



Standardization of Optimum Harvest Stage of Tender Cashew Kernel for Culinary Purposes

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Abstract

Cashew is dollar earning plantation crop commercially cultivated in India, even though it is not a native species. Various pre-harvest factors could lead to significant reduction in cashew yield. In west coast region, the harvesting green cashew nuts for tender kernels for culinary purposes is a common practice, which provides appreciable returns to the growers. This research was conducted for standardizing optimal harvest stage to achieve quality tender kernels. The five growth stages according to Biologische, Bundesanaltalscale, Bundessortenamt and Chemische industry (BBCH) scale were studied as treatments with four replications in Randomized Block Design. Hand pollination was carried out and various growth parameters of cashew nut, apple and kernels along with their proximate composition and sensory attributes were determined. The cashew apple length, diameter and weight increased throughout growth stages; however, cashew nut and cashew kernel length, breadth, width and weight were found to be the highest in treatment T3 (BBCH 719) and thereafter decreased due to moisture loss. The highest moisture content of 92.40% was observed in T1(BBCH 715), while, protein, fat and carbohydrates were recorded to be the highest in T5 (BBCH 7813). The highest overall organoleptic sensory score of 8.83 was observed for treatment T3 due to tenderness.



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Introduction

Cashew (*Anacardium occidentale L.*) a member of Anacardiaceae family, is also known as the Gold mine, Poor man's crop and Rich man's food.¹ There are 33 countries that cultivate cashew globally, and India is one of the top producers. India produces more than 0.8 million tons of cashew nuts from 0.7 million hectares of land.² Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha, West Bengal and some parts of North Eastern states grow cashew.³ In 2017, Maharashtra, Goa, Andhra Pradesh and Odisha produced 60% of India's total cashew nut production with about 449 thousand MT.⁴

One of the main constraints for getting maximum production in cashew is prevalence of pests. The cashew stem and root borer, tea mosquito bug, inflorescence thrips and apple and nut borer are the major pests that damage cashew particularly in the west coast of Maharashtra.⁵ These insects cause 30–50% losses in cashew due to blossom blight, shoot necrosis and damage to apple and nuts.⁶ Tea mosquito bug alone contribute to 20-60% of the crop loss. Cashew growers lose more than 30% of their profits because of inflorescence blight. Fruit bats mainly transport cashew apples along with nuts and spread them where bats often go. *Pteropus giganteus* ate 18% of the cashews during the fruiting season.⁷ Mostly, cashew growers collect fallen nuts every day to keep rodents, birds and thieves away. However, cashew producing areas like Konkan region of Maharashtra, Goa and northern parts of Karnataka have been plucking green cashew nuts for their soft, fresh kernels for culinary purpose. This traditional practice is now becoming more popular in the urban areas. Plucking green cashew nuts to get tender kernels could help to reduce the pre-harvest losses and maximize the returns due to with minimum requirement of processing. Identifying optimal harvest stage of green cashew nut for high quality tender kernels is quite difficult. Particularly in Konkan region of Maharashtra, early harvesting of tender cashew nuts led to poor size, inferior texture, reduced recovery and lowered the market value of the produce;⁸ while, late harvesting exhibited over maturity which resulted in loss in tenderness and increased hardness. Therefore, standardization of optimum harvest stage for tender cashew kernels is essential for obtaining quality produce, increase

the market value and provide maximum returns to the cashew growers. So far, no studies have been conducted on the standardization of optimum harvest stage with respect to proximate composition including moisture, protein, fat and carbohydrates of tender kernel for culinary purposes. This study was conducted to enhance the income of cashew producers through minimizing pre-harvest losses.

Materials and Methods

The experiment was carried out during the cashew fruiting season in 2023 and 2024 at Cashew Farm of the Regional Fruit Research Station, Vengurla, Sindhudurg, Maharashtra. Vengurla-4, the most popular variety among the cashew growers, was chosen for the study. The experiment was conducted with five treatments, replicated four times in Randomized Block Design. The five different harvesting stages of cashew nuts were selected in accordance with BBCH scale.⁶ The hand pollination techniques standardized by ICAR-Directorate of Cashew Research, Puttur, Karnataka were followed.⁹

A digital vernier calliper was used to measure the mean length and diameter of set of five cashew apples. Further, mean length, breadth and width was determined with set of five cashew nuts and kernels extracted from same. A digital weighing scale was used to determine mean weight of cashew apple, nut and its cashew kernel. The shelling percentage for the set of 25 cashew nut and kernels were calculated by dividing total weight of the kernels (g) to total weight of the green nuts (g). The number of harvesting days were determined by days between date of pollination to the day of harvesting.

Analysis of Variance was carried out to determine the significance of treatment effects and to assess whether the differences observed among year and treatments were statistically significant at 5% level.

The per cent proximate analysis for tender cashew kernels including moisture, protein, fat and carbohydrate was conducted in accordance with Association of Official Analytical Chemists methods.¹⁰ Sensory qualities of tender cashew kernels for colour, taste, texture and overall acceptability at five different harvest stages were recorded through semi-trained panel of 6 to 8 judges using a 9-point Hedonic scale.¹¹

Table 1: ANOVA analysis

SoV	d.f.	Mean Sum of Square																					
		Cashew apple			Cashew nut			Cashew kernel			Shelling percent	Days to harvest	Proximate composition			Sensory							
		Length (mm)	Diameter (mm)	Weight (g)	Length (mm)	Breadth (mm)	Width (mm)	Weight (g)	Length (mm)	Breadth (mm)			Width (mm)	Moisture (%)	Protein (%)	Fat (%)	CHO (%)	Colour	Taste	Texture	Overall acceptance		
Year	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Trea	4	1461.14*	903.13*	1090.16*	265.91*	104.29*	19.78*	56.35*	569.01*	95.11*	123.94*	2.485*	4.09*	438.16*	2177.15*	303.56*	176.06*	180.70*	35.1*	41.98*	50.74*	42.04*	
Y x T	4	NS	NS	NS	NS	NS	NS	NS	NS	0.02*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Error	30	1.79	0.60	0.24	0.22	0.36	0.14	0.03	0.08	0.004	0.005	0.003	0.12	1.62	0.12	0.01	0.01	0.01	0.20	0.27	0.41	0.10	0.10

*: Significant, NS: Non-Significant

Table 2: Physiological observations of cashew apple, nut and kernel as influenced by the growth stage

BBCH Stage	Cashew apple					Cashew nut					Cashew kernel				
	Length (mm)	Diameter (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Breadth (mm)	Width (mm)	Weight (g)	Length (mm)	Breadth (mm)	Width (mm)	Weight (g)	Shelling (%)	Days to harvest
T1: 715	15.09	11.69	8.84	23.84	10.41	9.99	4.86	4.41	1.71	16.41	40.63				
T2: 717	26.54	20.57	16.80	30.27	14.18	19.29	8.59	9.83	2.53	17.82	45.63				
T3: 719	35.77	27.48	25.70	37.70	16.50	30.07	13.55	12.56	3.00	18.19	52.75				
T4: 811	40.84	31.66	32.09	36.51	16.48	28.26	13.50	12.34	2.99	17.99	55.88				
T5: 813	50.36	39.54	36.84	35.70	16.47	27.90	13.45	12.13	2.97	17.93	58.50				
S.Em.±	0.47	0.27	0.83	0.17	0.02	0.10	0.03	0.05	0.02	0.12	0.45				
C.D. @ 5%	1.36	0.79	3.26	0.48	0.06	0.29	0.08	0.21	0.06	0.36	1.30				
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.				
CV	3.96	2.96	2.12	1.45	0.41	1.24	0.69	0.67	2.34	1.98	2.52				

Results and Discussion

From the Table 1, year to year and year to treatment interaction was found to be non-significant except cashew kernel breadth, indicating the consistence

performance over the years. The treatment effect was found significant for all the characters. Mean values and values and critical difference is presented in Table 2, 3 and 4.

Table 3: Proximate analysis of cashew kernel as influenced by the growth stage

BBCH Stage	Moisture (%)	Protein (%)	Fat (%)	Carbohydrate (%)
T1: 715	92.40	1.15	0.37	0.58
T2: 717	80.77	4.81	3.70	4.22
T3: 719	70.51	8.39	7.05	7.37
T4: 811	60.58	12.96	9.75	9.53
T5: 813	50.35	16.54	12.15	12.91
S.Em.±	0.12	0.04	0.04	0.04
CD @ 5%	0.36	0.13	0.11	0.12
F test	Sig.	Sig.	Sig.	Sig.
CV	0.49	1.43	1.64	1.72

Table 4: Organoleptic sensory evaluation of tender cashew kernel as influenced by the growth stage

BBCH Stage	Colour	Taste	Texture	Overall acceptability
T1: 715	3.56	3.63	3.00	3.39
T2: 717	5.56	4.81	5.06	5.14
T3: 719	8.81	9.00	9.06	8.83
T4: 811	8.06	8.06	8.31	8.14
T5: 813	7.06	7.63	7.63	7.44
S.Em.±	0.16	0.18	0.23	0.12
C.D. @ 5%	0.46	0.53	0.65	0.36
F test	Sig.	Sig.	Sig.	Sig.
CV	6.87	7.86	9.64	5.37

Physiological Observations of Cashew Apple

Length and diameter of cashew apple varied significantly during the growth stages. The highest values for these parameters were recorded in T₅ (50.36 mm and 39.54 mm), followed by T₄ (40.84 mm and 31.66 mm), T₃ (35.77 mm and 27.48 mm) and T₂ (26.54 mm and 20.57 mm), respectively, whereas lowest (15.09 mm and 11.69 mm) was recorded in T₁. The mean apple weight significantly increased with the advancement of maturity. The highest (36.84 g) cashew apple weight was recorded in treatment T₅, followed by T₄ (32.09 g), T₃ (25.70 g) and T₂ (16.80 g) respectively, whereas lowest

(8.84 g) was recorded in T₁. During initial phase of cashew development, there is rapid growth of the nut with little development of embryo and apple takes place, while in the second phase both nut and apple grow rapidly.¹² During initial development of fruit, fruit size increases due to cell division and enlargement as well as tissue differentiation.¹³ The earlier study suggested that weight and length of cashew apple increased from 23.5 g to 86.2 g and 68.2 mm to 79.6 mm in red cultivar, while those increased from 17.3 g to 66 g and 62.3 mm to 75.7 mm in yellow cultivar, respectively.¹⁴ The findings of present investigation are in accordance with these findings. Guava shown

a sigmoid growth pattern and fruit development, while differential growth pattern was observed in cashew apple and nut.^{15,16}

Physiological Observations of Cashew Nut

Cashew nut length, breadth and width significantly varied during growth stages. The highest nut length, breadth and width (37.70, 23.76 and 22.19 mm) were recorded in T₃, whereas minimum (23.84, 14.90 and 18.21 mm) in treatment T₁. However, in case of cashew nut weight, the maximum (16.50 g) nut weight was recorded in treatment T₃, followed by T₄ (16.48 g), T₅ (16.47 g) and T₂ (14.18 g) respectively. After attaining final developmental stage, cashew nuts start to mature. Their shell colour changes from dark green to grayish green. The dimensions of cashew nut changes due to loss of moisture present in the nut. The nut size gets reduced as they matured physiologically.⁷ Cashew nut size gets reduced due to shrinkage during advanced stage of maturity.¹⁷ However, the nut length, width and thickness have been reported to increase up to 40 days after fertilisation and decline in the later stages.¹⁸

Physiological Observations of Kernel

Tender cashew kernel length, breadth and width significantly varied and were found to be the highest (30.07, 13.55 and 12.56 mm) in T₃, followed by T₄ (28.26, 13.50 and 12.34 mm), T₅ (27.90, 13.45 and 12.13 mm) and T₂ (19.29, 8.59 and 9.83 mm). Similarly, tender cashew kernel weight was significantly the highest (3.00 g) in T₃ followed by T₄ (2.99 g), T₅ (2.97 g) and T₂ (2.53 g); whereas it was the lowest (1.71 g) in T₁. The immature cashew kernels are known to have high moisture content than the mature nuts. Loss in moisture percent might have caused reduction in kernel dimensions. During advanced stage of maturity of cashew nut development, nut size decreased due to shrinkage.¹⁷ Similarly, the immature kernels have more dimensions than mature once.¹⁹ Cashew kernels after reaching physiological maturity show reduced moisture content, which lead to an increase in the recovery of kernels per kilogram.²⁰

Shelling per-cent was significantly influenced by stages of nut development. The highest shelling per cent was observed in T₃ (18.19%), which was found at par with T₄ (17.99%) and T₅ (17.93%). The shelling per cent increased throughout the

physiological development stage but dropped at the advanced stages of maturity, probably because the moisture was lost during this phase. The moisture content in the shell, testa and kernel decreases as the accumulation of dry matter in the kernel occurs simultaneously. The shelling per-cent in maize increased during physiological maturity stages, while declined during advanced stage of maturity.²¹ Similarly, the shelling percentage was determined in immature nuts of six cashew varieties and they found that shelling percentages ranged between 14.83% to 17.88%.¹⁹ As per the earlier research, the shelling percentage in immature cashew nuts varied with varieties e.g. Madakkathara-1 (32.7%), Vridhachalam-3 (22.0%), Priyanka (20.7%), Dhana (18.3%), Poornima (18.0%) and Damodhar (17.0%).¹⁹

The mean numbers of days required for reaching different stages were: 58.50 days (T₅), 55.88 days (T₄), 52.75 days (T₃), 45.63 days (T₂) and 40.63 days (T₁). Fruit developmental stage followed by fruit maturity stage. As per BBCH scale, stage code 715, 717 and 719 represented fruit development stage, while 811 and 813 represented fruit maturity stage.⁷ While, the researcher studied the various characters of six different immature cashew nut varieties harvested 55 days after anthesis.¹⁹ However, the cashew nuts required 8 to 10 weeks to attain physiological maturity.¹⁷

Proximate Analysis

The proximate composition of tender cashew nut in different growth stages has been presented in Table 3. It is noticeable that there was significant difference in moisture content among the growth stages. The highest (92.40%) moisture was recorded in treatment T₁, and it reduced with advancement of maturity i.e. T₂ (80.77 %), T₃ (70.51 %), T₄ (60.58 %) and T₅ (50.35). The seed contains high moisture content during initial stages for supporting embryo growth; and during maturation; the water content decreases due to accumulation of dry matter. Previous study on Physic nuts suggested high moisture content at initial stage (89-90%) and decreased to 86.90% at physiological maturity.²² The fully matured dried cashew nut contained 11.6% to 13.8% moisture.¹⁷

The protein content in tender kernel varied significantly during cashew nut development. The highest protein (16.54%) was recorded in

T₅, followed by T₄ (12.96 %), T₃ (8.39 %) and T₄ (4.81 %) respectively, whereas lowest protein was recorded in T₁ (1.15%). During development stages, protein accumulates in nut as storage compound for development of embryo and gets further utilized for germination and growth. The mature cashew nut contain high protein content than the immature nuts.¹⁹ Protein content in six different cashew varieties in an earlier study ranged between 7.29 % and 12.45%; while, the protein content in other study was 21.32 % and 21.00%.^{23,24} Similarly, another study reported 18.81 ± 0.06 g/100g of protein in mature cashew nut.²⁵

Total fat content in tender cashew kernel significantly varied during different growth stages. The highest fat (12.15%) was recorded in treatment T₅, followed by T₄ (9.75 %), T₃ (7.05 %) and T₂ (3.70 %), whereas it was the lowest (0.37%) in T₁. Total fat content in cashew kernel gets increased as they mature. The proximate composition of six varieties of immature cashew nut harvested after 55 days of anthesis suggested the fat percentage of varied between 5.08% to 9.08%.¹⁹ The fat content in cashew nut is one of the macro nutrients present in abundance accounting for $48.3 \pm 1.6\%$.²⁶

The total carbohydrates content in tender cashew kernel significantly varied during growth stages. The highest carbohydrates content (12.91%) was recorded in T₅, followed by T₄ (9.53 %), T₃ (7.37 %) and T₂ (4.22 %), whereas, it was the lowest (0.58%) in T₁. Carbohydrate content may increase due to conversion of complex starches into simple sugars. The trend of changes in carbohydrates contents during different growth stages of cashew nut has not been recorded earlier. As per research findings, mature cashew nut kernel contains 25% carbohydrates.²⁴ Similarly, carbohydrates content in immature cashew nut kernel harvested 55 days after anthesis ranged between 4.88% and 9.63%.¹⁹

Organoleptic Sensory Evaluation

Sensory score for different growth stages of tender cashew nut kernels showed a noticeable difference in colour, taste, texture and overall acceptance, as illustrated in Table 4. There was an increasing trend in colour, taste, texture and overall acceptance score during initial stages, however the trend showed reduction during advanced stages of maturity.

The score for treatment T₃ was recorded to be significantly highest for all the sensory attributes considered under the study. Tender cashew kernels have more sugars in them, which might make them more flavourful and sweeter. But, as the cashew nuts become mature, they tend to have more starches which might make them less sweet. The 7 months old tender coconuts were more preferable by consumers than 8 months because of quantity of less water and little harder endosperm to eat.²⁷

Conclusion

Despite producing a significant amount of raw cashew nuts, farmers fail to get anticipated returns from the market. Tender cashew kernels extraction from mature green cashew nuts is an on-farm operation that has significant market value in rural and urban areas. From the present study harvesting tender cashew nuts at maturity of BBCH 719 stage could help in retaining the quality of tender cashew kernels. The standardization of the harvest stage for tender cashew kernels could not only increase farmer's income but also reduce pre-harvest losses. It is envisaged to develop storage and packaging methods to retain tenderness of harvested kernel throughout the year.

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This study did not involve human participants and therefore, informed consent was not required.

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Not applicable

Author Contributions

- **Siddhesh Pradip Salvi:** Collection of Data, Methodology, Writing – Original Draft.

- **Laxmi Narayan Mahawer:** Review & Editing.
- **Heera Lal Bairwa:** Offered Valuable Insights and Suggestions to Improve it.
- **Ram Hari Meena:** Resources, Supervision.
- **Pokhar Rawal:** Supervision, Project Administration.

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