**A.C. Odebode · J. Sanusi**

**Influence of fungi associated with bananas on nutritional content during storage**

Abstract *Botryodiplodia theobromae, Rhizopus oryzae, Aspergillus niger, A. flavus and Fusarium equiseti* were found to be associated with the ripening of bananas and also caused rot during storage. Bananas stored in baskets with ash fire wood ripened 2-3 days earlier than bananas stored in fibre sacks and under constant light. The infected bananas showed a decrease in the quantity of total soluble sugars, protein, lipid, crude fibre, ash, ascorbic acid and mineral elements when compared with the control fruit. Paper chromatographic studies showed the presence of glucose, sucrose, fructose, maltose and raffinose in healthy control fruit, while only sucrose appeared during storage in bananas infected with *B. theobromae*. The total soluble sugar and crude protein contents increased during ripening.

**Key words** Bananas · Fungal infection · Ripening · Ash treatment · Storage

**Introduction**

In Nigeria, banana fruits are consumed raw or cooked in large quantities daily, more than any other fruits. In Nigeria the peel constitutes a valuable fodder for goat and sheep [1]. When the fruit is completely ripe it is highly digestible and it is often prescribed to children and patients for digestive disorders. In some Nigerian tribes the fruit is an important ingredient in the preparation of cough syrup. Nutritionally, banana fruit is a good source of mineral elements and vitamins A and C [2, 3]. During ripening, the starch components are gradually converted to sucrose, glucose and fructose and in addition, water in the pulp increases [3].

Important as banana is, it is susceptible to different diseases of economic significance which have gained national and international attention [4–8]. These economic losses occur in the fruit between the period of production in the field and in the time of consumption. Changes associated with the process of ripening and subsequent spoilage by micro-organisms have been shown to influence the acceptability of the fruit [9]. The present study is aimed at discovering which fungi are associated with bananas stored under the three traditional conditions of ripening, and the effect of their spoilage on the food content of the fruit.

**Materials and methods**

Two bunches of mature green banana fruits were purchased from the local market in Ibadan, Oyo State, Nigeria. The two bunches had a total of about 100 fruits. The banana fruits were treated as follows: a batch of 25 fruits were put into a fibre sack and placed on an open shelf in the Laboratory, another batch was placed in a basket lined with a polythene sheet sprinkled with ash (obtained from burnt firewood) and then covered with banana leaves. The third batch was placed in a basket under continuous light. All the treated fruits were stored for 8–10 days depending on the length of time of ripening. The ripening period is from the time the matured green banana is harvested and stored until the skin turns yellow or golden and the banana is ready for immediate consumption.

**Isolation of associated organisms**. The ripening banana fruits were surfaced sterilized with 70% alcohol for 60 s and washed in sterile distilled water and blotted dry with sterile filter paper. The infected part was removed and sliced into small cubes and plated aseptically onto potato dextrose agar (PDA) in 9-cm sterile Petridishes at equidistant points and several replications were made. The plates were incubated at 28 ± 2°C for 3 days. Sub-culturing was done until pure cultures of the isolates were obtained and maintained on PDA slants in Macartney bottles. The *Aspergilli* were identified by reference to Raper and Fennel [10] and the rest of the isolates were sent to the International Mycological Institute, Kew, UK for identification.

**Effect of fungal infection on nutritional contents of banana fruits**. Unripe banana fruits were infected with the isolated fungi from rotten banana fruits. A hole was bored into each of ten healthy
surface-sterilized fruit with a 5-mm sterile cock borer. One 3-mm fungal mycelial disc was then inserted into the hole and the core of tissue removed was replaced and sealed with vaseline. The fruits were placed into polythene bags and incubated at 28 ± 2 °C for 8 days. The non-inoculated fruits served as controls: the treatment was replicated 3 times. At 2-day intervals, healthy and infected banana fruits were dried at 80 °C for 2 days. The dry samples were powdered by grinding in a mortar and sieved through a 250-μm sieve. The residue was repeatedly re-ground and re-sieved and the final powder was employed in the following proximate analysis.

Ash: Of powdered samples, 2 g was ashed in a pre-heated muffle furnace at 600 °C for 6 h. After this the crucibles were transferred into desiccators to cool. The cooled crucibles were weighed later and ash content calculated.

Crude fibre: This was determined using the method of the Association of Agricultural Chemists [11].

Ethanol-soluble sugar: Of the powdered sample 2 g was extracted with 30 ml of 80% ethanol. Ethanol-soluble sugar was determined quantitatively using the phenol sulphuric acid method of Dubois et al. [12].

Qualitative chromatography of sugars: This was determined using the methods described by Oladiran and Iwu [13].

Ascorbic acid: This was determined using the method as described by Lambert and Muin [14].

Total crude protein: This was carried out as described by the AOAC [11].

Lipid content: The lipid content was determined using the petroleum ether method, as described previously [15, 16].

**Results and discussion**

Fungi isolated from stored bananas

Five different fungi were isolated from the stored bananas. They were *Rhizopus oryzae*, *Botryodiplodia theobromae*, *Aspergillus niger*, *A. flavus* and *Fusarium equiseti* (Table 1). All the isolated fungi caused rot of the fruits as indicated by the rot diameter (Table 1). The fungi were known to be spoilage organisms and are associated with many fruits [17–19]. The ash reduced the number of fungi isolated, thereby reducing the infection of bananas during storage for ripening and also induced earlier ripening of bananas than those not treated.

<table>
<thead>
<tr>
<th>Fungi isolated</th>
<th>Methods of storage</th>
<th>Nutrient content estimated at alternate days of incubation</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basket ash Fibre sack Constant light Diameter of rot (mm)</td>
<td>Ash (g/100 g) Ethanol soluble sugar (mg/g) Lipid content (mg/g) Crude protein (g/100 g)</td>
<td></td>
</tr>
<tr>
<td><em>Botryodiplodia theobromae</em></td>
<td>††† ††† †††</td>
<td>2.75</td>
<td>2.5</td>
</tr>
<tr>
<td><em>Rhizopus oryzae</em></td>
<td>†</td>
<td>3.00</td>
<td>2.25</td>
</tr>
<tr>
<td><em>Aspergillus niger</em></td>
<td>†</td>
<td>2.75</td>
<td>2.75</td>
</tr>
<tr>
<td><em>A. flavus</em></td>
<td>††</td>
<td>2.25</td>
<td>2.25</td>
</tr>
<tr>
<td><em>Fusarium equiseti</em></td>
<td>††</td>
<td>2.80</td>
<td>2.80</td>
</tr>
</tbody>
</table>

†† Isolated, † not isolated

Table 1: Fungi isolated from bananas during storage and diameter of rot (mm) on inoculated bananas

Table 2: Nutrient contents of non-inoculated and inoculated banana fruits during storage. (Data are means of three determinations)