cooling systems, consumers are encouraged to purchase leafy vegetables in the morning hours since morning (9:00hrs) samples showed highly acceptable sensory attributes. Traders are also encouraged to adopt local cooling systems like charcoal coolers to help preserve the sensory attributes of vegetables.

References

[1] Hussin, S.R, Yee, W.F and Bojei, J. Essential quality attributes in fresh producepurchased by Malaysian consumers . *Journal of Agribusiness Marketing*, *3*, 1-19, 2010

[2] Oliveira, D. C. R. D., Leal, P. A. M., Honório, S. L. and Soares, E. K. B. Sensory quality attributes of lettuce obtained using different harvesting performance systems. *Food Science and Technology (Campinas)*, *33*(2), 239-244, 2013

[3] Martinez, I., Ares G. and Lema P. Influence of cut and packaging film on sensory quality of fresh-cut Butterhead Lettuce (*Lactuca Sativa* L., cv.Wang). *Journal of Food Quality*, 31, 48-66, 2008.

[4] Ali, A., Chow, W. L., Zahid, N. and Ong, M. K. Efficacy of Propolis and Cinnamon Oil Coating in Controlling Post-Harvest Anthracnose and Quality of Chilli (Capsicum annuum L.) during Cold Storage. *Food and Bioprocess Technology*, *7*, 2742-2748, 2014.

[5] Alvarez, M. V., Ponce, A. G. and Moreira, M. R. Combined effect of bioactive compounds and storage temperature on sensory quality and safety of minimally processed celery, leek and butternut squash. *Journal of Food Safety*, *35*(4), 560-574, 2015

[6] Kader, A. A. Increasing food availability by reducing postharvest losses of fresh produce. *Acta Horticulturae*, *682*, 2169-2176, 2005.

[7] Renna, M., Gonnella, M., Giannino, D. andSantamaria, P. Quality evaluation of cook-chilled chicory stems (Cichorium intybus L ., Catalogna group) by conventional and sous vide cooking methods. *Journal of Science of Food and Agriculture*. 2013.

[8] Piagentini, A. M., Mendez, J. C., Guemes, D. R. and Pirovani, M. E. Modeling changes of sensory attributes for individual and mixed fresh-cut leafy vegetables. *Postharvest Biology and Technology*, 38(3), 202-212, 2005.

[9] Ssekabembe, C. K., Bukenya, C., & Nakyagaba, W. Traditional knowledge and practices in local vegetable production in central Uganda. In *African Crop Science Conference Proceedings*, 6, 14-19, 2003.

[10] Lawless, H. T. and Heymann, H. *Sensory evaluation of food: principles and practices*. Springer Science & Business Media. 2010.

[11] Ferreira, E. L., Lencioni, C., Benassi, M. T., Barth, M. O. and Bastos, D. H. M. Descriptive sensory analysis and acceptance of stingless bee honey. *Revista de Agaroquimica y Tecnologia de Alimentos*, 15(3), 251-258, 2009.

[12] Papetti P. andCarelli A. Composition and sensory analysis for quality evaluation of a typical Italian cheese: influence of ripening period. *Czech Journal of Food Science*. 31: 438-444, 2013.

[13] Vilela, A., Monteiro, B. and Correia, E. Sensory profile of Port wines: Categorical Principal Component Analysis, an approach for sensory data treatment. *Ciência e Técnica Vitivinícola*, 30(1), 1-8, 2015.

[14] Wrzodak, A., Kapusta, E., Szwejda-Grzybowska, J. and Woszczyk, K. Sensory quality of carrots from organic and conventional cultivation. *Vegetable Crops Research Bulletin*, *77*, 75-88, 2012.

[15] Fernández-León, M. F., Fernández-León, a. M., Lozano, M., Ayuso, M. C. and González-Gómez, D. Different postharvest strategies to preserve broccoli quality during storage and shelf life: Controlled atmosphere and 1-MCP. *Food Chemistry*, *138*, 564-573, 2013.

[16] Leighton, C. S., Schönfeldt, H. C. and Kruger, R. Quantitative descriptive sensory analysis of five different cultivars of sweet potato to determine sensory and textural profiles. *Journal of Sensory Studies*, 25(1), 2-18, 2010.

[17] Aparicio, J. P., Medina, M. A. T. and Rosales, V. L. Descriptive sensory analysis in different classes of orange juice by a robust free-choice profile method. *Analytica Chimica Acta*, *595*(1-2), 238-247, 2007.

[18] Ofosu, I.W., Adjei, I.A., Bah, F.B.A., Kwetey, P.N., Gloria M. Ankar-Brewoo, G.M., Oduro, I. and William., O.E. Quantitative Descriptive Sensory Analysis of the Performance of Pregelatinised Starch-Protein Admixtures as Fat Mimetic in Wheat Bread. *Pakistan Journal of Nutrition*, 8 (10): 1559-1566, 2009.