ticle overlaid with a layer of pellicle; no surface secretion is present on the stigma which is thus of 'dry type'[2, 3]. Unpollinated, cross-pollinated and self-pollinated stigmas of this taxon were examined to see whether SEM would provide any evidence regarding the site of incompatibility reaction or show any difference in growth of compatible and incompatible pollen tubes before they penetrate the stigma.

In niger, much before anthesis, the stigmatic papillae are short and closely appressed to one another, but at the time of anthesis these papillae become longer, swollen and more widely spaced, presumably due to water uptake. Pollen grains are lodged on the papillae and the pollen grains have three germinal furrows.

In compatible pollination, pollen grains get hydrated and germinate on the stigma surface producing a pollen tube which goes down between the papillar cells and penetrates the bāsal portion of the papilla[4]. The place of penetration cannot be seen in the photograph (Figure 1*b*) owing to swollen papillae.

In incompatible pollination, pollen germination is usually inhibited but in some cases a few pollen grains do germinate, producing a pollen tube that twists over the surface of the papillae (Figure 1*c*,*d*), a characteristic reaction usually seen in a single plant of niger grown in isolation.

The reaction of incompatibility in flowers of *G. abyssinica* involves (i) low percentage of germination of pollen grains on the stigma, and (ii) twisting of pollen tubes over the stigmatic papillae. From the present study it is suggested that self-incompatibility in niger is homomorphic and of sporophytic type.

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Requirement of protein synthesis during ripening of abscisic acid-treated mangoes

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Abscisic acid (ABA) at 10^{-6} M enhances ripening in mangoes as evident from the increase in individual free sugars (not glucose) and total carbohydrates with a concomitant decrease in acid content. This is associated with increase in gluconeogenic enzymes like glucose-6-phosphatase (EC 3.1.3.9) and fructose-1,6-diphosphatase (EC 3.1.3.11) and also in cytosolic malate dehydrogenase (EC 1.1.1.37). Cycloheximide treatment inhibits the ABA-induced incorporation of radiolabel during ripening, suggesting that ABA action is mediated via protein synthesis.

MANGO is an important crop of India. Studies related to the regulation of the ripening process are essential for a better understanding of this phenomenon and to yield substantial economic gains. The naturally occurring plant hormones are known to regulate the process of ripening[1]. Ethylene, a key hormone, is known to trigger ripening in fruits such as apples, pears and bananas[2, 3]. Indoleacetic acid delays the onset of climacteric in pears and bananas[4], while gibberellic acid and cytokinins have been reported to delay the ripening of tomatoes and mangoes[1, 5]. Abscisic acid (ABA) has been shown to promote ripening in tomatoes[6], mangoes[1, 7] and grapes[8]. Earlier observations from this laboratory showed that post-harvest treatment of mangoes with ABA at 10^{-6} M concentration induces ripening[7]. The present investigation was undertaken with a view to examining the mode of action of ABA during ripening of mangoes.

Mangoes (*Mangifera indica* L. cv. *alphonso*) were purchased from the Bulsar district of Gujarat State and treated with ABA as described earlier[7]. Saccharides and acids were extracted and estimated as described by Palejwala *et al.*[8] Cell-free extract was prepared as reported earlier[9]. Glucose-6-phosphatase (G6Pase, EC 3.1.3.9) was assayed by the method of Swanson[10], fructose-1, 6-bisphosphatase (FDPase, EC 3.1.3.11) as described by Rao and Modi[11] and cytosolic malate dehydrogenase (MDH, EC 1.1.1.37) as described by Ochoa[12]. Bradford's method[13] was employed for estimating protein. Protein synthesis in mangoes was studied by following the incorporation of [^{14}C]-chlorella protein hydrolysate into proteins as described by Palejwala *et al.*[14]

Sugars are an important constituent of the fruits. The maintenance of appropriate sugar-to-acid balance contributes mainly to the appealing flavour[15]. The levels of total acids during ripening decrease with a concomitant increase in the total sugar content of mangoes. The involvement of gluconeogenic process is evident during ripening of mangoes[11]. Cell-free extracts of the fruit tissue have shown to convert organic acids to sugars[16]. Citric acid and malic acid are the major acids of the mangoes[16]. The metabolism of malic acid takes place faster than that of citric acid[16]. As shown in Table 1, ABA-treated mangoes showed higher content of sugars and lower acids compared to

Table 1. Levels of glucose, fructose, sucrose, total sugar, acids and the sugar : acid ratio in *Alphonso* mangoes treated with ABA, cycloheximide and a combination of both.

Treatment given to mangoes	Levels* (in g%) of Sucrose	Fructose	Glucose	Total sugar	Acids	Sugar: acid
None	5.8	2.9	2.2	10.0	0.66	12.2
ABA (10^{-6} M)	8.0	4.1	1.6	13.3	0.2	53.7
Cycloheximide (1 mg/ml)	1.4	1.3	3.6	5.9	1.8	3.2
Cycloheximide + ABA	1.9	1.3	3.8	6.3	1.4	4.5

* Values are mean of five different sets of experiments.

the controls. The level of sucrose, fructose and total carbohydrates increases by 39%, 41% and 32% respectively, compared to the untreated controls, whereas the level of glucose was lowered by 36%. The lower level of glucose indicates that it is possibly being utilized for sucrose production. The level of total acids, as measured in terms of malic acid, was 3.3-fold lower in ABA-treated mangoes compared to the untreated counterparts. ABA-treated fruits showed 4.4-fold higher sugar-to-acid ratio compared to the controls, suggesting as one of the possibilities enhanced conversion of acids to sugars and thereby rendering fruits more sweet. Cycloheximide-treated fruits exhibited higher levels of acids and lower level of total carbohydrates. The sugar-to-acid ratio was also suppressed in presence of cycloheximide. ABA treatment could not reverse the antibiotic effect.

The activities of some of the sugar-metabolizing enzymes, viz. FDPase, G6Pase, and MDH were examined. As observed in Table 2, ABA treatment elevated the levels of MDH, FDPase and G6Pase by 2.9-fold, 1.7-fold and 2.3-fold respectively, compared to the controls. Cycloheximide-treated fruits showed lower levels of all enzymes and ABA treatment could not reverse the antibiotic effect.

The increase in activities of various enzymes during ripening indicated an involvement of protein synthesis during ripening. Moreover, the inhibition of ripening process in presence of protein synthesis inhibitor, cycloheximide[17] also supported the view that the process of ripening is associated with the process of protein synthesis. A possible involvement of protein synthesis in the ripening process was studied by monitoring the rate of incorporation of a radioactively labelled amino acid into proteins. Figure 1 shows that the incorporation of [^{14}C]-chlorella protein hydrolysate into TCA-insoluble fraction increased by about 15% on the 2nd day of ripening which coincided with the respiratory climacteric[7] and then declined. The TCA-insoluble fraction of ABA-treated fruits showed 15% less incorporation on the 2nd day of ripening compared to the controls, possibly because ABA-treated fruits showed high metabolic activities and increased softening such that the isotope might get channelized to other metabolic processes. Since [^{14}C]-chlorella protein hydrolysate contains 19 uniformly labelled amino acids, the possibility of a particular amino acid channelizing for

Table 2. Levels of some of the sugar metabolizing enzymes in *alphonso* mangoes after treatment with ABA, cycloheximide and a combination of both.

Treatment given to mangoes	Specific activities* of Glucose-6-phosphatase	Fructose-1, 6-bisphosphatase	Malate dehydrogenase
None	0.22	1.7	14.0
ABA (10^{-6} M)	0.51	2.9	26.6
Cycloheximide (1 mg/ml)	0.14	1.05	6.8
Cycloheximide + ABA	0.17	1.15	10.6

*Specific activity is defined as the unit per mg protein under experimental conditions.

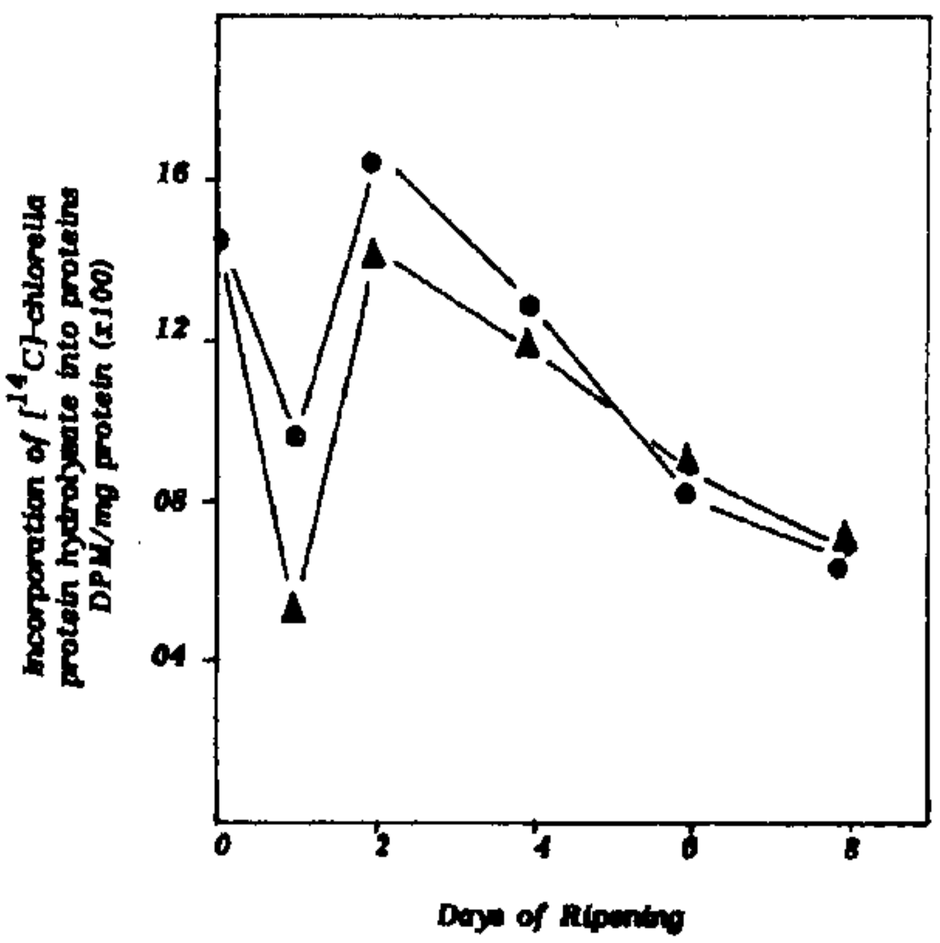

Figure 1. Incorporation of [^{14}C]-chlorella protein hydrolysate during different days of ripening of control (●–●) and ABA-treated (▲–▲) mangoes. Values expressed are a result obtained from five different fruits.

the formation of other metabolites would be higher, e.g. leucine as a precursor for carotene biosynthesis, glutamic acid gets converted to γ-amino butyric acid and then gets incorporated into the TCA cycle[16, 18]. ABA treatment accelerates these processes, thus explaining lower incorporation of radiolabelled amino acid into proteins. Moreover, cycloheximide has been shown to inhibit the ABA-induced incorporation of the isotope during ripening of langra mangoes[19], suggesting that ABA action is mediated via protein synthesis.

Thus these results establish that ABA treatment enhances ripening of mangoes without causing any deleterious effects and at the same time increases their eating quality. Its action is mediated via protein synthesis. It is not clear at this stage whether ABA stimultes the synthesis of any specific enzyme(s) involved in the process of ripening, or whether it promotes the synthesis of a proteinic factor which indirectly governs the activity of all the enzymes required for the process.

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Occurrence of vesicular-arbuscular mycorrhizal fungi in some *Cymbopogon* species of north-east India

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Vesicular-arbuscular mycorrhizal associations were observed in many aromatic *Cymbopogon* species cultivated in north-east India. Among them *Cymbopogon citratus* Stapf. showed maximum colonization (82.2%). Arbuscules, the functional units of mycorrhizal colonies, were also observed in four *Cymbopogons* tested.

As a component of rhizosphere the vesicular-arbuscular mycorrhizal fungi (VAM) help the host plant in uptaking nutrients particularly phosphorus[1, 2] for which the vegetative growth of plant species increases considerably. VAM associations were also observed in many aromatic plants[3, 4]. However reports on such mycorrhizal associations are not adequately available on aromatic *Cymbopogon* species cultivated most extensively in different regions of north-east India.

In this study seven *Cymbopogon* species were screened for VAM association. Species were collected from the experimental farm of Regional Research Laboratory, Jorhat, where soil is silty clay loam with pH 4.8 and available N, P, K as 0.037, 0.009 and 0.006% respectively.

These were *Cymbopogon winterianus* Jowitt, *C. martini* Stapf. var motia, *C. flexuosus* Stapf, *C. citratus* Stapf, *C. flexuosus* (Nees ex Steud) Wats, var-*sikimensis*, *C. khashianus* (Hack) Stapf (ex Bor), *C. jwarancusa* Schulf. These *Cymbopogons* were commercially important for their respective constituents, viz. citronellal, citronellol, geraniol, citrol, methyl eugenol, etc.

Randomly selected 1 cm root segments of each plant species were cleared in 10% KOH solution and stained with 0.05% trypan-blue in loctoglycerol as described by Phillips and Hayman[5]. The per cent colonization was determined by following the slide technique[6].

Distinct variations in per cent colonization of VAM fungi, the presence of vesicles and arbuscules were noticed. Among the species *C. citratus* showed maximum VAM fungal colonization with moderate presence of vesicles (Figure 1) and arbuscules. The presence of vesicles was quite high in *C. winterianus* (Figure 2), moderate in *C. citratus* and *C. flexuosus sikimensis*, scanty in *C. flexuosus* and absent in *C. khashianus*, *C. jwarancusa* and *C. martini* var *motia*.