

Physico-chemical Changes during Growth and Development of different Varieties of mango (*Mangifera indica* L.) under Western Maharashtra

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ABSTRACT: The present investigation was carried at Instructional-cum- Research farm of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during 2020-2021 with ten mango varieties in Randomized Block design with three replications. To get full marketable potential it is important to evaluate the cultivars and also to get quality fruits it should be harvested at proper stage of maturity. The physico-chemical parameters were studied in present investigation. The data revealed that, Sai Sugandh recorded maximum length at marble stage (3.28 cm), egg stage (8.10 cm), mature stage (18.83 cm) and ripe stage (18.77 cm) of growth. Cultivar Rajapuri reported maximum diameter at ripe stage (12.87 cm), maximum fruit weight at egg stage (85.33 g), mature stage (603.00 g) and ripe stage (594.00 g) and maximum volume at mature stage (593.33 ml) and at ripe stage (586.67 ml). Vanraj recorded maximum fruit volume at marble stage (7.77 ml) and egg stage (81.83 ml). Marked variation was observed in fruit shape for different mango cultivars at different stages of growth. Cultivar Mallika reported highest TSS at ripe stage (22.33°B); lowest acidity was observed in Alphonso at ripe stage (0.20 %) whereas it was highest in case of Vanraj (0.41 %). Highest sugar: acid ratio was observed in Alphonso at ripe stage (74.78 %). Cultivar Mallika had highest amount of total sugars (16.33%) at ripe stage of growth.

Keywords: Physico-chemical, TSS, growth and development, quality, mango.

INTRODUCTION

The mango (*Mangifera indica* L.), a dicotyledonous fruit in the Anacardiaceae family, is indigenous to the Indo-Burma region. There are 69 species in the *Mangifera* genus (Kosterman and Bompard, 1993) belonging to the order Sapindales. It includes 30 species of tropical fruiting trees (Ram and Rajan, 2003). It is also called as “King of the fruits” in India due to its historical and religious importance, attractive aroma, and capitative taste (Dutta *et al.*, 2013). Determine the best time to harvest mangoes so that high-quality fruit is accessible on the market. To achieve excellent quality fruit, mangoes must be harvested at the right stage of ripeness. Over-maturity or under-maturity adversely affects the quality of mangoes. Mangoes are typically harvested 15 to 16 weeks after fruit set, when they are physiologically mature (Lakshminarayana *et al.*, 1970). If fruit are permitted to remain beyond this stage, postharvest ripening becomes uneven (Lakshminarayana, 1975). The harvestable physiological maturity of mango is associated with

several morphological, biochemical and physiological characteristics. The physical attributes *viz.* fruit weight, colour, pulp, taste, pulp contents, stone and pulp contents and chemical characters like TSS, acidity, reducing and non-reducing sugars of the mango are used to judge the maturity indices and harvesting stages on mango (Hamdard *et al.*, 2004). Total sugars (sucrose, fructose, glucose) are one of the biochemical components of fruit quality which is related to sink strength and is important in fruit development. (Sitthiwong *et al.*, 2005). As compared to morphological and physiological characters, biochemical parameters give more reliable results and are handy to perform. The biochemical composition of mango fruit differs among the cultivars and the stage of maturity. (Singh and Singh, 1996). Quality characteristics in terms of biochemical parameters were previously only investigated at the ripe stage. However, the bio- chemical characteristics of the different cultivars at the mustard, pea, marble, mature and ripe phases of growth and development have not been

examined yet. An essential pre-requisite for effective mango growing is the evaluation of mango varieties for a particular set of ecological conditions (Singh and Singh, 1996).

MATERIAL AND METHODS

Ten varieties of mango fruit namely Sai Sugandh, Kesar, Alphonso, Mallika, Vanraj, Totapuri, Ratna, Pairi, Neelum and Rajapuri were used as experimental material which were collected at different stages such as mustard, pea, marble, egg, mature and ripe stages from the Instructional cum Research farm, Department of Horticulture, MPKV, Rahuri, Dist. Ahmednagar during the year 2020-2021. The experiment was conducted in Randomized Block Design (RBD) with three replications and ten cultivars as treatments. The parameters like length and diameter measured with the help of a Vernier Caliper and expressed in centimeter (cm). Collected fruit were weighed on electronic weighing balance and expressed in grams (g). The volume of selected mango fruit was measured by water displacement method. The colour of fruit at different stages was determined on visual basis. The fruit were visually observed and shape was recorded as per descriptor (IPGRI, 2006). The total soluble solids (TSS) content of mango juice extracted from the pulp is directly measured with the help of Erma Hand Refractometer (0-32°Brix) described by Ranganna (1990). TSS expressed in degree brix (°Brix). Acidity was estimated as per the method given by A. O. A. C. (1984) The total sugars of mango fruit were determined by the method of Lane and Eynon (1923) as described by Ranganna (1990).

RESULT AND DISCUSSION

A. Physical Parameters

(i) Fruit length (cm). There was no significance difference observed in length of mustard and pea stages of mango varieties as shown in Table 1. However cultivar Sai Sugandh recorded maximum length at marble stage (3.28 cm), egg stage (8.10 cm), mature stage (18.83 cm) and ripe stage (18.77 cm) of growth. While Neelum showed minimum length at marble stage (2.14 cm), Pairi at egg stage (6.57 cm), mature stage (12.33 cm) and ripe stage (12.20 cm). There was gradual increase in fruit length from mustard to mature stage and slight decrease at ripe stage of mango varieties. Banik and Sen (2004) observed that the length increased until maturity but later decreases at ripe stage in different varieties of mango.

(ii) Fruit diameter (cm). There was no significant difference observed among the diameter of fruit at mustard stage but diameter was differ significantly at pea, mustard, egg, mature and ripe stages in different varieties of mango Table 1. At pea stage maximum fruit diameter was observed in Vanraj (0.97 cm). Cultivar Rajapuri reported maximum diameter at marble stage (2.14 cm), egg (5.83 cm), mature (12.93 cm) and ripe stage (12.87 cm) while minimum diameter was noticed in Pairi at pea stage (0.58 cm), in Neelum at marble (1.16 cm), in Alphonso at egg (3.47 cm), Neelum at mature (8.63 cm) and ripe (8.57 cm) stage of growth. Data clearly indicated that the fruit diameter was progressively increased with the advancement of time up to mature stage and slightly decreased at ripe stage. Chatterjee *et al.*, (2005); Aktar (2013) reported that diameter of mango fruit varied according to varieties at different stages of growth and development.

Table 1: Length and diameter of mango fruit at different stages of growth and development (cm).

Variety	Mustard stage		Pea stage		Marble stage		Egg stage		Mature stage		Ripe stage	
	L	D	L	D	L	D	L	D	L	D	L	D
Sai Sugandh	0.24	0.21	1.15	0.81	3.28	1.77	8.10	4.87	18.83	10.23	18.77	10.17
Kesar	0.24	0.19	1.09	0.84	2.48	1.68	7.23	4.55	14.67	9.77	14.53	9.67
Alphonso	0.25	0.21	1.05	0.91	2.37	1.62	7.19	3.47	13.10	9.34	13.03	9.20
Mallika	0.24	0.20	1.15	0.80	2.76	1.75	7.73	4.69	16.53	10.10	15.43	10.07
Vanraj	0.25	0.21	1.16	0.97	2.97	2.00	7.77	5.55	15.60	12.80	16.47	12.70
Totapuri	0.22	0.23	1.17	0.90	3.16	1.86	7.80	5.37	17.67	11.30	17.53	11.10
Ratna	0.24	0.19	1.02	0.81	2.47	1.89	7.10	4.90	13.47	10.45	13.13	10.32
Pairi	0.24	0.19	0.99	0.58	2.35	1.57	6.57	4.67	12.33	8.70	12.20	8.67
Neelum	0.25	0.20	1.08	0.72	2.14	1.16	6.84	4.53	12.73	8.63	12.67	8.57
Rajapuri	0.25	0.22	1.23	0.88	2.73	2.14	7.63	5.83	14.97	12.93	14.87	12.87
SE(m)±	0.01	0.00	0.05	0.05	0.10	0.42	0.14	0.37	0.23	0.21	0.29	0.11
CD at 5%	NS	NS	NS	0.14	0.28	0.43	0.40	1.11	0.69	0.61	0.87	0.33

(iii) Fruit weight (g). Weight of fruit at mustard stage was not influenced significantly by varieties but at pea, marble, egg, mature and ripe stage it was significantly influenced by varieties at different stages of growth and development as shown in Table 2. At pea stage maximum fruit weight was noticed in cultivar Rajapuri (0.57g), however at marble stage maximum fruit weight was observed in Vanraj (7.00 g), Cultivar Rajapuri reported maximum fruit weight at egg stage (85.33 g), mature stage (603.00 g) and ripe stage (594.00 g).

While minimum fruit weight was observed in Sai Sugandh at pea (0.33 g) and marble (5.13 g) stage of growth. Alphonso at egg stage (67.00 g), Neelum at mature stage (246.68 g) and Pairi at ripe stage (225.71 g). There was an increase in fruit weight from mustard to mature stage, which later on decreased slightly at ripe stage in all the mango cultivars. This may be due to hydrolysis of starch, as starch accumulation increases fruit weight (Lechaudel *et al.*, 2005).

(iv) **Fruit volume (ml).** Fruit volume of different mango cultivars at mustard stage was observed non-significant but noticed significant difference in fruit volume at pea, marble, egg, mature and ripe stages of different mango cultivars as shown in Table 2. At pea stage maximum fruit volume was recorded in Totapuri and Rajapuri (0.67 ml, each). Vanraj recorded maximum fruit volume at marble stage (7.77 ml) and egg stage (81.83 ml). Rajapuri recorded maximum fruit

volume at mature stage (593.33 ml) and at ripe stage (586.67 ml). While minimum fruit volume was observed in Sai Sugandh at pea stage (0.43 ml), at marble stage (6.17 ml) in Neelum, at egg stage (71.33 ml) in Alphonso and at mature stage (238.33 ml) and ripe stage (231.67 ml) in Neelum, there was gradual increase in fruit volume from mustard to mature stage but then it was slightly reduced at ripe stage. Similar results also reported by Badhe *et al.*, (2007).

Table 2: Weight (g) and volume (ml) of mango fruit at different stages of growth and development.

Variety	Mustard stage		Pea stage		Marble stage		Egg stage		Mature stage		Ripe stage	
	W	V	W	V	W	V	W	V	W	V	W	V
Sai Sugandh	0.030	0.035	0.33	0.43	5.13	6.23	77.47	81.30	429.67	420.00	414.33	409.67
Kesar	0.030	0.037	0.40	0.57	5.70	6.40	75.20	79.57	315.00	310.00	301.00	296.00
Alphonso	0.027	0.037	0.40	0.53	5.57	6.60	67.00	71.33	273.67	266.67	265.00	260.33
Mallika	0.033	0.036	0.50	0.60	6.27	7.17	78.40	82.10	543.33	533.67	535.67	528.00
Vanraj	0.035	0.040	0.50	0.63	7.00	7.77	85.03	88.83	550.00	535.33	538.33	533.00
Totapuri	0.036	0.040	0.53	0.67	5.80	6.77	84.30	88.60	443.33	430.00	430.38	426.00
Ratna	0.033	0.037	0.40	0.53	6.50	7.17	76.60	82.03	429.67	416.33	411.00	405.00
Pairi	0.032	0.036	0.37	0.50	5.50	6.50	67.37	72.23	248.68	242.68	225.71	244.00
Neelum	0.035	0.039	0.40	0.53	5.30	6.17	73.34	77.83	246.67	238.33	236.66	231.67
Rajapuri	0.037	0.040	0.57	0.67	6.73	7.70	85.33	88.33	603.00	593.32	594.00	586.67
SE(m)±	0.003	0.003	0.04	0.05	0.35	0.33	1.50	1.69	26.59	28.79	31.05	33.11
CD at 5%	NS	NS	0.13	0.14	1.04	0.97	4.45	5.02	79.00	85.55	92.25	98.37

(v) **Fruit colour.** According to Table 3 the fruit colour of all the varieties at mustard stage was green except Vanraj and Ratna had light green colour. Sai Sugandh and Vanraj had green colour with red blush at pea, marble and egg stages. At mature stage Sai Sugandh turned greenish yellow. At ripe stage it turned golden yellow and Vanraj turned yellow with red blush. Other varieties like Kesar, Totapuri, Ratna, Pairi, Neelum and Rajapuri were green at mustard, pea, marble and egg stages and later turned yellowish green at mature stage and yellow at ripe stage. Alphonso turned yellow colour with red blush at ripe stage. Fruit colour is one of the most important quality features for recognizing fruit, as well as influencing customer preferences. The variance shown in this study confirmed the results given by Mukharjee, (1959) that fruit colour at maturity was determined by genotype.

(vi) **Fruit shape.** Marked variation was observed in fruit shape for different mango cultivars at different stages of growth, based on fruit shape, the mango cultivars were classified as oblong, roundish and obovoid as shown in Table 4. At mustard stage all the varieties were with roundish shape. Sai Sugandh, Kesar, Mallika, Totapuri, Neelum and Rajapuri had oblong shape at pea, marble, egg, mature and ripe stages. Whereas Alphonso and Vanraj had obovoid shape. Ratna and Pairi had roundish shape. Mango fruit shape differed from variety to variety and during different growth stages. Fruit morphologies vary across mango varieties, which might be attributable to genetic or physiological factors. The findings are similar to those of Bhalodiya *et al.*, (2016), in Rajapuri and Kesar mangoes that had an oblong shape.

Table 3: Colour of mango varieties at different growth stages of fruit.

Variety	Mustard	Pea	Marble	Egg	Mature	Ripe
Sai Sugandh	Green	Green with red blush	Green with red blush	Green with red blush	Green with red blush	Golden Yellow
Kesar	Green	Green	Green	Green	Greenish Yellow	Yellow
Alphonso	Green	Green	Green	Green	Yellowish green	Yellow with red blush
Mallika	Green	Green	Green	Green	Yellowish green	Yellow
Vanraj	Light Green	Light green with red blush	Light green with red blush	Light green with red blush	Green with red blush	Yellow with red blush
Totapuri	Green	Green	Green	Green	Yellowish green	Yellow
Ratna	Light green	Green	Green	Green	Yellowish green	Yellow
Pairi	Green	Green	Green	Green	Yellowish green	Yellow
Neelum	Green	Green	Green	Green	Yellowish green	Yellow
Rajapuri	Green	Green	Green	Green	Yellowish green	Yellow

Table 4: Shape of mango varieties at different growth stages of fruit.

Variety	Stage	Mustard	Pea	Marble	Egg	Mature	Ripe
Sai Sugandh		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong
Kesar		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong
Alphonso		Roundish	Obovoid	Obovoid	Obovoid	Obovoid	Obovoid
Mallika		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong
Vanraj		Roundish	Obovoid	Obovoid	Obovoid	Obovoid	Obovoid
Totapuri		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong
Ratna		Roundish	Roundish	Roundish	Roundish	Roundish	Roundish
Pairi		Roundish	Roundish	Roundish	Roundish	Roundish	Roundish
Neelum		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong
Rajapuri		Roundish	Oblong	Oblong	Oblong	Oblong	Oblong

B. Chemical Parameters

(i) Total soluble solids (TSS) (°B). Total soluble solids (TSS) content varied significantly according to varieties and stages of development as shown in Table 5. The maximum TSS content was recorded in Pairi (3.90°B) at mustard stage, Pairi (5.40°B) at pea stage. Cultivar Neelum reported maximum TSS at marble stage (7.17°B), Ratna at mature stage (12.93°B) and Mallika at ripe stage (22.33°B) of growth and development. However, minimum TSS was noticed in Kesar (3.00°B) at mustard stage, Kesar and Alphonso (3.90°B, each) at pea stage. Ratna at marble stage (6.60°B), Vanraj at egg stage (7.92°B) Totapuri at mature stage (8.99°B) and Neelum at ripe stage (17.47°B) of growth and development. According to the data, total soluble solids increased with the advancement of size of fruit from mustard to ripe stage. These findings are in accordance with those published by Kudachikar *et al.*, (2001), who

observed that TSS in Neelum rises as the species matures.

(ii) Acidity (%). The maximum acidity was recorded in Neelum at mustard stage (0.79 %), Vanraj at pea stage (0.93 %), Ratna at marble stage (1.20 %), Rajapuri at egg stage (0.82%) and mature stage (0.71 %), Vanraj at ripe stage of growth (0.41%). However minimum acidity was observed in Sai Sugandh at mustard stage (0.67 %), Mallika at pea stage (0.78 %), egg stage (0.58 %) and mature stage (0.44 %). Alphonso reported minimum acidity at ripe stage (0.20 %) of growth. The results in Table 5 showed that acidity increased from mustard to marble and then reduced until the ripe stage, which might be related to starch breakdown into sugars. Zagade and Relekar (2014) observed a similar pattern. The acid level decreased as a result of the acid used in respiration to provide energy for starch synthesis activities (Trong *et al.*, 2020).

Table 5: TSS (°B) and acidity (%) of mango varieties at different growth stages of fruit.

Variety	Mustard stage		Pea stage		Marble stage		Egg stage		Mature stage		Ripe stage	
	TSS	Acidity	TSS	Acidity	TSS	Acidity	TSS	Acidity	TSS	Acidity	TSS	Acidity
Sai Sugandh	3.46	0.67	4.07	0.88	6.82	0.89	8.61	0.69	10.02	0.44	19.37	0.29
Kesar	3.00	0.76	3.90	0.87	6.95	1.03	8.23	0.68	10.56	0.41	19.97	0.22
Alphonso	3.20	0.72	3.90	0.85	6.91	0.88	9.20	0.65	11.79	0.48	21.87	0.20
Mallika	3.43	0.68	5.00	0.78	6.91	1.10	9.37	0.58	12.78	0.34	22.33	0.26
Vanraj	3.76	0.77	5.10	0.93	6.68	0.96	7.92	0.81	9.31	0.55	17.77	0.41
Totapuri	3.10	0.74	4.83	0.86	7.00	0.98	8.81	0.71	8.99	0.37	17.87	0.28
Ratna	3.26	0.72	4.77	0.84	6.60	1.20	9.19	0.67	12.93	0.46	20.53	0.31
Pairi	3.90	0.78	5.40	0.88	6.94	1.02	8.72	0.72	11.17	0.38	17.60	0.39
Neelum	3.86	0.79	4.77	0.87	7.17	0.97	8.46	0.79	9.63	0.51	17.47	0.34
Rajapuri	3.33	0.76	4.37	0.89	7.09	1.09	8.52	0.82	10.78	0.61	17.67	0.40
SE(m)±	0.09	0.02	0.10	0.01	0.18	0.03	0.07	0.01	0.31	0.01	0.31	0.01
CD at 5%	0.29	0.06	0.29	0.04	0.53	0.09	0.22	0.04	0.91	0.03	0.92	0.02

(iii) Sugar: acid ratio. The sugar: acid ratio was influenced significantly by varieties from mustard to ripe stage as shown in Fig. 1. The maximum sugar: acid ratio was observed in Mallika at mustard stage (5.13), pea stage (5.55), egg stage (11.45) and mature stage (20.23) and in Alphonso at marble stage (6.16) and ripe stage (74.78). While minimum sugar: acid ratio was observed in Pairi at mustard stage (3.44) and ripe stage (29.52), but in Rajapuri it was less at pea (3.84), egg (6.77) and mature stage (10.70). The results clearly showed that the sugar to acid ratio differed with variety and increased with advancement of time. Sugar-acid ratio, like TSS content, is used to evaluate the quality of fruit. Fruit of better quality have a higher sugar-acid ratio, whereas fruit of poorer quality have a lower sugar: acid ratio. Sugar: acid ratio varied according to

varieties (Anila and Radha, 2003; Singh *et al.*, 2020).

(iv) Total sugars (%). Total sugars at various stage of growth were significantly influenced by different cultivars of mango as shown in Fig. 2. At mustard stage highest total sugars were observed in Totapuri (3.59 %), Mallika at pea stage (4.31 %), egg stage (6.67%), mature stage (8.88 %) and ripe stage (16.33 %), and Alphonso at marble stage (5.42 %). Whereas lowest total sugars content was observed in Pairi (2.67 %) at mustard stage, Rajapuri at pea stage (3.40%), Kesar at marble stage (4.13%) and Pairi at egg stage (5.30 %), mature stage (7.30 %) and ripe stage (11.51 %). Shafique *et al.*, (2006) also observed that total sugar content increases as fruit reaches the maturity. Padhiar *et al.*, (2011); Singh *et al.*, (2020) also reported that total sugar content varied according to varieties.

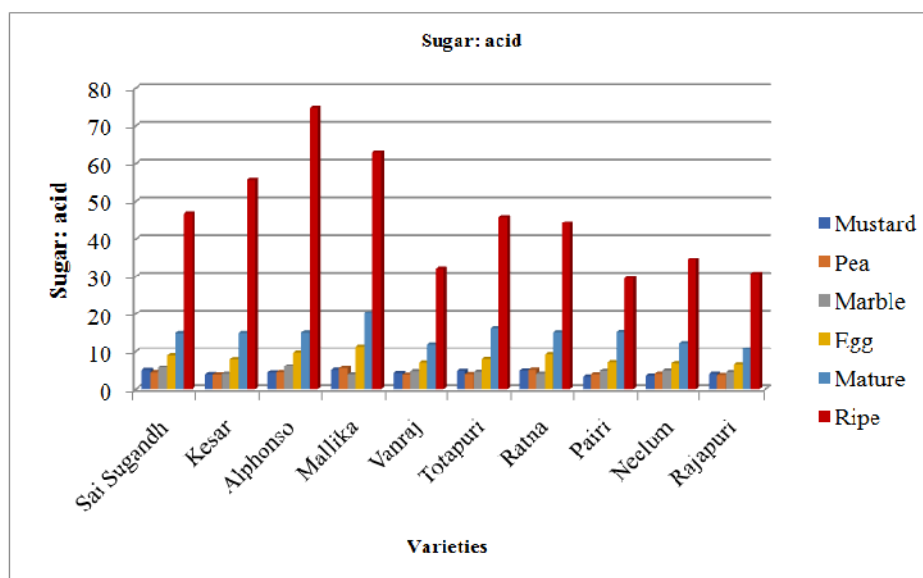


Fig. 1. Sugar: acid of mango fruit at different stages.

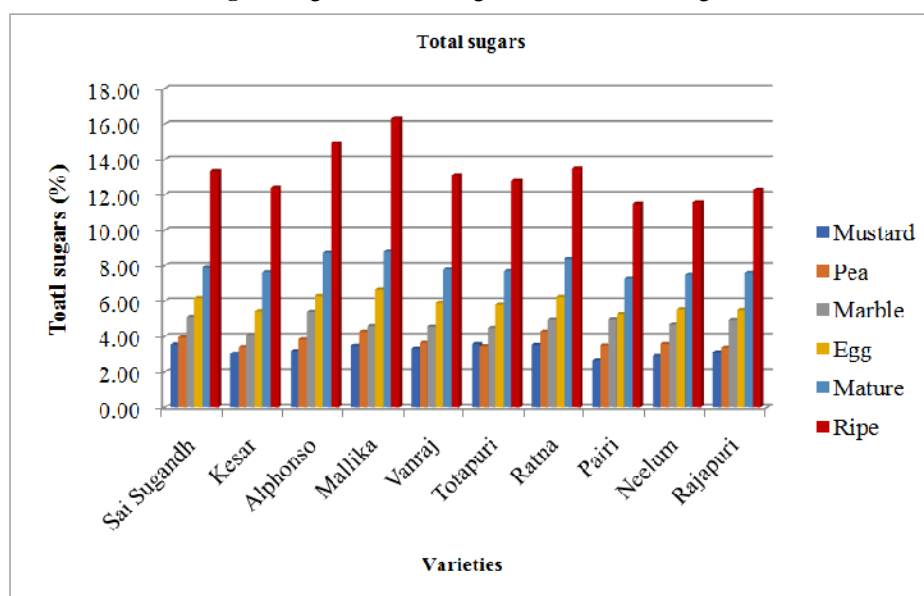


Fig. 2. Total sugars of mango fruit at different stages (%).

CONCLUSION

From the experiment it was observed that among the cultivar, Alphonso was found to be the best of all the cultivars. Characterization of available mango genetic resources is helpful for identification of suitable and promising cultivars for fresh consumption and/or storage. From any experimental results obtained from a single year study is not sufficient to draw a valid conclusion. So the same experiment should be repeated under the same environment for further verification of the results.

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Conflict of Interest. None.

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