LEAF FORMULATIONS OF KEPPETIYA (*Croton aromaticus* L.) AND BILIN (*Averrhoa bilimbi* L.) ACCELERATE RIPENING IN BANANA VARIETY "Embul"

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Introduction

Today, majority of the fruits available in the markets are heavily contaminated with harmful chemical residues which are sprayed deliberately from production to ripening to improve the aroma. Even though, most of the chemicals sprayed during production process may degrade by the time of harvesting, the chemicals applied after harvesting may persist at the time when the commodity is consumed. This poses a high risk on consumer health and, despite receiving established health benefits, their consumption can be life threatening. Therefore, this research was conducted with the objective of exploring conventional fruit ripening methods and to incorporate this knowledge with modern science and technology to develop an organic ripening agent. As an initiative, the possibility of using plant leaves namely *keppetiya* (*Croton aromaticus* L.) and *bilin* (*Averrhoa bilimbi* L.) as ripening stimulants of banana variety *Embul* was investigated.

Methodology

Preparation of biomaterials:

Young and mature leaves of *keppetiya* (*Croton aromaticus* L.) and *bilin* (*Averrhoa bilimbi* L.) were collected from the wild in the morning and transported to the laboratory. The moisture content of fresh leaves of *bilin* and *keppetiya*, measured by using moisture balance (OHAUS, MB 45) were 61.2 and 61.6% respectively. These leaves were separated from their stalks, put in trays and kept in an oven (Memmert, ULE 500) at 40 ^{o}C for 14-16 h for *bilin* and 16-18 h for *keppetiya* leaves. After that, these were ground by using a home scale grinder and sieved to obtain fine powder. The moisture content of *bilin* and *keppetiya* powder was determined.

Experimental procedure:

Banana variety *Embul* was harvested at their optimum maturity (mature green, round fingers, average finger weight and diameter were 64.3±5.5 g and 34.6±1.9 mm respectively) from Markfed orchard at Thalawa (14 km away from the institute) and transported as a whole bunch after wrapping with banana leaves. These were de-handed and the first and last hands were removed to minimize variation due to maturity gradient. The rest were separated into clusters containing 3-4 fingers and mixed well before allocating them into treatments. Approximately 1 kg of clusters was allocated into each treatment randomly in triplicate. The treatment structure was decided based on results of the preliminary trials. The dosages starting from 10% was used with reference to the weight of green mature banana which are intended for ripening *i.e.* each 100 g of green mature banana were exposed to 10 g of the dried powder. Therefore, the treatments were 10% *bilin*, 10% *keppetiya*, a mixture of 2% *keppetiya* + 2% *bilin* and banana samples without any bio material (control). The dried powder prepared as described above was put on plastic trays and kept within the glass chambers where

banana clusters were arranged around the trays before closing the lids. The temperature and relative humidity (RH) inside the glass chambers as well as ambient temperature were measured by using temperature humidity meter (TECPEL, 322 S) connected with k type thermocouples. The chambers were opened at 12 h intervals and kept opened for 20 minutes in order to avoid excessive accumulation of carbon dioxide and to facilitate entering of fresh air. At the onset of autocatalytic ethylene production (with the appearance of mild yellowness) the trays containing dried leaf powder samples were removed and bananas were allowed to ripen under ambient conditions.

Data collection:

One finger from each hand was taken and made into a bulk for collecting initial data (before treatment also known as day 0 and green mature stage). The parameters measured were weight (top loading balance; OHAUS; ARA 520), peel colour (colour difference meter; Konica Minolta CR 400), firmness (digital fruit firmness tester; TURONI, 53205), total soluble solids expressed as brix^{o} (refractometer; ATAGO, HR-5) and titratable acid (TA) by titrating a known volume of juice with 0.1 N NaOH (Ranganna, 1986). The TA was expressed as a percentage (g of malic acid equivalents per 100 mL of juice). The measurements were repeated at 2 and 4 days after treatment. A sensory evaluation test was conducted at 4 days after treatment using a semi trained in-house panel.

Statistical analysis:

The treatments were distributed according to a Complete Randomized Resign (CRD) with three replicates. Data were analyzed for variance by using SAS (V 9.0, SAS Institute Inc., USA) package. When interactions between treatments were significant ($P \leq 0.05$), the effect of each treatment was determined separating the means by Least Significant Difference (LSD). Data on organoleptic quality were analyzed by Friedman test using MINITAB (V 15, Minitab Inc., USA).

Results and Discussion

The moisture content of *bilin* and *keppetiya* powder was 13.8 and 10.2% respectively. The average temperature inside the treatment chambers was 34.9±0.2 $^{\circ}$C and similar to that of the ambient temperature which was recorded as 33.0±1.5 ^{o}C. In contrast, average RH inside the chambers was 92.4±2.7%, higher than the ambient RH by 27.1%. As reported previously, having high RH (90-95%) and low temperature (18-25 $^{\circ}$C) are desirable to maintain flavour volatiles or aroma compounds within the fruit (Thompson & Crisosto, 2015). In our treatment chambers this optimum RH conditions were achieved, but not the temperature.

Variation in Physical and chemical properties during ripening

Peel colour and pulp firmness: **Change in peel colour from green to yellow is the first visible index in ripening of banana. This occurs due to degradation of chlorophyll pigments unmasking carotenoid pigments underneath. Traces of yellow were first observed in the banana samples exposed to combination of *keppetiya* and *bilin* leaf powder after 24 h of treatment. Peel colour measured in terms of CIE *Lab* parameters at 48 h after treatment is given in the Table 1. Out of these three parameters *a** (greenness) showed a significant difference at 2 days after treatment. Greenness**

decreased rapidly in all treatments and rate of reduction was higher in the banana samples exposed to 10% *bilin* and the combination of *bilin* and *keppetiya* (2% each) on the contrary to control and the *keppetiya* alone samples.

Table 1. Mean peel colour (*L*, a*, b), pulp firmness, TSS and TA of banana variety *Embul* as affected by different doses of *keppetiya* and *bilin* leaf powders at 2 days after treatment**

Treatment	Peel colour			Pulp firmness (N)	TSS (^{o}brix)	TA (%)
	*L**	*a**	*b**			
K 10%	72.5±4.8	-11.8±1.9^{b}	44.1±2.9	8.4±0.5^{a}	19.2^{b}	1.26^{b}
B 10%	67.1±2.9	-5.9±1.0^{a}	44.8±2.3	7.8±0.4^{b}	20.5^{a}	1.22^{bc}
K 2% + B 2%	69.4±3.1	-7.7±0.9^{a}	48.6±1.6	6.7±0.04^{c}	20.5^{a}	1.41^{a}
Control	71.7±3.6	-12.7±1.0^{b}	46.4±1.0	8.4±0.3^{a}	19.2^{b}	1.16^{c}
P	0.080	0.005	0.100	0.008	0.004	0.002
LSD	-	2.42	-	0.62	0.77	0.09

Initial (day 0, at mature green): L* = 57.8±4.8, a*= -19.0±1.1, b*= 36.1±1.5, firmness = 45.7±12.6 N, TSS = 4.1±0.15, TA = 0.042±0.1. L* 0=black, 100=white, a*= (-) greenness, (+) redness, b* (-) = blueness, (+) = yellowness. Means in a column with the same letter are not significantly different at (P<0.05) according to LSD. Each value represents average of 3 replicates ± standard deviation. (n=15 for colour, n=9 for firmness, TSS and TA). K= keppetiya, B= bilin.

During the process of ripening, softening occurs due to enzymatic breakdown of cell walls and starch hydrolysis which is indicated by dramatic reduction in pulp firmness. The lowest pulp firmness was observed in banana samples exposed to the mixture of *keppetiya* and *bilin* (2% each) at 48 h after treatment. Reduction in firmness at a rapid rate in contrast to the other two treatments and to the control shows that, the mixture of *keppetiya* and *bilin* leaf powder is more effective than applying either of them alone.

Total soluble solids, titratable acidity and juice pH: **Total soluble solids (TSS) increased significantly (P<0.05) and banana samples exposed to 10% *bilin* leaf powder and the mixture of *keppetiya* and *bilin* (2% each) showed the highest TSS (Table 1). TSS of these two treatments was higher by 1.3 ^{o}brix than that of the control and the *keppetiya* alone. Titratable acidity (TA) of *Embul* bananas increased with ripening (Table 1). Highest TA was observed in banana treated with *keppetiya* and *bilin* mixture (2% each). TSS and TA are considered as two most important parameters that indicates palatability of ripen bananas. Juice pH also showed significant difference (P<0.05) and the lowest juice pH was observed in banana samples exposed to the combination of *keppetiya* and *bilin* leaves and *bilin* alone (data not shown).**

Sensory evaluation: **Sensory evaluation conducted at 4 days after treatment showed no significant difference among the treated and the control samples (data not shown).**

Conclusions and Recommendations

Evidently, combination of *bilin* and *keppetiya* leaf powders (at the dose of 2% each) promoted ripening in *Embul* bananas in contrast to the control and when these were used alone. Further studies are going on including measurements of gaseous emanations from these biomaterials in order to develop a sound product to be used in commercial scale.

References

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