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A Study on Colour and Dimensional Assessment of Different Apple cultivars present in Domestic Fruit Market of NCR Region

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Abstract: Colour in fruits is an important tool concerning quality, consumer acceptance. A study was undertaken to study the colorimetric variations of selected apple cultivars in NCR region with a view to assess the quality and understand the consumer preferences while purchasing domestic or imported apples. Four most popular apples cultivars having dominance in market were selected which included two imported (Washington apple (USA) & China 'Fuji' Apple) and two domestic (Himachal apple & Kashmir apple) cultivars. Colorimetric assessment included calculation of L*, a*, b* and ΔE^* , Hue angle and Chroma. The statistical analysis of data was done using Duncan test. The highest brightness level (L*) was observed in Fuji apple (54.12 ± 2.11). As far as the a* values (which represents chromaticity on a green to red axis) are considered, both the domestic cultivars have significantly lower values of redness than imported cultivars. The b* value assessment representing chromaticity on a blue (-) to yellow axis (+) indicated higher yellow pigment concentration in domestic cultivars as compared to imported cultivars whereas more redness was observed in imported cultivars. Higher Chroma values are observed in Kashmir apple (31.10 ± 1.91) and Fuji apple (33.02 ± 2.0). Among all four apple cultivars, Washington apple (26.19 ± 2.46) has the least value of Chroma but Himachal apple (28.74 ± 1.17) has significantly higher value. Washington apple (0.28 ± 0.04) has least value of Hue compared to Fuji apple (0.54 ± 0.10). Washington apples has the highest value of length (L=8.13 cm) whereas Fuji apples has the lowest value of length (L=7.11 cm). Fuji apple has maximum breadth and width values (8.06 cm and 6.76 cm respectively). Himachal apples have more defined structure with Sphericity values of 0.98 and 0.97 cm. Washington apples (204.31 gm) have more average mean value of weight as compared to other apple cultivars. Domestic apples recorded less acid values as compared to imported apples. Fuji apple (Force=113.37 Kg/sec) are comparatively much harder than the other three cultivars. On the basis

of uniformity of color Washington apples were more preferred where as on the basis of blend of taste Himachal apples were more preferred. The data obtained on color, physical and textural features during the study can further be used for software development on image processing of apples.

Key words: Apple, Color, Hue, Chroma, Consumer preference

INTRODUCTION

The apple (*Malus domestica*) is a deciduous tree in the rose family which is best known for its sweet, pomaceous fruit. In India, Apples are mainly cultivated in North West Hills Region of India, comprising of states of Jammu & Kashmir (J&K), Himachal Pradesh (H.P), Uttarakhand and in the North Eastern Hills Region in the States of Arunachal Pradesh, Nagaland, Meghalaya and Manipur. Commercial growers due to market preferences aim to produce an apple that is 7.0 cm to 8.3 cm (2.75 to 3.25 inches) in diameter. Some consumers, especially those in Japan, prefer a larger apple, while apples below 5.7 cm (2.25 inches) are generally used for making juice and have little fresh market value. The skin of ripe apples is generally red, yellow, green, pink, or russeted although many bi- or tri-colored cultivars may be found. Consumer make their preferences for a specific apple cultivar depending upon its shape, size, color and taste. Among various factors, uniform colour and shape of apples attract more consumers and it also provides better revenue margins to fruit dealers (Peleg, 1985). Keeping this in view, the current study was undertaken for colorimetric and dimensional assessment of different apple cultivars in domestic market supporting easier computer based automated identification for grading and sorting of apples. The major objectives of the study were assess the quality of major apples cultivars present in the domestic market and to study the colorimetric variations of selected apple cultivars.

SIGNIFICANCE OF THE STUDY

Apple, the most widely grown species in the genus *Malus* has more than 7500 known cultivars

worldwide. Among these many cultivars are imported in our domestic market due to their availability with better quality and comparatively cheaper prices. Imported apples generally tend to retail at Rs. 120 per Kg at the APMC market in Azadpur Mandi, New Delhi. India is the world's third largest producer of apples and yet imports from the US, China, Chile, Fiji, Iran and New Zealand. Apple imports stood at 1.97 lakh tonnes valued at 1,388.72 crore in 2014-15 fiscal against 1.75 lakh tonnes valued at 1,176.03 crore in fiscal 2013-14 and (Anon., 2015). Such increase is imposing a threat to our local fruit industry. So, the current study targets dimensional and colorimetric assessment of different cultivars of apples present in our domestic market (Delhi-NCR) which further may be used by industries to prepare a computer simulated model for sorting and grading of different variants of apples. Consumers also prefer fruit of uniform color, weight and shape. Therefore, mass grading fruit can contribute for optimum packaging configuration while reducing packaging and transportation costs (Peleg, 1985).

MATERIALS & METHODS

Four cultivars of apples from Azadpur fruit market in Delhi-NCR (New Delhi, India) were selected on the basis of popularity i.e. two domestic (Himachal apple & Kashmir Apple) and two imported cultivars (Washington Apple, Fuji Apple). The color parameters: L*, a*, b* and ΔE^* were measured with a CR-400 Chroma meter (Konica Minolta). Numerical values of a* and b* were used to calculate Hue angle ($H^\circ = \tan^{-1}(b^*/a^*)$) and Chroma ($C = (a^{*2} + b^{*2})^{1/2}$). For each cultivar, two set of readings were recorded in three replicates each. Each replicate

contains four apples and for each apple colour readings were recorded at 10 defined coordinates as mentioned in Fig. 1. The apples used for study are presented in the Fig 2.

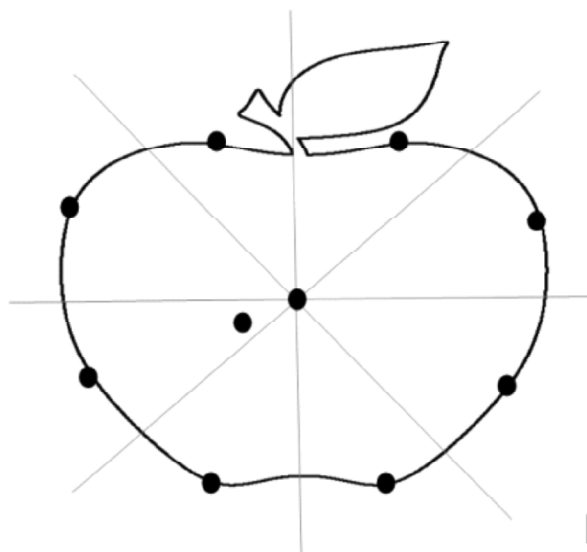


Figure 1: Coordinates location for color assessment

Size was determined using Vernier Caliper 0-150 mm (Aerospace) where Length (L), Width (B) and Thickness (W). Geometric mean diameter (GMD) and Sphericity were calculated by using the equation as reported by Mohsenin (1986) i.e. Geometric mean diameter (GMD) = $(LBW)^{1/3}$, and Sphericity = GMD/L . The fruit weight (gram) was measured by Sartorius Weighing Scale (max. - 220g, d - 0.1 mg). TSS was measured by using hand-refractometer and expressed in per cent. Acidity was measure as % Malic acid (AOAC 2010). Texture Profile Analysis (TPA) was performed using a Stable Micro Systems TA-HD-plus Texture Analyser with a load cell of 100N. A flat 75mm aluminum compression probe with the contact area of 4417.86 mm² was used in the TPA tests. Sensory studies were done by using a 9-point hedonic scale model questionnaire which included external appearance and internal properties. The scale included likeness ranging from: Dislike extremely, Dislike very much,

Dislike moderately, Dislike slightly, Neither like nor dislike, Like slightly, Like moderately, Like very much, and Like extremely. Statistical analysis was done using IBM SPSS Statistics software Version 23.0.

RESULTS & DISCUSSION

Apple Color

The calculated average mean values of L^* , a^* , b^* , ΔE^* , Chroma and Hue of selected apple apples cultivars are presented in the Table 1. The statistical analysis revealed that there were significant color differences between domestic and imported cultivars. The brightness level (L^*) of domestic cultivars Himachal apple and Kashmir apple is statistically at par (46.07 ± 5.66 & 48.85 ± 3.72) but significantly higher than Washington apple (35.50 ± 1.20). The highest brightness was observed in Fuji apple (54.12 ± 2.11). As far as the a^* values (which represents chromaticity on a green to red axis) are considered, both the domestic cultivars have significantly lower values of redness than imported cultivars. Highest values of redness were recorded with Fuji apples (28.17 ± 3.42). The ' b^* ' values represents chromaticity on a blue (-) to yellow axis (+). The yellow pigment was more observed in the domestic cultivars and was highest Kashmir Apples (23.06 ± 4.67) and lowest in Washington apples (7.67 ± 1.50). Chroma represents the amount of visual difference from a grey of the same value. It is also used to assess the quality of color by which we can distinguish a strong color from weak one. The higher Chroma values are observed in Kashmir apple (31.10 ± 1.91) and Fuji apple (33.02 ± 2.0). Miller and Delwiche (1989) studied color vision for peach grading. Tomato classification for color and shape defects using image processing has been reported by Sarker and Wolfe (1985) and Laykin *et al.* (2002). Davenel *et al.* (1988) and Rehkugler and Throop (1989) presented a method for detecting apple defects in automatic fruit sorting. Similar kind of studies have also been done by Chen and Sun (1991)

Table 1
Colorimetric assessment of selected apple cultivars

Cultivars	Colour Parameters					
	Brightness (L^*)	Redness (a^*)	Yellowness (b^*)	Total Difference (ΔE^*)	Chroma	Hue
Himachal	46.07 ± 5.66 ^b	19.57 ± 3.79 ^a	18.46 ± 2.87 ^b	60.74 ± 1.91 ^b	28.74 ± 1.17 ^b	0.67 ± 0.12 ^c
Kashmir	48.85 ± 3.72 ^b	16.20 ± 6.72 ^a	23.06 ± 4.67 ^c	58.53 ± 2.17 ^b	31.10 ± 1.91 ^c	0.68 ± 0.99 ^c
Fuji	54.12 ± 2.11 ^c	28.17 ± 3.42 ^b	16.29 ± 1.57 ^b	50.90 ± 2.50 ^a	33.02 ± 2.0 ^c	0.54 ± 0.10 ^G
Washington	35.50 ± 1.20 ^a	24.86 ± 2.16 ^b	7.67 ± 1.50 ^a	67.83 ± 4.48 ^c	26.19 ± 2.46 ^a	0.28 ± 0.04 ^a

analyzed as per Duncan^{ab} Test with $\alpha = 0.05$, SPSS ver 23.0

on non-destructive methods for quality evaluation and sorting of agro-produce. Colorimetric classification in citrus fruits has also been studied by Iqbal *et al.* (2016).

Size & Weight

Washington apples has the highest value of length ($L=8.13$ cm) whereas Fuji apples has the lowest value of length ($L=7.11$ cm). Fuji apple has maximum breadth and width values with 8.06 cm and 6.76 cm respectively. Geometric Mean Diameter was highest in Washington apples (7.35 cm). Sphericity determines the overall shape of the apple. As far as values of Sphericity are considered Fuji (0.98) and Himachal apple (0.97) have more defined shape. Washington apples ($W=204.31$ g) have highest

weight as compared to other apple cultivars. The details are mentioned in the Table 2.

According to Codex standard (Stan299 – 2010), Size in apple is determined by maximum diameter of the equatorial section or by weight of each apple and in accordance with the maximum defects allowed for apples, they can be further be classified in three classes “Extra” Class, Class I, Class II. For all cultivars and all classes of apples the minimum size is 60 mm if measured by diameter or 90 g if measured by weight. Fruit of smaller sizes may be accepted provided the Brix level of the produce meets or exceeds 10.5° Brix and the size is not smaller than 50 mm or 70 g. Among various physical characteristics, mass, volume, projected area, and center of gravity are the most important ones in

Table 2
Mean values of different size parameters and weight of apples

Dimensional parameters		Domestic Cultivars		Imported cultivars	
		Himachal	Kashmir	Fuji	Washington
Size	Length (L) (cm)	7.2	7.68	7.11	8.13
	Breadth (B) (cm)	7.6	7.68	8.06	7.67
	Width (W) (cm)	6.22	6.37	6.76	6.39
	GMD (cm)	6.97	7.2	7.28	7.35
	Sphericity (S)	0.97	0.93	0.98	0.90
Weight (gm)		186.76	203.90	198.9	204.31

GMD=Geometric Mean Diameter

determining sizing systems in fruits (Peleg and Ramraj, 1975; Khodabandehloo, 1999). Other important parameters are width, length, and thickness (Mohsenin, 1986). Wolfe and Swaminathan (1987) studied the orientation and shape of bell peppers using the Hough transform. At times weight sizing mechanisms are recommended for irregularly shaped product and dimensional method (of length, area, and volume) could easily be applied to fruits (Tabatabaefar, and Rajabipour (2005). Similar fruit size assessment studies have also been undertaken on pomegranate (Khoshnam et al. 2007) and apricot (Naderi-Boldaji et al. 2008).

Total Soluble Solids (TSS) & Acidity

Highest TSS values were recorded in Kashmir apple (Brix value=3.41%). Both imported cultivars have lower Brix values with Fuji at 2.57% and Washington at 2.86%. Fuji apples were more acidic (0.45%) followed by Washington apple (0.35%). Both the domestic cultivars have lower acidity values (Table 3).

Table 3
Average TSS and Acidity values of four apple cultivars

<i>Apple Cultivars</i>	<i>TSS (%)</i>	<i>Acidity (%)</i>	<i>TSS / Acidity</i>
Himachal	3.10 %	0.25	12.4
Kashmir	3.41 %	0.22	15.5
Fuji	2.57 %	0.45	5.71
Washington	2.86 %	0.35	8.17

Texture (Firmness)

In texture analysis, the level of hardness which is calculated as first peak force of compression has been recorded for the apple cultivars under study. Fuji apples (Force=113.37 Kg/sec) were comparatively much harder than the other three cultivars. Washington apple are softest ones with F=49.28 Kg/sec. Both the domestic cultivars have nearly same values of firmness with Himachal apple being softer (68.13 Kg/sec) than Kashmir apple with

higher force of compression (73.24 Kg/sec). Similar studies has also been done by Alvarez et al. (2002), Barrett et al. (2010), Arshad et al. (2014), Arivazhagan et al. (2010) and Alvarez et al. (2002) in different fruits and vegetables.

Sensory Analysis

Sensory analysis is performed based on 9-point hedonic scale which included exterior properties (size, shape, skin colour) and pulp traits (colour, consistency, juiciness, taste, flavour, softness) of apple. The results revealed that imported cultivars are more preferred based on exterior aspects than domestic apple cultivars (Table 4a and 4b).

Table 4a
Sensory Analysis of apple cultivars based on exterior aspects

<i>Exterior Aspects</i>	<i>Domestic cultivars</i>		<i>Imported Cultivars</i>	
	<i>Himachal apple</i>	<i>Kashmir apple</i>	<i>Fuji apple</i>	<i>Washington apple</i>
Fruit Size	7.27	7.33	7.83	7.97
Fruit Shape	7.07	7.17	7.83	7.87
Skin Colour	7.03	7.00	7.70	7.97

For assessing the sensory concerns of apple cultivars based on pulp traits, six pulp traits were studied viz., pulp colour, consistency, juiciness, taste, flavor and softness. Pulp colour of Washington apple (7.97) was highly preferred. Fuji apple has the highest score ((7.9) of polp consistency. Imported apples have more consistent texture than domestic apples (Himachal apple= 7.33, Kashmir apple= 7.1). Fuji apple has more juiciness than other three apple cultivars. Taste of Washington apple was most preferred with average score of 8.03. Flavour of Washington apple was more preferred as compared to other apples. A similar kind of study was undertaken by Catalina et al. (2015) to understand the consumer perception of apple fruit consumers concerning fruit quality.

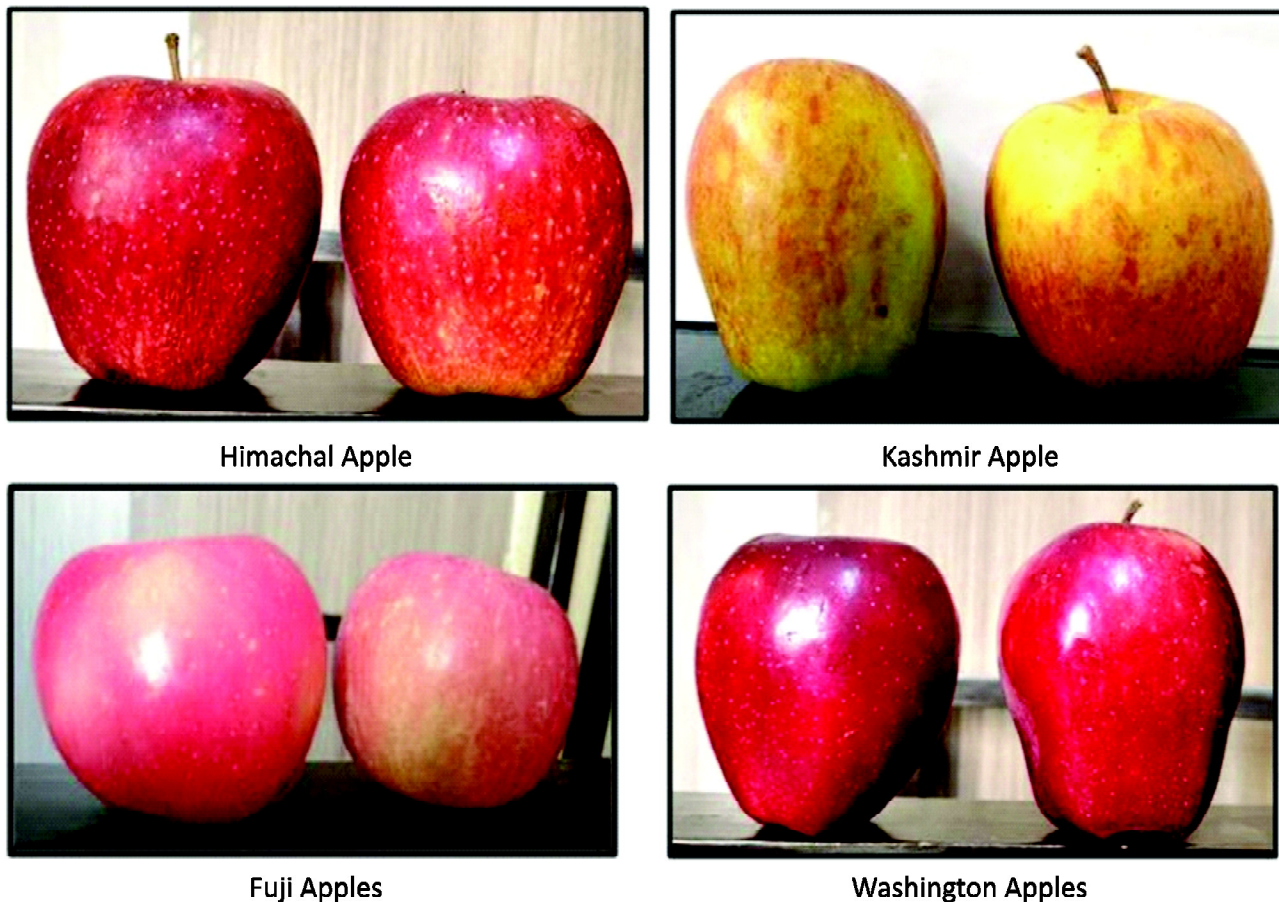


Figure 2: Apple cultivars for study

Table 4b
Sensory Analysis of apple cultivars based on pulp traits

Pulp Traits	Himachal	Kashmir	Fuji	Washington
• Pulp Colour	7.2	7.23	7.67	7.97
• Consistency	7.33	7.1	7.9	7.67
• Juiciness	7.63	7.4	7.8	7.7
• Taste	7.34	7.37	7.43	8.03
• Flavour	7.23	7.07	7.3	7.7
• Softness	7.13	7.4	7.17	7.63

CONCLUSION

In this study, we have selected the four apple cultivars (Himachal, Kashmir, Fuji, Washington) based upon their popularity and abundance in Delhi NCR fruit market. A comparison between domestic and

imported apple cultivars were studied for colorimetric, dimensional and sensory analysis as quality concern is one of the most important criteria for market acceptance, price fixation and consumer preference. In Colorimetric analysis, Fuji apple has the highest value of brightness. Fuji apples and Washington apples have more redness than domestic apple cultivars. Yellow pigment was more observed in Kashmir apples than other three cultivars. Chroma value was higher in Fuji apples and Hue value was higher in Kashmir apple. In Dimensional analysis, Washington apples are more elongated in size but Fuji apples are found to be having more defined sphericity. In terms of hardness, Fuji apple is harder and it has the maximum value of first force of compression. In terms of acidity, Fuji apple has more acidic taste than other three cultivars. Total soluble

solid content is more Kashmir apple. In Sensory analysis, imported apples are more preferred than domestic apples in both exterior and interior aspect. The presented data on color and texture features can further be processed and utilized in computer based programming for development of colorimetric based varietal recognition system in combination with shape and size and textural features. The results obtained can also be utilized for developing smart self-service scales by the small vendors or development of computer vision strategies for color shade cards.

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