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PHYSICO-CHEMICAL CHARACTERIZATION OF FRUIT TRAITS IN WOOD APPLE (*LIMONIA ACIDISSIMA* L.) GENOTYPES IN BUNDELKHAND REGION OF INDIA

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ABSTRACT

Considering the importance of wood apple fruit, physico-chemical properties of eight selected local genotypes have been studied. Within various fruit physical characters such as its shape, size, fruit weight, fruit length, fruit width, pulp weight, shell weight and shell thickness, shell percent, pulp percent and fruit volume, the WAMO- 5 and WABG-3 had found to have maximum values. Fruit length and width ranged from 65.46 mm to 92.79 mm and 59.41mm to 88.87 mm, respectively. Fruit weight has been ranged from 142.50 g to 287.79 g, while pulp weight ranged from88.52g to 201.98g. shell weight exhibited from 53.97g to 85.81g. With respect to quality of the fruits, maximum TSS was recorded in Genotype WABG-3(20.33 °Brix) and minimum in Genotype WABN-7 (14°Brix). Highest total sugars were noticed in Genotype WALD-2 (12.56 %) and reducing sugars was maximum in Genotype WABN-7(7.53 %). Fruits of different genotypes exhibited acidity ranging from 1.85 % to 3.60 % while ascorbic acid 14.43 mg/100g to 17.20 mg/100g. From the above results it can be concluded that Genotype WAMO-5 and WABG-3 exhibited superior fruit weight, length and width, pulp.

The findings support selection of elite genotypes for breeding and processing in semi arid Bundelkhand agro ecosystems.

***Key words*:** *Limonia acidissima*, wood apple, physico chemical traits, genotypes, Bundelkhand, fruit quality.

Introduction

Among underutilized indigenous fruit species, wood apple is one, known by several names like elephant apple, curd apple, monkey fruit, kavat, kathbel, Kotha, kottamda, Vilanga, Kapith and Vela marum (Mazumder *et al.*, 2006). Due to its high religious, cultural, nutritional and medicinal values, this is one of the fruits awarded with "Shree" title. In Sanskrit language, its name is "Shree Phalam" or "Amrit Phal". The wood apple (*Limonia acidissima* L.), belongs to the family Rutaceae having chromosome number 2n = 18. It is native and common in dry plains of India and Ceylon (Morton, 1987). Globally, it is growing in Thailand, Malasiya, Cambodia and other parts of Southeast Asia. More common in states including Maharashtra, Madhya Pradesh, Uttar Pradesh, Gujrat, West Bengal, Chhattisgarh, Bihar, Jharkhand, Andra Pradesh, Tamil Nadu, Karnataka and Western Himalayas. It is distributed up to an elevation of about 500 m (Sukhadev, 2017; Kumar and Deen, 2017; Yadav *et al.*, 2018). It is a potential fruit crop for drought, semi-arid tropics, dry forest and suitable for problem soils particularly saline soil (Rajangam *et al.*, 2021). A deciduous, slow-growing, erect tree with a few upward-reaching branches bending outwards near the summit where they are subdivided into slender branchlets drooping at the tips. Its fruit is spherical in shape with 5-12.5 cm diameter. The rind is 6 -mm thick and grayish-white in colour. It has woody and extremely hard outer shell (called as rind) which is very difficult to crack open. Hammer is used to crack the hard rind of *L. acidissima* fruit. The

Table 1: Site of collection of wood apple fruits.

Genotype	Village	Block	District	Latitude	Longitude
WAKK-1	Karkos	Chirgaon	Jhansi	25.3547°N	78.7205°E
WALD-2	Ludhiyai	Chirgaon	Jhansi	25.6276°N	78.8962°E
WABG-3	Birguwa	Badagaon	Jhansi	25.4484°N	78.5696°E
WABJ-4	Bhojla	Badagaon	Jhansi	25.4441°N	78.5676°E
WAMO-5	Moth	Moth	Jhansi	25.7500°N	78.8800°E
WACN-6	Chirgaon	Chirgaon	Jhansi	25.5251°N	78.8140°E
WABN-7	Baragaon	Baragaon	Jhansi	25.4755°N	78.7122°E
WABI-8	Bijroli	Moth	Jhansi	25.6816°N	78.9241°E

pulp is brown, mealy, aromatic, resinous, sour, or sweetish with many small white seeds embedded in it. The fruit may be eaten raw but it has a sour taste and requires sweetening. The fruits are consuming as good source of juice during its harvesting season due to their low cost and thirst-quenching ability. A homemade drink popularly known as "*Sarbat*" is prepared from the wood apple fruits. Wood apple is highly cross-pollinated crop and mostly seed propagated, therefore exhibits wide variability. It has innumerable types with different fruit characteristics. The types differ among themselves in the fruit characters like shape, size, fruit weight, shell weight, seed weight, fibre weight, quality and maturity period and quality traits like sweetness, acidity, pectin content, mineral composition, flavour and taste are observed in wood apple growing areas. It is a climacteric fruit, ripening may also take place after fruit harvest but do not consume as fresh fruit due to high acidic and astringent taste. Fruits are very well known for their medicinal properties due to its nutritive value. After ripening fruits become soft in flesh and decreases the acidity and astringency in taste and increases the flavour. The fruit comprises (40.47 to 66.46%) pulp, seed (3.31 to 12.48%), fibre (3.85 to 5.08%), moisture (65.32 to 74.04%), TSS (12.08 to 18.44ºBrix), acidity (2.44 to 6.12%), brix: acid (2.46 to 6.48), pH (2.80 to 3.54), total sugars (2.23 to 6.83%), pectin (1.02 to 2.13%), vit-C (2.88 to 6.24 mg/100 g), vit-B12 (0.05 to 0.27 mg/100 g), calcium (80.1 to 111.35 mg/100 g), phosphorus (37.10 to 69.17 mg/100 g) and iron (0.05 to 16.29 mg/100 g) (Gorabal, 2020). In India, there are no such improved or recognized wood apple varieties. Due to the lack of recognized superior varieties, the production of this underutilized fruit crop is extremely low despite its high popularity and demand. The anticipated increase in this crop's production has not yet been achieved due to a lack of suitable cultivars. Therefore, finding the right genotypes becomes essential to increasing its output, quality, and productivity. In order to evaluate the diversity of certain wood apple genotypes, the current study was carried out.

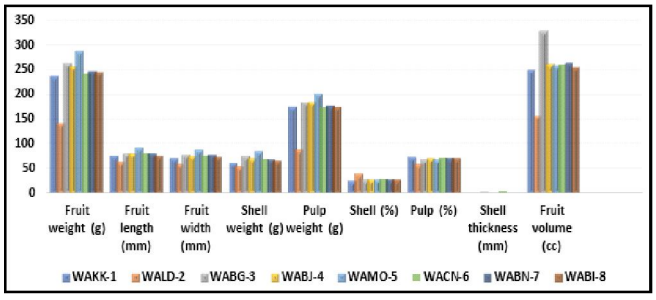

Fig. 1: Fruit physical characters of eight wood apple genotypes.

Materials and Methods

The research was carried out during the academic years 2023-2024 and 2024-2025 at the Central Post-Harvest Technology Laboratory and the Postgraduate Laboratory of the Department of Fruit Science, College of Horticulture and Forestry, Rani Lakshmi Bai Central Agricultural University, Gwalior Road, Jhansi, Uttar Pradesh, India. The purpose this experiment to evaluate the genotypic diversity in the physical and biochemical properties of wood apple fruits collected from different part of the Jhansi district, which represent distinct ecological zones and genetic backgrounds. Ripe wood apple fruits were collected from naturally grown trees across eight different villages in Jhansi district, Uttar Pradesh (Table 1). In order, to ensure that genotypic diversity was represented, the sites selected based on variability. Fruits were harvested manually using sanitized tools to avoid contamination. Immediately after harvesting, the fruits were cleaned with distilled water, air-dried, labeled according to their respective locations, and sorted for uniformity in size, maturity, and external appearance. From each genotype, five representative fruits were randomly chosen for analysis. Each fruit was considered an independent replication, making a total of five replications per genotype. The physical and biochemical parameters were evaluated for each fruit separately. The physical parameters for study were fruit weight, fruit length, fruit width, shell weight, pulp weight, shell percentage, pulp percentage, shell thickness, fruit volume biochemical parameters viz., TSS, titratable acidity,

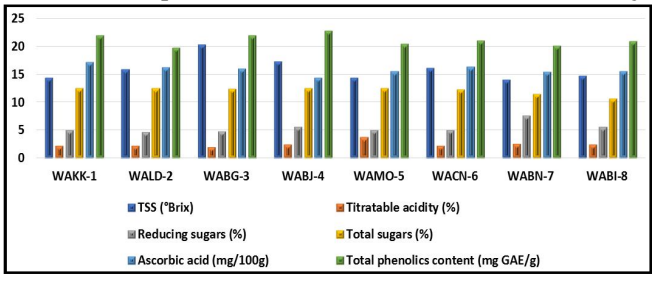

Fig. 2: Fruit biochemical characters of eight wood apple genotypes.

Table 2: Fruit physical characters of eight wood apple genotypes.

Genotype	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Shell weight (g)	Pulp weight (g)	Shell (%)	Pulp (%)	Shell thickness (mm)	Fruit volume (cc)
WAKK-1	237.37	77.48	71.78	62.65	174.46	26.16	73.84	3.18	250.40
WALD-2	142.50	65.46	59.41	53.97	88.52	40.51	59.47	2.64	156.85
WABG-3	262.63	81.83	78.93	77.45	184.93	29.34	70.50	4.43	329.34
WABJ-4	257.40	81.86	76.12	71.96	185.36	27.61	72.38	2.64	261.80
WAMO-5	287.79	92.79	88.87	85.81	201.98	29.82	70.56	2.92	259.43
WACN-6	242.34	80.74	75.77	69.47	173.02	28.49	71.50	3.01	260.20
WABN-7	246.92	81.39	78.51	69.78	176.99	27.95	72.04	2.72	264.40
WABI-8	243.42	77.28	74.55	67.87	175.52	27.59	72.43	2.92	254.50
C.D. @ 5%	56.94	12.33	11.19	19.42	41.35	6.86	6.85	0.67	39.04
SE(m)	19.55	4.23	3.845	6.70	14.20	2.35	2.35	0.23	13.41

reducing sugars, total sugars, ascorbic acid (vitamin C), total phenolic content were recorded from each genotype. The weight of each individual fruit was measured immediately after harvesting using an electronic weighing balance. The length of each fruit was measured along the longitudinal axis using a digital Vernier caliper. The measurements were taken in millimeters (mm), and the average length of five fruits was recorded. After removing the shell from each fruit, the shell was weighed separately using an electronic balance. Pulp weight was determined by subtracting the shell weight from the total fruit weight. Total Soluble Solids (TSS) of wood apple pulp were measured using an Erma hand refractometer. Titratable acidity was determined following the standard procedure described by Ranganna (2000). A known weight of crushed fruit sample was taken and diluted to 100 ml with distilled water in a volumetric flask. After filtration, 10 ml of the extract was titrated against 0.1 N sodium hydroxide using phenolphthalein as an indicator. The appearance of a light pink endpoint indicated completion of the titration. Ascorbic acid (Vitamin C) content in wood apple fruit was estimated following the standard procedure given by Ranganna (2000). Total sugar content was determined by acid hydrolysis of the non-reducing sugars into reducing sugars using the Lane and Eynon (1923) method, as described in Ranganna (1997). The total phenolic content (TPC) of the samples was determined by the Folin–Ciocalteu colorimetric method as described by Bray and Thorpe (1954), using catechol as the standard.

Results and Discussion

Fruit physical characters

The perusal of the data presented in Table 2 represented the wide variation of fruit physical attributes of wood apple genotypes studied under the experiment. Fruit weight varied significantly among wood apple genotypes, with the maximum fruit weight recorded in the WAMO-5 and the minimum in the WALD-2. Genotype WAMO-5 had the maximum fruit weight (287.79 g), which was higher than the other genotypes, while genotype WALD-2 had the lowest (142.50 g) fruit weight. These findings are in compliance with what Raut *et al.*, (2022) observed at PDKV, Akola, where they obtained fruit weight from 190.5 g to 389.9 g. Highest fruit length was observed in genotype WAMO-5 (92.79 mm) followed by genotype WABG-3 (81.83 mm) whereas least was recorded in genotype WALD-2 (65.46 mm). Shukla *et*

Table 3: Fruit biochemical characters of eight wood apple genotypes.

Genotype	TSS (°Brix)	Titratable acidity (%)	Reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100g)	Total phenolics content (mg GAE/g)
WAKK-1	14.33	2.18	4.98	12.49	17.20	21.99
WALD-2	15.90	2.18	4.64	12.56	16.21	19.76
WABG-3	20.33	1.85	4.72	12.39	15.97	21.95
WABJ-4	17.26	2.40	5.47	12.56	14.43	22.76
WAMO-5	14.43	3.60	4.92	12.50	15.59	20.4
WACN-6	16.13	2.09	4.98	12.30	16.36	21.05
WABN-7	14.05	2.52	7.53	11.51	15.41	20.15
WABI-8	14.79	2.32	5.53	10.66	15.52	20.95
C.D.@5%	0.71	0.38	0.68	0.92	1.40	1.89
SE(m)	0.246	0.13	0.23	0.31	0.48	0.65

al., (2025) stated variation in fruit length ranging from 52.70 mm to 94.56 mm in their evaluation of 29 genotypes from Uttar Pradesh. Fruit width was found highest in genotype WAMO-5 (88.87 mm) and smallest was seen in genotype WALD-2 (59.41 mm), which was statistically significantly smaller than the other genotypes. Shell weight ranged from WALD-2(53.97 g) to WAMO-5 (85.81 g). Shell weight was recorded lowest in genotype WALD-2(53.97 g), followed by genotypeWAKK-1 (62.65 g), and highest in genotype WAM0-5 (85.81 g), followed by genotype WABG-3 (77.45 g). Highest pulp weight was recorded in genotype WAMO-5 (201.98 g) followed by genotype WABJ-4 (185.36 g) and lowest was found in genotype WALD-2 (88.52 g) followed by genotype WACN-6 (173.02 g). The shell percentage varied from WALD (40.51%) to WAKK-1 (26.16 %). Greatest shell percentage was seen in WALD-2 (40.51 %) followed by WAMO-5 (29.8 2%) and least was found in genotype WAKK-1 (26.16%). Tayde *et al.*, (2024) showed a negative correlation between pulp yield and shell percentage, showing that genotypes with thinner shells are better suited for processing. Pulp percentage was seen largest in WAKK-1 (73.84 %) followed by WABI-8 (72.43 %) and smallest was observed in genotype WALD-2 (59.47 %). Maximum shell thickness was observed in genotype WABG-3 (4.43 mm) followed by genotype WAKK-1 (3.18 mm) while minimum was found in genotype WALD-2 (2.64 mm). The largest fruit volume was found in WABG-3 (329.34 cc) which was significantly greater than the other seven genotypes. study on 25 genotypes from Bundelkhand region recorded fruit volume ranging from 59 cm^3 to 312 cm^3 by Kumar, P. (2020). Similarly average fruit volume was found as 182.22 to 240 cm^3 in individual fruit according to Khan *et al*., (2019).

Fruit bio-chemical character

Data related to biochemical characteristics of wood apple exhibited a significant variation with respect to TSS, titratable acidity, reducing and total sugars, ascorbic acid, total phenolics content (Table 3). The greatest total soluble solid value found in genotype WABG-3 (20.33°Brix) followed by WABJ-4 (17.26°Brix) and smallest was recorded in genotype WABN-7 (14.05°Brix) followed by WAKK-1 (14.33°Brix). Gorabal, K. (2020) surveyed and recorded that total soluble solid content ranging from 12.37°Brix to 14.14°Brix, with higher was observed in genotype AWS-23, AWS-78, AWS-106, which was recommended for jam and jelly processing. Genotype WAMO-5 (3.60 %) had the highest titratable acidity, which was significantly higher than the other genotype under research. This investigation is consistent with Anuradha, K. (2005), who found that an average acidity of 2.3% in ripened wood apple pulp. Reducing sugar percent was seen highest in WABN-7 (7.53 %) followed by WABI-8 (5.53 %) whereas, genotype WALD-2 had least value (4.64 %). Dowarah *et al*., (2021), studied twelve locally collected wood apple genotypes from West Bengal. Their results were in close conformity to the research under present investigation. Maximum total sugars in WABJ-4 and WALD-2 (12.56 %) and minimum were noted in WABI-8 (10.66 %), which was significantly lower. Genotype WAKK-1 (17.20 mg/100g) was recorded superior ascorbic acid closely followed by WACN-6 (16.36 mg/100g) and WABJ-4 (14.43 mg/100g) observed smallest value followed by genotype WABN-7 (15.41 mg/100g). Maximum phenols content in WABJ-4 (22.76 mg GAE/g) which was found higher than others, while minimum phenols content was observed in WA LD-2 (19.76 mg GAE/g) exhibiting statistically at par with WABN-7 (20.15 mg GAE/g). Total phenolic content was recorded 22 to 25 mg /100g by Kumar and Deen (2017) in fully ripe wood apple fruits and after that gradual decline seen during fruit maturation.

Conclusion

From the results of the experiment, it can be concluded that there was a wide variation in physico-chemical attributes of wood genotypes which were explored. The results indicate that WAMO-5, WABG-3, and WABN-7 showed great potential in terms of improved fruit size, edible matter and highly encouraging in relation to fruit quality parameters like TSS, acidity, ascorbic content, total sugar, and reducing sugar, total phenols content. An efficient breeding program for the genetic improvement or upgradation of this valuable crop would benefit from knowledge of the nature and extent of genetic variability as well as association between important traits.

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