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POST-HARVEST DISEASES OF ARRACACHA (*ARRACACIA XANTHORRHIZA* BANCROFT) IN BRAZIL

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Abstract

The shelf life of arracacha (*Arracacia xanthorrhiza* Bancroft) is usually very short, especially when the roots are exposed to mechanical damage and post-harvest diseases. During a 2-year period, more than 400 isolates of fungi and bacteria associated with harvested roots were made on PDA and 523 media. The following pathogens were identified: *Rhizopus* sp., *Fusarium* spp., *Phoma* sp., *Geotrichum* sp., *Penicillium* sp., *Aspergillus* spp., *Erwinia carotovora* subsp. *carotovora*, *E. c.* subsp. *atroseptica*, and *E. c.* subsp. *chrysanthemi*. To fulfil Koch's postulates, all pathogens were artificially inoculated on arracacha roots. The most potentially destructive were *Rhizopus* and the three *Erwinia* subspecies, which disrupted root tissues completely, causing soft rot within 2 or 3 days. *Fusarium*, the commonest isolated (26.2%), caused dry rot. *Geotrichum* and *Phoma* were weak pathogens, while *Penicillium* and *Aspergillus* did not infect the roots.

Introduction

A major constraint to growing arracacha (Peruvian carrot, or *Arracacia xanthorrhiza* Bancroft) in Brazil is the extremely short shelf life of its roots, causing heavy losses during marketing. Normally, roots are marketable for only 3-6 days, mainly because post-harvest pathogens attack, causing deterioration and affecting the roots' commercial appearance (Henz et al. 1991). As a result, the price of this valuable vegetable crop is usually higher than that of other commodities, reaching as much as US$0.80/kg.

Those studies conducted to extend post-harvest life used mostly plastic films and refrigeration. Czyhrinciw and Jaffe (1951) concluded that 3 ^{o}C was the most suitable temperature for storing arracacha. In Brazil, arracacha roots are normally marketed without wrappings and are sold under conditions that reduce their shelf life (i.e., at 23-26 ^{o}C and 65%-85% r.h.).

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Several publications have discussed post-harvest diseases: the occurrence of the bacteria *Erwinia* in Venezuela (Camino and Diaz Polanco 1972), Colombia (Zapata and Pardo 1974), and Brazil (Henz et al. 1991; Romeiro et al. 1988); and *Fusarium* (Burton 1970; Diaz Polanco and Camino 1976; Henz et al. 1991). In washings of stored arracacha roots, Thompson (1980) found species of *Geotrichum, Phoma, Mucor, Aspergillus, Penicillium, Nigrospora,* and *Syncephalastrum*.

We attempted to identify further pathogens involved in post-harvest diseases of arracacha roots.

Materials and Methods

Obtaining isolates

For 2 years, we made more than 400 isolates of pathogens associated with arracacha roots after harvest. Diseased roots were collected in local markets and, depending on the kind of lesion present, isolates were made in Petri plates containing PDA (fungi) or 523 (bacteria) medium. The isolates were then incubated at 25 ^{o}C (fungi) in the dark for 5-7 days, or at 28 ^{o}C (bacteria) for 1-2 days. Fungi were identified according to morphological characteristics, following Barnett and Hunter (1972).

The tests performed for identifying species and subspecies of *Erwinia* included the ability to cause soft rot on potato slices; growth at 38 ^{o}C; production of oxidase, catalase, phosphatase, and lecithinase; and acid production from α-methyl-glucoside and maltose. All isolates were maintained in tubes containing PDA or 523 medium.

Pathogenicity of isolates

After being properly identified, the isolates of both bacteria and fungi were inoculated onto slices of arracacha roots, and kept at about 25 ^{o}C and 100% r.h. Fungi were inoculated with a plug (0.5 cm in diameter) of mycelia grown in PDA medium, and bacteria with a loopful of colonies grown in 523 medium. Evaluation—performed 2 days (bacterial) and 2-5 days (fungi) later—was based on symptoms such as soft or dry rot and other lesions. Later, re-isolations were performed to fulfil Koch's postulates.

Results and Discussion

Based on morphological characteristics, the following genera and species were identified (Barnett and Hunter 1972): *Rhizopus, Fusarium solani, F. oxysporum, Geotrichum, Phoma, Penicillium,* and *Aspergillus.* Species of *Erwinia* were classified into *E. carotovora* subsp. *carotovora, E. c.* subsp. *atroseptica,* and *E. c.* subsp. *chrysanthemi,* according to their response to growth at 37 ^{o}C; production of oxidase, catalase, phosphatase, and lecithinase; and acid production from α-methyl-glucoside and maltose (Table 1).

To fulfil Koch's postulates, all isolates were inoculated on arracacha roots. Of these, only *Penicillium* and *Aspergillus* were non-pathogenic. The most aggressive and potentially destructive were *Rhizopus* and the three *Erwinia* subspecies, which disrupted the root tissues completely, causing soft rot in 2 or 3 days. *Fusarium* caused a typical dry rot with lesions that progressed more slowly than did those of *Rhizopus*. *Geotrichum* and *Phoma* were weak pathogens (Table 2).

Thompson (1980) isolated *Rhizopus, Penicillium, Aspergillus, Nigrospora, Mucor,* and *Syncephalastrum* from the washings of stored roots; but did not mention proof of pathogenicity. The author also mentioned soft rot lesions, probably caused by unidentified bacteria during storage.

Diaz Polanco and Camino (1976) identified *Fusarium solani* as a problem in Venezuela, and Burton (1970) reported *F. oxysporum* as an important pathogen in arracacha in the Chicago market.

Although *Erwinia* is mentioned by many authors as an important post-harvest pathogen of arracacha, they may have mis-identified the subspecies involved: *E. amylovora* in Venezuela (Diaz Polanco and Camino 1976), *Erwinia* sp. in Colombia (Zapata and Pardo 1974), and, from 31 isolates tested, *E. carotovora* in Brazil (Romeiro et al. 1988).

We found the bacteria to be the predominant and most important pathogens, corresponding to 59% of the isolates. Based on biochemical tests, *E. c.* subsp. *chrysanthemi* (34.9% of the isolates), *E. c.* subsp. *atroseptica* (12.7%), and *E. c.* subsp. *carotovora* (11.4%) were identified and proved to be highly pathogenic to arracacha roots. Apparently, this report is the first to identify the three *Erwinia* subspecies as true pathogens of *A. xanthorrhiza* roots.

Fusarium solani and *F. oxysporum* together were the most frequently identified fungi (26.2%), but did not compare with *Rhizopus* for aggressiveness (Table 2).

Although many of these pathogens are also reported as pre-harvest constraints (e.g., *Erwinia* and *Fusarium*), they may, in fact, be favoured by problems in handling and transportation. In Brazil, almost all arracacha is washed before marketing, but usually without proper care. The resulting mechanical damage and bruising provide entry for many of these pathogens (Henz et al. 1991).

To extend the short shelf life of this product some authors suggest film wrapping and storage at low temperatures (Czyhrinciw and Jaffe 1951).

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Table 1. Biochemical tests used to identify *Erwinia carotovora* subsp. *atroseptica* (Eca), *E. c.* subsp. *carotovora* (Ecc), and *E. c.* subsp. *chrysanthemi* (Ech).

Characteristic	Eca	Ecc	Ech
Growth at 37 ^{o}C	-	-	+
Oxidase	-	-	-
Catalase	+	+	+
Phosphatase	-	-	+
Lecithinase	-	-	+
Acid from maltose	+	-	-
Acid from α-methyl-glucoside	+	-	-

Table 2. Isolation frequency (%) and relative aggressiveness of pathogens isolated from arracacha (*Arracacha xanthorrhiza* Bancroft) roots.

Pathogen	Frequency (%)	Aggressiveness[a]
Erwinia carotovora subsp. *atroseptica*	12.7	+++
E. c. subsp. *carotovora*	11.4	+++
E. c. subsp. *chrysanthemi*	34.9	+++
Fusarium solani	12.7	++
F. oxysporum	13.5	++
Rhizopus sp.	11.4	+++
Geotrichum sp.	2.4	+
Phoma sp.	0.2	+
Aspergillus sp.	0.4	n.p.
Penicillium sp.	0.4	n.p.

a. +++ = very aggressive; ++ = moderately aggressive; + = weak; n.p. = not pathogenic.