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Effects of various indigenous ripening methods on phonological and physical characteristics of banana

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Abstract
The present experiment was conducted with an aim to study the effect of indigenous ripening methods on phonological and physical characteristics of banana at Biswanath College of Agriculture, Biswanath Charilai, Assam Agricultural University, Jorhat, Assam during 2018-19. The ripening methods was *viz.* ripening in covered pit with smoke; ripening with ripe tomato fruit; ripening with paddy straw; ripening in covered pit without smoke; ripening with calcium carbide and ripening naturally at room temperature. The result revealed that among the methods used for ripening, fruit ripened with calcium carbide took minimum days for ripening period, color initiation, minimum shelf life. Similarly, maximum shelf life was obtained in control (10.67 days) with longest ripening period of 12 days. The preferential score in terms of flavor and taste was highest in banana fruit ripened with tomato while maximum score for color was obtained in calcium carbide ripened fruit.

Keywords: Banana, Chenichampa, ripening, calcium carbide, shelf life

1. Introduction

The high calorie and nutritional value of bananas makes them special. They also play a key part in the diet of humans by giving vitamins, minerals, and dietary fiber (Khader *et al.*, 1990) [13]. It belongs to the Musaceae family and is a significant commercial fruit crop farmed throughout the world in tropical and subtropical climates. In terms of global fruit trade, it came in second to citrus. Bananas come in a variety of flavors and appearances, and they are all consumed once mature (Dadzie and Orchard, 1997) [6]. Amritsagar (AAA), one of the most widely grown cultivars in Assam's North Bank Plain Zone, is one of the state's most important fruit varieties. Assam's climate is ideal for growing bananas, and the state produces a lot of them. Once more, this cultivar is crucial from a social and economic standpoint, and they are widely accessible on the market. Recent years have seen a rise in concern over artificial ripening. Different artificial fruit ripening techniques have been noted, usually to satisfy consumer preferences along with additional economic factors. Consuming fruits that have been chemically ripened (with calcium carbide) is dangerous and puts customers' health at risk (Rahim, 2012) [22]. In order to satisfy the high demand and maximize profits from seasonal fruits, fruit vendors, particularly those in Assam, typically artificially ripen green fruits. Fruit may require several days to be transported and distributed from farmers' orchards to consumers' baskets. Such naturally ripened fruits during this period are susceptible to harm from the rough conditions of transportation. Fruit vendors occasionally choose to collect unripe fruit and artificially ripen them before selling them to consumers in order to reduce loss (Mursalat *et al.*, 2013) [19]. This causes them to experience a significant economic loss.

Banana fruit is highly perishable once it has been picked, and its short shelf life causes large post-harvest losses of roughly 20–50% as a result of improper treatment. Bananas are collected at a green in color, fully developed stage and chemically ripened when necessary using ripening chemicals in order to lower the substantial post-harvest losses. These include African bush mango fruit (*Irvingia gabonesis*), *Jathropha curcas* leaves, palm nuts, cassia leaves, yellow papaya leaves (Ajayi and Mbah, 2007; Adewole and Duruji, 2010) [3, 1], the torch light batteries, calcium carbide, and potash ash (Singal *et al.*, 2012) [27]; gases such as ethephon, ethylene glycol, ethrel, and calcium carbide. Although other chemicals used as ripening agents such ethephon, ethrel, and ethylene glycol, among others, are also regarded dangerous to the health of people and they have to be used within suggested safe levels, the detrimental effect of calcium carbide being used as a ripening reagent has been demonstrated (Singal *et al.*,

2012) [27]. According to Hakim *et al.* (2012) [10], the application of artificial agents may produce fruits with a more palatable hue than naturally ripened fruits, but it also raises the possibility of food contamination. Due to concentrations of arsenic and phosphorous hydride, calcium carbide poses a number of health risks and is carcinogenic (Rahman *et al.*, 2008) [23]. The current study compares the effects of calcium carbide and natural ripening agents on the maturation and shelf life of the fruit of bananas.

2. Materials and Methods

The present investigation entitled "Effects of various indigenous ripening methods on phonological and physical characteristics of Banana" was carried out in the laboratories of the Department of Horticulture, Biswanath College of Agriculture, Biswanath Chariali, Assam Agricultural University. Two banana cultivars 'Amritsagar' (AAA) and 'Chenichampa' (AAB) were collected from commercial growers of Jamuguri of Sonitpur districts of Assam. Fruits were harvested at mature green stage and immediately after arrival; the bunches were dehanded, washed with chlorinated water and air dried. Uniform size fruits were selected for the various postharvest treatments under the study.

3. Experimental Design and Treatments

Treatments were arranged in completely randomized block design with three replications. The ripening methods were T_1: Ripening in covered pit with smoke; T_2: Ripening with ripe tomato fruit; T_3: Ripening with paddy straw; T_4: Ripening in covered pit without smoke; T_5: Ripening with chemicals (calcium carbide); T_6: Ripening naturally at room temperature. The two cultivars was V_1: Amritsagar and V_2: Chenichampa.

4. Parameters of study

Phonological parameters such as ripening period, shelf life, color of banana peel, pulp peel ratio, specific gravity and physiological loss in weight of fruit was determined. Ripening period and shelf life were determined considering the changes in the physico-chemical qualities.

4.1 Physical parameters

4.1.1 Ripening period: According to changes in the color, hardness, and TSS value of the banana, the ripening period was calculated (Dadzie and Orchard, 1997) [6]. The total number of days it took for the fruit in every treatment to reach the fully mature phase (Color stage 6) was taken into account as the ripening duration.

4.1.2 Shelf life: According to Dadzie and Orchard (1997) [6], shelf life is the time between the start of fruit ripening and the end of the fruit's saleable or edible life. This was determined by visually inspecting fruits on alternate days.

4.1.3 Banana peel color: A common color wheel was used to identify the peel's color. The stages of banana peel color were denoted on a scale of 1 to 8 (Collin and Dalnic, 1991) [5]. The scale listed each color stage, from 1 for hard green through 2 for green with a hint of yellow, 3 for more green than yellow, 4 for more yellow than green, 5 for green tips, 6 for fully yellow, 7 for yellow flecked with brown, and 8 for browning and overripe.

4.1.4 Banana pulp to peel ratio: The amount of pulp to peel ratio was calculated by dividing the weight of the pulp by the weight of the peel. According to Dadzie and Orchard (1997) [6], pulp and peel were separated, weighed, and represented as a pulp to peel ratio.

4.1.5 Fruit specific gravity: Banana fruit's specific gravity was calculated by dividing its weight in grams per cubic centimeter by the quantity of water it displaced.
Specific gravity is calculated as follows:
Weight of the fruit (g) / volume of water it displaces (cc).

4.1.6 Physiological loss in weight: Mohammed *et al.* (1999) [18] methods were used to calculate physiologically loss in weight (PLW). Losing weight was calculated as a percentage therefore, WL (%) = (Wi-Wf) /Wi x 100 by dividing the end weight by the fruit's initial weight. where Wi is the starting weight and Final weight is Wf.

5. Results and Discussion

5.1 Phonological character

5.1.1 Ripening period (days)

Table 1 shows the difference in the number of days it takes a banana to reach the completely mature stage (color score 6). The fruits of bananas treated with calcium carbide (T_5) reached the completely ripe stage in 2.5 days, but fruits treated with smoke (T_1) reached the stage in 5 days of storage, indicating that they attained the acceptable level of ripening during that time. T_4 (without smoke) treatment-ripened banana fruits reached full yellow hue in 8.5 days, which was comparable to T_3 (9.50 days). Control took the longest (13 days) to reach completely ripe state. The length of time it takes for a banana to ripen has also been significantly impacted by variety. Comparing the two varieties, Amritsagar's ripening time was less (6.67 days) than Chenichampa's (8.16 days). Additionally, it was determined that the interactions between ripening and variety were not significant. Fruits treated with calcium carbide may ripen more quickly because acetylene starts the ethylene reaction, which speeds up the ripening process. The outcomes were consistent with those from Smith and Thompson (1987) [35] in papaya, Ajayi and Mbah (2007) [3]. Both Chandramonti *et al.* (1991) [4] and Joon *et al.* (2001) [11] reported similar findings with mango fruits.

5.1.2 Shelf life (days)

The shelf life of banana fruit was found to have significant difference among the various ripening methods (Table 1). Maximum shelf life (12.50 days) was obtained in control fruits (T_6), which was followed by treatment T_2 and T_4. Among the treatments, fruit ripened with calcium carbide (T_5) had the shortest shelf life of 5.33 days. Shelf life of banana fruits differed significantly between the varieties. Chenichampa fruits exhibited longer shelf life (11.61 days) than the Amritsagar fruits (8.48 days). However, interaction between treatments and variety was found to be non-significant. The longest shelf life (14.33 days) was observed in control fruit (T_6V_2) while lowest was found in T_5V_1 (4.33 days). The very brief ripening period in fruits treated with calcium carbide may have shortened the banana's shelf life. The use of the calcium carbide also accelerates respiration, releases more heat that causes rapid ripening, and ultimately causes the lifespan of the banana fruits to be shortened.

In banana fruits treated with ripe tomato and smoke, the maturing stage lasted 5–6 days. The emitted amount of ethylene by ripe tomato fruits may be the cause of the shorter maturation duration in ripe treated fruits, but the production of both heat and ethylene during the maturation of fruit in enclosed pits with smoke shortened the ripening period. On the other hand, fruits that ripened naturally (control) showed a prolonged ripening period and longest shelf life. This might be because the fruits were left out in the open without any climatic influences, which slowed down the ripening process. The basic pattern of these findings matches that of Adeyemi *et al.* (2018) [2] and Thomson and Seymour (1982). Amritsagar fruits had a shorter shelf life than Chenichampa fruits among the cultivars and ripened more quickly. The outcomes could be attributed to an increase in respiration, which in Amritsagar (V_1) produces a significant quantity of heat and ethylene. Bananas have a respiration peak during ripening, advancing their ripening duration because they are also climacteric fruits. In the case of bananas, Gane (1936) and Masimbe (1997) [8] reported similar outcomes. This conclusion concurred with those offered by Adewole and Duruji (2010) [1]. Because Chenichampa fruit (V_2) ripened more slowly than Amritsagar fruits, the longer shelf life of the Chenichampa cultivar in the current study may have been a result of this slower ripening rate. The result is supported by the findings of Godambe (2012) [9].

5.2 Physical characters of banana fruits

5.2.1. Color initiation of banana peel (days)

Variation in banana peel color development is presented in Table 2. Among the treatments fast color development was noticed in treatment T_5 (ripened with calcium carbide). In calcium carbide and smoke treated banana, color initiation occurred within 2 and 3.5 days respectively. Chemically ripened banana fruit showed a bright yellow color which was followed by treatment T_2 (ripened with tomato) as compared to rest of the treatments. On the other hand, slow ripening was observed in untreated control fruits (T_6) which took 11 days for color initiation. Among different varieties, Amritsagar took minimum days (5.00 days) for color initiation than chenichampa variety. However, interaction between treatments and variety was found to be non-significant According to Tourky *et al.* (2014) [33] for bananas and Salvador *et al.* (2007) [26] for persimmons, this may be caused by the peel losing its green hue as a result of the continual deterioration of its chlorophyll structure during ripening. Amritsagar among the cultivars had a quicker onset of color than Chenichampa, although Chenichampa had a greater pulp-peel ratio (2.16). The quicker chlorophyll degradation and genetic factors in Amritsagar may be the cause of the faster color start.

5.2.2 Pulp-peel ratio

The pulp-peel ratio of bananas differed significantly among the ripening methods (Table 2). The result indicated higher pulp peel ratio (2.20) in treatment T_2 (ripened with tomato) followed by treatment T_1 (smoke) which was 2.02. The lowest ratio (1.83) was being found in treatment T_4 (without smoke). Similarly, significant difference was found between the varieties in terms of pulp-peel ratio. Higher pulp-peel ratio (2.16) was found in Chenichampa (V_2) than Amritsagar (1.76). Due to interaction effect, the highest pulp-peel ratio (2.23) was observed in banana treated with paddy straw in treatment combination (T_3V_2) and lowest value (1.53) was found in treatment combination T_4V_1. The value for pulp-peel ratio was in the range of 1.53 to 2.23. The fruits that ripened with ripened tomato had the highest ratio of banana pulp to skin. The moisture that accumulated in the pulp as a result of the breakdown of carbohydrates and osmotic transfer from peel to pulp was what caused the rise. The pulp-peel ratio rose with the rise in TSS and the amount of moisture because raising the quantity of sugar in the pulp may have made it possible for water to pass through the peel to pulp. The outcomes agreed with those of Narasimham *et al.* (1971) [20]. As the fruit ripened, the Chenichampa banana's peel lost water to the atmosphere through transpiration as well as to the pulp through osmosis. As a result, the pulp's fresh weight increased. The weight of the pulp increased as the sugar content in the pulp increased (Stover and Simmonds, 1987; Dadzie and Orchard, 1997 in banana) [31, 6].

5.2.3 Specific gravity

There were no significant differences among the treatments and between the varieties of banana in terms of specific gravity (Table 3). However, among the treatments, specific gravity of the fruit was found maximum in treatment T_4 (1.21g/cc). Interaction between treatments and variety was found to be non-significant. The rise in specific gravity throughout ripening showed that the volume of the fruit decreased more than its weight did. Accelerated respiration and metabolic reactions may have played a role in the rise in specific gravity. According to the tight relationship between the pulp, peel-ratio, and specific gravity, a biochemical compound's migrating from the peel to the pulp may be the cause of the rise in specific gravity. Similar findings had been made, according to Joshi *et al.* (1986) [12] along with Pawar *et al.* (2011) [21], in karonda and sapota, respectively.

5.2.4 Physiological loss in weight

Data on the effect of various ripening methods on physiological loss in weight is presented in Table 4. The result revealed that there was a progressive increase in physiological loss in weight of banana with an increase in ripening period. The fruits of Amritsagar (V_1) showed higher physiological loss in weight as compared to Chenichampa (V_2) during ripening period. A relatively higher weight loss (14.30 %) was observed in the calcium carbide (T_5) treated fruits on 6^{th} day in variety V_1 (Amritsagar) and 11.02 per cent in variety V_2 (Chenichampa) on 8^{th} day. However, naturally ripened and other indigenously ripened fruits lost more than 12 per cent of their weight on day 14^{th} day after treatment.

In spite of various ripening techniques, the physiological weight loss of bananas grew over time. The rise in physiological weight loss in calcium carbide-treated fruits during ripening may be caused by an increase in respiration rate, which causes ripening to occur more quickly and uniformly than with other treatments. Both Mahajan *et al.* (2008) [16] and Singh *et al.* (1977) [28] reported results that were similar. The progression of storage time and ripening increased the percentage of weight loss in all treatments, which may have been caused by the fruits' transpiration and respiration processes. According to Dharmasena and Kumari's (2005) [7] reconstruction, weight loss resulted from the release of thermal energy from the fruits' respiration process via water evaporation. Similar results in banana fruits were previously reported by Kumar (2006) [14], Venktasubbaiah *et al.* (2013) [34], and Mahajan *et al.* (2010) [15].

Table 1: Effect of different indigenous ripening methods on ripening period (days) and shelf life (days) of banana fruit

Treatment	Ripening period (Days)			Shelf life (days)		
	V_1 (Amritsagar)	V_2 (Chenichampa)	Mean	V_1 (Amritsagar)	V_2 (Chenichampa)	Mean
T_1: Smoke	4.00	6.00	5.00	7.00	11.00	9.00
T_2: Ripe tomato	5. 00	7.00	6.00	9.33	14.00	11.66
T_3: Paddy straw	9.00	10.00	9.50	9.33	11.33	10.33
T_4: Without smoke	8.00	9.00	8.50	10.25	12.66	11.45
T_5: Calcium carbide	2.00	3.00	2.50	4.33	6.33	5.33
T_6: Control	12.00	14.00	13.00	10.67	14.33	12.50
Mean	6.67	8.16	---	8.48	11.61	---
LSD (P=0.05)	T=1.29	V=0.74	T×V=NS	T=1.34	V=0.77	T × V =NS

Table 2: Effect of different indigenous ripening methods on peel color (days) and pulp-peel ratio of banana fruit

Treatment	Colour initiation (days)			Pulp-peel ratio		
	V_1 (Amritsagar)	V_2 (Chenichampa)	Mean	V_1 (Amritsagar)	V_2 (Chenichampa)	Mean
T_1: Smoke	3.00	4.00	3.50	1.82	2.21	2.02
T_2: Ripe tomato	3.00	5.00	4.00	2.21	2.19	2.20
T_3: Paddy straw	7.00	8.00	7.50	1.54	2.23	1.88
T_4: Without smoke	5.00	7.00	6.00	1.53	2.13	1.83
T_5: Calcium carbide	2.00	2.00	2.00	1.70	2.08	1.89
T_6: Control	10.00	12.00	11.00	1.76	2.13	1.95
Mean	5.00	6.33	---	1.76	2.16	---
LSD (P=0.05)	T=0.77	V=0.44	T×V=NS	T=0.21	V=0.12	T × V =0.30

Table 3: Effect of different indigenous ripening methods on specific gravity (g/cc) of banana fruit

Treatment	Variety		Mean
	V_1 (Amritsagar)	V_2 (Chenichampa)	
T_1: Smoke	1.23	0.97	1.10
T_2: Ripe tomato	1.15	1.07	1.11
T_3: Paddy straw	0.97	0.98	0.97
T_4: Without smoke	1.29	1.14	1.21
T_5: Calcium carbide	1.20	1.19	1.19
T_6: Control	1.29	1.02	1.16
Mean	1.19	1.06	---
LSD (P=0.05)	T=NS	V=NS	T × V =NS

Table 4: Effect of different indigenous ripening methods on physiological loss in weight (%) of banana fruit

Treatment	Variety	Days after treatment						
		2	4	6	8	10	12	14
T_1	V_1	3.02	6.84	9.43	-	-	-	-
	V_2	3.47	5.14	7.23	9.07	-	-	-
T_2	V_1	2.43	5.32	7.94	10.26	12.30	-	-
	V_2	2.88	4.41	6.24	8.22	9.71	11.08	-
T_3	V_1	3.65	4.67	6.84	8.61	10.67	-	-
	V_2	3.38	5.04	6.56	8.91	9.94	11.06	-
T_4	V_1	3.23	4.15	6.19	8.81	9.61	-	-
	V_2	2.08	2.93	4.83	7.92	8.23	10.62	12.33
T_5	V_1	5.68	8.25	14.30	-	-	-	-
	V_2	3.95	6.47	9.76	11.02	-	-	-
T_6	V_1	2.55	4.02	6.33	9.13	11.74	-	-
	V_2	2.12	3.85	6.19	8.10	10.13	11.67	12.16

V_1=Amritsagar, V_2=Chenichampa

6. Conclusion

The results led to the conclusion that banana fruits might be successfully ripened using either chemical or traditional methods. Calcium carbide matured fruits changed color more quickly, turning bright yellow, but they had a poorer flavor and a shorter shelf life. Since the use of carbide has been shown to be carcinogenic, as previously reported, a different approach for stimulating the ripening of the banana fruit by ripe tomato or to ripen bananas in wrapped pits with smoke may be used to ripen bananas with desired qualities in terms of color, shorten the ripening period, and increase shelf life. For small traders in particular, ripening bananas with ripe tomatoes or in wrapped pits with smoke may be considered efficient ways. The market price of naturally ripened fruits may decline due to their poor color, but they have the greatest shelf life. Further research on the amount of ethylene emitted by various ripening treatments might provide insight into how to improve native ripening techniques. The quantity of ripening agents needed for artificial ripening could be determined by measuring the release of ethylene by various ripening agents.

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