Bangladesh J. Bot. **45**(5): 1127-1134, 2016 (December)

DETERMINATION OF MATURITY INDICES OF STRAWBERRY IN DHAKA, BANGLADESH

M MOSHIUR RAHMAN*

Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

Key words: Strawberry, Maturity indices, Fruit quality, Sensory attributes

Abstract

Strawberry is a new exotic crop in Bangladesh. To determine the optimum maturity stage in the present climatic condition, five strawberry cultivars *viz.,* Camarosa, Festival, Sweet Charlie, FA 008 and BARI Strawberry-1 were harvested under one-third, two-third and full maturity stages. The results showed that two- third matured fruits of cv. Camarosa exhibited maximum firmness. Irrespective of germplasm fully matured fruits showed the minimum shelf life. The genotype cv. Festival gave the highest sugar-acid ratio and ascorbic acid content among the maturity stage. Sensory evaluation indicates that fully matured fruits of studied cultivars preferred better. Based on firmness, surface color, nutritive value, sugar-acid ratio and sensory attributes, fully matured fruits of strawberry were suggested for harvest. Two-third matured fruits of Festival and Camarosa produced a considerable amount of TSS, sugar-acid ratio and shelf life, and thus, fruits of these two cultivars harvested at two- third matured stage were found suitable for distant marketing.

Introduction

Strawberries (*Fragaria* × *Ananassa* Duch.) are unique short duration fruit crops with desirable taste and flavour. It is rich in ascorbic acid, secondary metabolites, simple sugars and acids (Wang *et al.* 2002). It is a crop of temperature climate but nowadays, its commercial cultivation has been started in Bangladesh. Strawberry is a seasonal crop and perishable in nature, because of soft texture, poor shelf life, and susceptible to fungal decay (Shin *et al*. 2008). So harvesting of strawberries at proper stage is important both for maintaining quality and marketing. If strawberries are harvested before optimum maturity its shelf life is extended but nutritive value and quality are reduced, in contrast fully matured fruits are desirable but shelf life and keeping quality are very short. Over-matured fruits on the other hand, lose their attractiveness, nutrients and crispiness (Pareek 2001, Pritts 2004). Strawberry is a non-climacteric fruit, (Perkins-Veazie 1995) which is harvested at different stages of maturity based on the cultivars and market preference. Fruits of the most cultivars should be harvested for export purposes when the surface of the fruit is dark red, although fruits of less firm cultivars should be harvested at a light red color stage (Picha 2006) depending on consumers' preference. Consumers purchase strawberries mainly for an enjoyable eating experience. Fruit color and texture are important characteristics, which strongly influence the consumers' choices. These characters include sensory attributes such as firmness, appearance and flavour, as well as nutritional value and health benefits.

It is reported that fruit qualities largely depend on maturity indices, and harvesting time varied mostly with the cultivars (Kader 1999, Cordenunsi *et al*. 2002, Kafkas *et al*. 2007) and location. Fruits of strawberry are highly perishable, which is accelerated under subtropical humid climate of Bangladesh. So it is necessary to determine the maturity indices of strawberry under Bangladesh condition. Therefore, the present experiment was carried out to find out to determination of maturity stages of strawberry as well as to observe the effect of maturity stages on shelf life and nutritive quality of selected strawberry cultivars in Bangladesh.

*Author for correspondence: <moshiur.bari@yahoo.com>.

Materials and Methods

The study was conducted at the Fruit Research Farm ($23^0$59′ N, $90^0$24′ E, 14.33 m) of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during September-April, 2010-11 and 2011-12. This region is under sub-tropical zone having hot humid summers (May-August) and mild winter (December-February). Fruits were harvested from the soil grown strawberry plants, planted on 100 × 500 cm open beds having 50 × 40 cm spacing. Beds were raised 30 cm above the main field with 50 cm drain in between 2 beds. Each plot contains double row and accommodating 24 plants. The fruit quality, chemical composition and nutritive value were evaluated at the laboratory of Pomology Division, HRC and Postharvest Technology Division under BARI. The experiment was carried out in a Complete Randomized Design (CRD) with three replications. The experiment consisted of two factors which are factor A: three maturity stages *viz.* one-third maturity (fruit surface turn white to pink color), two-third maturity (fruit surface turn pink to red color) and full maturity stage (>80% of the fruit surface showing deep red color), and factor B: five cultivars *viz.,* Camarosa, Festival, Sweet Charlie, FA 008 and BARI Strawberry-1. Immediately after harvest damaged fruits were eliminated and, ten fruits were selected randomly from each treatment combination based on uniform size and color for data collection on (i) flesh firmness, (ii) surface colour, (iii) shelf life, (iv) total soluble solids, (v) sugar to acid ratio, (vi) ascorbic acid content; and (vii) sensory evaluation. Sensory evaluation was done by a panel of judges consisted of 15 members to give opinion on color, flavour, taste, juiciness, sweetness and overall acceptability of freshly harvested fruits.

The flesh firmness of the strawberry fruit was measured using a Digital Firmness Tester (DFT 14, Agro Technologie, France) equipped with 5 mm diameter stainless probe following the method of Rahman *et al*. (2014). The surface colour of strawberry was evaluated with a Chroma Meter (Model CR-400, Minolta Corp., Japan) by using the method of Wang and Camp (2000). For determination of shelf life fruits were placed in 2 litre plastic box having some holes and kept in ambient room conditions (25 ± 1°C and 70 ± 5% RH). Each treatment combination contained five boxes. According to Christi and Kader (1983), the sensory evaluation was carried out using a "9 Points Hedonic Scale" for each attribute as per method described by Wills *et al*. (1998). Two years' data of previously mentioned parameters were pooled and analyzed with the help of MSTAT-C programme. Means were separated using DMRT described by Gomez and Gomez (1984).

Results and Discussion

The flesh firmness of strawberry fruits varied significantly as influenced by interaction of maturity stage and cultivars (Table 1). Irrespective of maturity stages, fruits of Camarosa exhibited the highest firmness followed by Festival, while BARI Strawberry-1 and FA 008 showed the lowest firmness. One-third and two-third matured fruits of Camarosa and Festival showed he highest and full matured fruits of BARI Strawberry-1 showed the lowest firmness which is in line with the findings of Munbodh and Aumjaud (2003). They found that, flesh firmness of strawberry was progressively decreased with extend of maturity and found to be minimum at full maturity. It might be due to the increase in cell wall softening with the increase in maturity. Rosli *et al*. (2004) found that Camarosa had the largest amount of hydrochloric acid-soluble pectins, which decreased during ripening.

Considering color of fruits, the L^*, C^* and h^0 values at one-third maturity were found maximum which indicated to be more bright, less colored and less redness. The creamy white fruit skin gradually decreased with the extended harvesting time and turned to dark red as evidenced by decreasing of L^*, C^* and h^0 values with the extent of harvest period, which indicates significant rate of color changes in strawberry (Table 1). At two-third maturity stage fruits of Camarosa, Festival and Sweet Charlie

showed the lowest L^* and C^* value with moderate h^0 values indicating bright red skin colour and found suitable for harvesting. At full maturity stage, fruits of all cultivars exhibited the lowest L^*, C^* and h^0 values indicating dark red skin colour. This is in consonance with Shin *et al*. (2008) who stated that L^*, C^* and h^0 values of strawberry fruits were higher at white tip (less matured) stage and lower at red ripe (full matured) stage.

Table 1. Interaction effect of maturity stages and strawberry cultivars on flesh firmness and surface colour in strawberry fruits.

Treatment	Firmness (kg-f/cm^2)	Lightness (L^*)	Chroma (C^*)	Hue angle (h^0)
1/3rd matured fruits of Camarosa	1.53 ab	55.33 a	39.84 fg	49.74 c
1/3rd matured fruits of Festival	1.50 ab	42.27 cd	42.19 de	47.30 d
1/3rd matured fruits of Sweet Charlie	1.37 c	47.08 b	47.47 a	54.30 b
1/3rd matured fruits of FA 008	1.19 ef	44.23 bc	45.26 bc	58.23 a
1/3rd matured fruits of BARI Strawberry -1	1.33 cd	52.59 a	41.00 ef	54.61 b
2/3rd matured fruits of Camarosa	1.61 a	35.26 fg	42.56 de	42.55 e
2/3rd matured fruits of Festival	1.42 bc	37.41 ef	43.76 cd	39.92 f
2/3rd matured fruits of Sweet Charlie	1.32 cd	37.22 ef	44.04 cd	40.78 ef
2/3rd matured fruits of FA 008	1.21 de	39.56 de	46.97 ab	31.51 h
2/3rd matured fruits of BARI Strawberry -1	1.22 de	35.79 fg	45.58 a-c	35.28 g
Fully matured fruits of Camarosa	1.10 ef	31.97 hi	37.71 h	23.22 k
Fully matured fruits of Festival	1.09 f	30.01 i	39.30 f-h	31.90 h
Fully matured fruits of Sweet Charlie	0.94 g	31.39 hi	38.84 gh	26.18 j
Fully matured fruits of FA 008	0.81 h	31.78 hi	41.12 ef	28.61 i
Fully matured fruits of BARI Strawberry -1	0.59 i	33.40 gh	39.42 f-h	30.84 hi
Level of significance	**	**	*	**
CV (%)	4.45	3.44	2.65	2.12

Figures having the same letter(s) in a vertical column do not differ significantly by DMRT; * at 5 and ** at 1% level.

Fruits harvested at one-third maturity stage showed the highest and fully matured fruits the lowest shelf life (Table 2). Shelf life of fruits decreased with the increase in maturity stages due to cell wall softening. This corroborated the results of Shin *et al*. (2008). They found that shelf life of fruit at less matured stage was higher than that of red ripe (more matured) stage.

Strawberry harvested at three quarters red ripe stage can be stored for longer period with better color and firmness than the fruits harvested at full red stage (Nunes *et al*. 2006). Shelf life of fruits varied considerably among the cultivars and fruits of Camarosa had maximum shelf life (5.67 days) followed by those of Festival, which were statistically similar, while fruits of BARI Strawberry-1 and FA 008 had the lowest shelf life (Table 2). The present experimental result was in line with (Nunes *et al*. 2006), they found a wide variation in shelf life of strawberry fruits among the varieties. Significant differences ($p \leq 0.01$) in shelf life of fruits were observed for interaction effect (Table 2). Irrespective of maturity stage fruits of Camarosa exhibited the longest shelf life, followed by Festival. While the fruits of BARI Strawberry-1 and FA 008 showed the shortest shelf life at the same maturity stage. Shin *et al*. (2008) found that irrespective of cultivars, less ripe fruits of strawberry exhibit extend storage period.

An increasing trend of total soluble solids (TSS) content was observed in fruits with the progress of the maturity of strawberry and it varied significantly (Table 2). Maximum TSS was recorded in

fruits harvested at full maturity stage followed by that of two-third matured fruits, while minimum TSS was found in fruits which were harvested at one-third maturity stage. These results are in agreement with the reports of Munbodh and Aumjaud (2003) and Strum *et al*. (2003). Munbodh and Aumjaud (2003) stated that, TSS content of Marquise strawberry varied significantly with the harvesting stages. Strum *et al*. (2003) found and increasing trend of TSS from less matured fruits to full matured fruits of strawberry. Fruits of Camarosa exhibited the highest TSS content (7.33%), while FA 008 exhibited the

Table 2. Effect of maturity stages and cultivars on shelf life, TSS, sugar to acid ratio and ascorbic acid content of strawberry fruits.

Treatment	Shelf life (days)	TSS (%)	Sugar-acid ratio	Ascorbic acid (mg/100 g)
Main effect of maturity stage				
1/3rd matured	7.80 a	6.18 c	4.57 c	63. b
2/3 rd matured	4.60 b	6.80 b	5.16 b	68.40 a
Full matured	2.40 c	7.46 a	5.75 a	72.40 a
Level of significance	**	**	**	**
Main effect of cultivars				
Camarosa	5.67 a	7.33 a	5.48 b	68.00 b
Festival	5.33 b	7.27 a	5.83 a	75.00 a
Sweet Charlie	5.00 c	6.93 b	5.19 c	72.00 ab
FA 008	4.33 d	6.03 d	4.43 e	66.67 b
BARI Strawberry-1	4.33 d	6.50 c	4.56 d	59.00 c
Level of significance	**	**	**	**
Interaction effect of maturity stage and cultivars				
1/3rd matured fruits of Camarosa	8.50 a	6.30 e	4.66 f	64.00
1/3rd matured fruits of Festival	8.50 a	6.50 e	5.30 d	70.00
1/3rd matured fruits of Sweet Charlie	8.00 b	6.50 e	4.60 f	68.00
1/3rd matured fruits of FA 008	7.00 c	5.60 g	4.09 g	62.00
1/3rd matured fruits of BARI Strawberry -1	7.00 c	6.00 f	4.20 g	54.00
2/3rd matured fruits of Camarosa	5.50 d	7.20 cd	5.72 c	68.00
2/3rd matured fruits of Festival	5.00 e	7.30 c	5.88 d	76.00
2/3rd matured fruits of Sweet Charlie	4.50 f	7.00 d	5.18 d	72.00
2/3rd matured fruits of FA 008	4.00 g	6.00 f	4.61 f	66.00
2/3rd matured fruits of BARI Strawberry -1	4.00 g	6.50 e	4.55 f	60.00
Fully matured fruits of Camarosa	3.00 h	8.50 a	6.22 a	72.00
Fully matured fruits of Festival	2.50 i	8.00 b	6.32 a	79.00
Fully matured fruits of Sweet Charlie	2.50 i	7.30 c	5.77 bc	76.00
Fully matured fruits of FA 008	2.00 i	6.50 e	4.60 f	72.00
Fully matured fruits of BARI Strawberry -1	2.00 i	7.00 d	4.94 e	63.00
Level of significance	**	**	**	ns
CV (%)	**4.24**	**1.54**	**6.90**	**6.92**

Figures having the same letter(s) in a vertical column do not differ significantly by DMRT; * at 5 and ** at 1% level.

lowest TSS. This result corroborates with the reports of Cordenunsi *et al*. (2002), Strum *et al*. (2003) and Kafkas *et al*. (2007). The TSS of all the cultivars were minimum at one-third maturity stage and

attained up to the mark during full maturity stage ($p \leq 0.01$). During one-third maturity stage, the highest TSS was found in Sweet Charlie and Festival followed by that of Camarosa, which was statistically alike. In interaction two-third matured fruits of Festival exhibited upper most TSS, followed by Camarasa and suitable for harvesting. Kader (1999) stated that minimum soluble solids content of fruits was 7% for acceptable quality of strawberries. At full maturity stage, fruits of Camarosa exhibited maximum TSS followed by Festival. While regardless of maturity stages fruits of FA 008 exhibited the lowest amount of TSS. These results are in agreement with the reports of Munbodh and Aumjaud (2003) who stated that TSS content of Marquise Strawberry varied significantly and higher in fully matured fruits, while the lowest TSS in one-third matured fruits.

Sugar to acid ratio is an important parameter for determination of maturity. Under this experiment, an increasing effect on sugar-acid ratio was observed during rising in maturity stages of strawberry and it varied significantly (Table 2). The highest value of sugar-acid ratio was observed in fruits harvested at full maturity stage followed by two-third maturity stage, while minimum sugar-acid ratio was found in fruits harvested at one-third maturity stage. The increase in sugar-acid ratio due to higher sugar and TSS content with the corresponding acidity in the development process of fruits. For most of the fruits, a higher sugar-acid ratio was interpreted as better eating quality (Kader 1991). The fruits defined as sweet, the sugar-acid ratio was 7 : 1, and in the fruits defined as acid, this ratio was 6 : 1 (Wozniak *et al*. 1997). Among the strawberry cultivars, the sugar-acid ratio was considerably diverse, and fruits of Festival demonstrated the highest sugar-acid ratio followed by those of Camarosa, while FA 008 exhibited the lowest sugar-acid ratio which corroborates the findings of Kafkas *et al*. (2007) and Strum *et al*. (2003). The interaction effect of maturity stages and cultivars exhibited wide-range of variation in sugar-acid ratio (Table 2). Regardless of cultivars sugar-acid ratio were the lowest in one-third maturity and those were the highest in full maturity. The highest sugar-acid ratios recorded from the fruits of Festival and Camarosa at full maturity stage, while the lowest was found in FA 008 and BARI Strawberry-1 at one-third matured fruits. Two-third matured fruits of Festival and Camarosa contained 5.88 and 5.72 sugar to acid ratio, respectively and suitable for harvesting, because sugar to acid ratio more than 5 is suitable for harvest (Kafkas *et al*. 2007). The present results are in perfect agreement with Kafkas *et al*. (2007) and Strum *et al*. (2003). Flavour of strawberry fruits governed the sugar-acid ratio which determined the optimum time for harvesting, because it was considered to be an index of quality (Cordenunsi *et al*. 2002, Shaw 1988). Kader (1991) stated that high sugar and relatively high acids are required for good flavor.

Ascorbic acid content of strawberry fruits differed significantly by maturity stages (Table 2). The highest ascorbic acid content was observed in fruits harvested at full maturity stage followed by that of two-third matured fruits, while minimum was found in one-third matured fruits. Munbodh and Aumjaud (2003) found that ascorbic acid content of strawberry was higher in fully matured fruits in contrast to less matured fruits. Montero *et al*. (1996) and Cordenunsi *et al*. (2002) found an increase in ascorbic acid level during the development stage of strawberries. The present findings are in line with the above researchers.

Among the strawberry cultivars, considerable variation in ascorbic acid content of fruits was observed and the fruits of Festival demonstrated the highest ascorbic acid content, while the fruits of BARI Strawberry-1 exhibited the lowest (Table 2). It was in line with the findings of Kidmose *et al*. (1996) and Kafkas *et al*. (2007). Kidmose *et al*. (1996) found that ascorbic acid content varied from 35 to 75 mg/100 g among the 12 strawberry cultivars studied. The interaction effect of maturity stages and cultivars on ascorbic acid content of strawberry was insignificant (Table 2). This result is in agreement with the findings of Shaw (1988), who found an insignificant different in ascorbic acid content, while Kafkas *et al*. (2007) found the significant differences in ascorbic acid content among the experimental cultivars. This might be due to genetic variation or environmental effect on ascorbic acid accumulation in strawberry.

Some sensory attributes at different maturity stages of strawberry cultivars were evaluated by the taste panel. Sensory performance of fruit on colour, flavour, taste, juiciness, sweetness and overall acceptability, scored the lowest at one-third maturity stage regardless of cultivars and increasing with maturity and become the highest at full maturity stage (Table 3). Studied sensory attributes of fruits of Camarosa, Festival and Sweet Charlie exhibited the considerable score among the two-third matured fruits and preferred by the consumers for consumption, and considered for harvesting. The experimental results are in line with the reports of Kader (1991) and Munbodh and Aumjaud (2003). Munbodh and Aumjaud (2003) reported that strawberry harvested at the fully ripe stage had most intense flavour, sweetness and juiciness compared to three-fourth and one-third ripe fruits of strawberry, but three-fourth matured fruits also acceptable for harvesting due to satisfactory flavour, color, sweetness and juiciness by the judges. Kader (1991) stated that color, flavour, sweetness, juiciness and overall acceptability of fruits are fully dependent on internal nutrient content and chemical component of fruits. These components were genetically controlled and varied significantly among the stages of maturity. Might be due to chemical component of fruits varied significantly among the germplasm as well as maturity stages of fruits.

Table 3. Interaction effect of different maturity stages and cultivars on some sensory attributes of strawberry fruits based on nine points hedonic scale.

Treatment	Colour	Flavour	Taste	Juiciness	Sweetness	Acceptability
1/3rd matured fruits of Camarosa	4.0 f	4.40	3.80 c	5.50 d-f	5.20 f	4.20 g-i
1/3rd matured fruits of Festival	5.0 e	4.30	3.70 c	5.40 ef	5.10 f	4.40 gh
1/3rd matured fruits of Sweet Charlie	5.50 de	4.20	3.60 c	5.30 f	5.10 f	4.50 g
1/3rd matured fruits of FA 008	3.0 h	4.0	3.50 c	5.60 c-f	5.0 f	4.10 hi
1/3rd matured fruits of BARI Strawberry -1	3.50 gh	4.10	3.60 c	5.70 b-f	5.0 f	4.0 i
2/3rd matured fruits of Camarosa	6.0 d	4.70	6.30 b	6.10 bc	6.0 de	7.0 ef
2/3rd matured fruits of Festival	6.67 cd	4.80	6.20 b	6.0 b-d	6.10 de	7.20 de
2/3rd matured fruits of Sweet Charlie	7.17 c	4.60	6.10 b	5.90 b-e	6.20 d	7.40 d
2/3rd matured fruits of FA 008	5.0 e	4.40	5.90 b	6.10 bc	5.70 e	6.70 f
2/3rd matured fruits of BARI Strawberry -1	5.50 de	4.50	6.0 b	6.20 b	5.70 e	6.80 f
Fully matured fruits of Camarosa	8.0 b	7.70	7.40 a	7.80 a	8.40 a-c	8.60 ab
Fully matured fruits of Festival	8.50 ab	7.60	7.30 a	7.70 a	8.50 ab	8.70 a
Fully matured fruits of Sweet Charlie	9.0 a	7.50	7.40 a	7.60 a	8.60 a	8.80 a
Fully matured fruits of FA 008	7.0 c	7.10	7.10 a	8.10 a	8.10 bc	8.20 c
Fully matured fruits of BARI Strawberry -1	7.50 bc	7.20	7.20 a	8.0 a	8.0 c	8.30 bc
Level of significance	**	ns	**	*	*	**
CV (%)	4.15	3.49	4.48	3.24	3.02	2.48

1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much and 9 = Like extremely. Figures having the same letter(s) in a vertical column do not differ significantly by DMRT; * at 5% and ** at 1% level.

Considering firmness, surface color, nutritive value, sugar to acid ratio and sensory attributes, fully matured fruits of strawberry were appropriate. Fruits of full maturity stage on the other hand, showed the minimum shelf life. So it is necessary to make an amicable settlement between shelf life and fruit quality. It can be concluded that TSS content of fruits more than 7% and sugar to acid- ratio more than 5 is good for strawberry harvest. Considering colour, taste, juiciness, sweetness and overall acceptability, fully matured fruits of Sweet Charlie was found the best, followed by Festival and

Camarosa. Hence, two-third matured fruits of Festival and Camarosa contained a considerable amount of TSS, sugar to acid ratio and shelf life and found suitable for harvest. In this regard, Festival and Camarosa harvested at two-third maturity stage were suitable for distance marketing. But, fruits of BARI Strawberry-1 and FA 008 were comparatively juicier and exhibited less shelf life; in this consideration fruits of these two cultivars should be harvested at full maturity stage and were suitable for local marketing.

References

Christi MH and Kader AA 1983. Procedures for the sensory evaluation of horticultural crops. Hort Sci. **18**(1): 19-22.

Cordenunsi BR, Nascimento JRO, Genovese MI and Lajolo FM 2002. Influence of cultivation quality parameters and chemical composition of strawberry fruits grown in Brazil. J. Agric. Food Chem**. 50**: 2581-2586.

Gomez K A, and Gomez AA 1984. Statistical procedure for agricultural research. (2nd ed.). pp. 150-324. John Wiley and Sons, Inc. Singapore.

Kader AA 1991. Quality and its maintenance in relation to the postharvest physiology of strawberry. *In:* The Strawberry into the 21st Century. (J.J. Luby and A. Dale Eds.). pp. 145-154. Timber Press, Portland, Ore, USA.

Kader AA 1999. Effect of pre and post harvest factors of storage on Fruit. Proceedings for International Symposium. Univ. Calif., Davis. pp. 204-207.

Kafkas E, Kosar M, Paydas S, Kafkas S and Baser KHC 2007. Quality characteristics of strawberry cultivars at different maturation stages. Food Chem. **100**: 1229-1236.

Kidmose V, Andersen H and Vang-Petersen O. 1996. Yield and quality attributes of strawberry cultivars grown in Denmark during 1990-1991. Fruit Var. J. **50**(3): 160-167.

Montero TM, Molla EM, Esteban RM and Lopezandreu FJ 1996. Quality attributes of strawberry during ripening. Sci. Hort. **65**(4): 239-250.

Munbodh RS and Aumjaud BE 2003. Quality attributes of marquise strawberry variety. AMAS. Food and Agric. Res. Council, Réduit, Mauritius. **1**:59-65.

Nunes MCN, Brecht JK, Morais A and Sargent SA 2006. Physicochemical changes during strawberry development in the field compared to those that occur in harvested fruit during storage. J. Sci. Food Agric**. 86**: 180-190.

Pareek OP 2001. Ber. International Centre for Under-utilized Crops. Southampton**.** 17 IBJ, UK. pp. 290.

Perkins-Veazie P 1995. Growth and ripening of strawberry fruit. Hortic. Rev. **17**: 267-297.

Picha D 2006. Post Harvest Care of Strawberries in Moldova. Agribusiness Development Project. USAID. pp. 24.

Pritts M 2004. Growing strawberries, healthy communities, strong economies and clean environments: what is the role of the researcher? Acta Hortic. **567**: 411- 417.

Rahman MA, Halim GMA, Chowdhury MGF, Hossain MA and Rahman MM 2014. Changes in physicochemical attributes of sweet pepper (*Capsicum annum* L.) during fruit growth and development. Bangladesh J. Agril. Res. **39**(2): 373-383.

Rosli HG, Civello PM and Martínez GA 2004. Changes in cell wall composition of three *Fragaria* x *ananassa* cultivars with different softening rate during ripening. Plant Physiol. Biochem. **42**(10): 823-31.

Shaw DV 1988. Genotypic variation and genotypic correlation for sugars and organic acids of strawberries. J. Am. Soc. Hort. Sci. **113**: 770-774.

Shin Y, Ryu JA, Liu RH, Nock JF and Watkins CB 2008. Harvest maturity, storage temperature and relative humidity affect fruit quality, antioxidant contents and activity, and inhibition of cell proliferation of strawberry fruit. Postharvest Biol. Technol. **49**: 201-209.

Strum K, Koron D and Stampart F 2003 The composition of fruit of different strawberry varieties depending on maturity stage. Food Chem**. 83**: 417-424.

Wang SY and Camp MJ 2000. Temperatures after bloom affect plant growth and fruit quality of strawberry. Sci. Hort. **85**: 183-199.

Wang SY, Zheng W and Galletta GJ 2002. Cultural system affects quality and antioxidant capacity in strawberries. J. Agric. and Food Chem. **50:** 6534-6542.

Wills R, Mc Glasson B, Graham D and Joyce D 1998. Postharvest. CAB International, Wallingford, UK. pp.168.

Wozniak W, Radajewska B, Reszelska-Sieciechowicz A and Dejwor I 1997. Sugars and acid content influence organoleptic evaluation of fruits of six strawberry cultivars from controlled cultivation. Acta Hortic. **439**: 333-336.

(Manuscript received on 20 August, 2015; revised on 1 November, 2015)