



# FOOD DRYING

Proceedings of a Workshop  
Held at Edmonton, Alberta, 6-9 July 1981

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# **Food Drying**

**Proceedings of a workshop held at Edmonton  
Alberta, 6-9 July 1981**

**Editor: Gordon Yaciuk**

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International Development Research Centre,  
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*in collaboration with*  
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Edmonton, Canada

### Abstract/Résumé/Resumen

The authors of this volume include researchers and scientists from many countries that encompass diverse climatic, geographic, and socioeconomic conditions. Their disciplines were also numerous: home economics, food science, nutrition, physics, and engineering.

The workshop covered the most important areas in the design and operation of a drying system. These are: drying requirements, consumer acceptance, heat and mass transfer, and heat sources. Within drying requirements, the need for drying the product is discussed as well as drying times and rates, sample preparation, quality changes during drying, rehydration problems, and problems with storage of the dried product. The section on consumer acceptance includes the effects of drying on the nutritive value of food, the introduction of a dried food to the consumer market, and how consumers provide valuable information to scientists to help in improving a process or product. The theory and design of a drying chamber and process control are explained under heat and mass transfer and an operational, full-scale drying system is examined. Finally, under heat sources, a number of examples are given in the use of the sun, petroleum products, agriculture wastes, and wood as heat sources for a drying process. A final concluding commentary is made on the overall recommendations derived from the workshop and proposals for future work are given.

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Les auteurs de ce volume sont des chercheurs et des techniciens venus de pays très différents les uns des autres du point de vue climat, géographie et conditions socio-économiques. Les disciplines représentées étaient aussi très diverses: économie domestique, alimentation, nutrition, physique, génie mécanique.

Le colloque a examiné les questions les plus importantes en ce qui concerne la conception et l'utilisation d'une installation de séchage: besoins en matière de séchage, l'accueil du consommateur, transmission de la chaleur et évacuation de l'humidité, sources de chaleur. Le chapitre sur les besoins en matière de séchage traite de la nécessité et de la durée de cette opération, de la préparation des échantillons, de l'action du séchage sur la qualité du produit, des problèmes de réhydratation et des problèmes de stockage du produit sec. Le chapitre sur l'accueil du consommateur traite des effets du séchage sur la valeur nutritive du produit, de la commercialisation d'un produit sec et de l'aide que peuvent apporter les consommateurs à l'amélioration d'un procédé ou d'un produit. Le chapitre sur la transmission de la chaleur et l'évacuation de l'humidité traite de la théorie et de la conception d'un séchoir, des modes de réglage et décrit une installation en service. Enfin, le chapitre sur les sources de chaleur donne des exemples l'utilisation du soleil, des produits pétroliers, des déchets agricoles et du bois. Un exposé des conclusions dégagées par le colloque et de ses recommandations est présenté à la fin de l'ouvrage.

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Los autores de este volumen comprenden investigadores y científicos de varios países que, en conjunto, abarcan diversas condiciones climáticas, geográficas y socio-económicas. Sus disciplinas respectivas también son numerosas: economía del hogar, ciencias de alimentación, nutrición, física e ingeniería.

El cursillo abarcó los aspectos más importantes en el diseño y operación de un sistema de deshidratación. Estos son: requisitos de la deshidratación, aceptación por el consumidor, transferencia de calor y masa y fuentes de calor. Entre los requisitos se examina la necesidad de deshidratar el producto así como los tiempos e índices del proceso, preparación de muestras, cambios en calidad durante la deshidratación, problemas que presenta la rehidratación y problemas resultantes del almacenamiento del producto deshidratado. La sección de aceptación por el consumidor comprende los efectos de la deshidratación sobre el valor nutritivo del alimento, la introducción de un alimento deshidratado en el mercado del consumidor, y como éstos a su vez proveen información valiosa a los científicos ayudándoles a mejorar un proceso o producto. Se explican la teoría y diseño de la cámara de deshidratación y el proceso de control bajo transferencia de calor y masa, examinándose un sistema operativo de deshidratación a escala comercial. Finalmente, y bajo el concepto de fuentes de calor, se citan varios ejemplos relacionados con el uso del sol, de productos petrolíferos, y desechos agrícolas, así como el de la madera como fuentes de calor para procesos de deshidratación. Se efectúa un comentario final sobre recomendaciones generales derivadas del cursillo al tiempo que se efectúan propuestas para el trabajo futuro.

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## Foreword

For as long as we have historical record, the heat of the sun has been used to dry cereal grains, vegetables, fruit, fish, and meat. Solar radiation is widely used as a direct source of energy by which to dry and dehydrate foods of many kinds in many countries. As fossil fuel costs continue to rise, direct and indirect solar drying will gain increasing importance as a method of food preservation throughout the world.

The International Development Research Centre (IDRC) is supporting several research projects in which solar radiation alone or together with combusted agricultural wastes is used to dry crops and other food materials, in several of which the influence of variable drying conditions upon nutrient retention is being studied.

Because the food dehydration and crop drying projects financed by IDRC are located in countries with widely different environmental conditions and the spectrum of research activities calls for a variety of scientific disciplines, it appeared desirable to bring together research workers representative of the geographic and scientific diversity involved.

A workshop was, therefore, organized from 6 to 9 July 1981, at the University of Alberta and in collaboration with the Alberta Department of Agriculture (ADA), which included 2 days of formal sessions; a 1-day tour organized by the ADA of a grain dryer manufacturing plant, a local farm, and a primary elevator; and 1 day of informal visits to various university departments and commercial organizations by individual participants. Those attending the workshop came from Bangladesh, Chile, Egypt, Guatemala, India, Indonesia, Kenya, Korea, Malaysia, Mali, Niger, Costa Rica, Peru, the Philippines, Sierra Leone, Singapore, Thailand, and Zambia, encompassing immensely diverse climatic, geographic, and socioeconomic conditions and with experience that embraced home economics, food science, nutrition, physics, and engineering. The main topics covered included drying requirements, consumer acceptance, heat and mass transfer, and heat sources. This publication comprises the papers presented and discussed, together with a commentary by the technical coordinator of the meeting.

It is the belief of my colleagues in the Agriculture, Food and Nutrition Sciences (AFNS) Division that, thanks to the contributions by those who took part, this publication may prove of lasting value to others in developing countries who share similar interests and concerns.

**J.H. Hulse**

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## **Drying of Potatoes (*Papa Seca*) in Peru**

**C. Lescano<sup>1</sup>**

**Abstract.** A laboratory-level process for obtaining two grades of *papa seca* of improved quality was developed: extra (> 8 cm diameter) and first grade (6.5–8 cm diameter). The process includes: grading, mechanical washing, abrasive peeling, cutting into strips (1 × 1 cm), steam cooking (1.7 kg/cm<sup>2</sup> absolute pressure), heated air drying (50°C dry-bulb temperature), grinding, and packaging.

Experiments on drying of cooked potatoes, using a laboratory cabinet dryer, demonstrated that: potato varieties with low-solid contents (Yungay, Ticahuasi, and Revolucion) provided better quality products than high-solid varieties; gelatinization of starch affected the water-sorption isotherms and slowed down the drying rate, as compared with uncooked potatoes; and the absence of the constant-rate period of drying and the presence of more than three falling-rate periods of drying for strips (1 × 1 × 4 cm) and slices (1 × 5 cm diameter).

Many developing countries are located in tropical zones where the potato grows well. However, only in the Andean region of South America, where the cultivated potato originated as a wild plant, does the potato play an important role in feeding the population. In Peru, the consumption per capita is 142 kg/year, rising to 288 kg in the Peruvian Altiplano (Christiansen 1977).

It is well known that the potato produces a higher yield of calories, protein, and many essential vitamins and minerals per unit area per unit time than the major cereal crops and other root crops. The production and utilization of fresh potatoes as a low-cost food in developing countries is held back because of problems encountered in the storage, transportation, and marketing of this bulky, high-moisture, and highly perishable product and by the wide-ranging seasonal fluctuations in price.

### **Traditional Preservation Methods**

Improved means of preservation are required to avoid these problems. In South America, traditional methods for the preservation of

potatoes have evolved over centuries. Today, they still involve primitive techniques to produce dehydrated products. Generally, potatoes chosen to be processed by these methods cannot be consumed in fresh form. The bitter varieties, which are the only ones grown in the highest valleys (more than 3600 m above sea level), are processed into *chuño*. Common, nonbitter varieties grown throughout the lower regions of the highlands are processed into *papa seca* and, in smaller amounts, into starch.

Individual families make *papa seca* by boiling, peeling, chopping, and sun-drying spoiled or damaged potatoes. Once dried, the *papa seca* is often ground. The final product is brown in colour, of mixed particle size, and often adulterated with dirt and small stones.

*Papa seca* is very popular throughout Peru. It is mainly used in one dish, *carapulca*, which is made by first toasting the *papa seca*, then boiling it in water with pork, tomatoes, onions, and garlic. Many families supplement their income by producing *papa seca* in excess of their own needs and selling it in the rural and urban markets.

### **Development of an Improved Method**

Under a 2-year grant provided by the International Development Research Centre (IDRC), the Universidad Nacional Agraria (UNA) La

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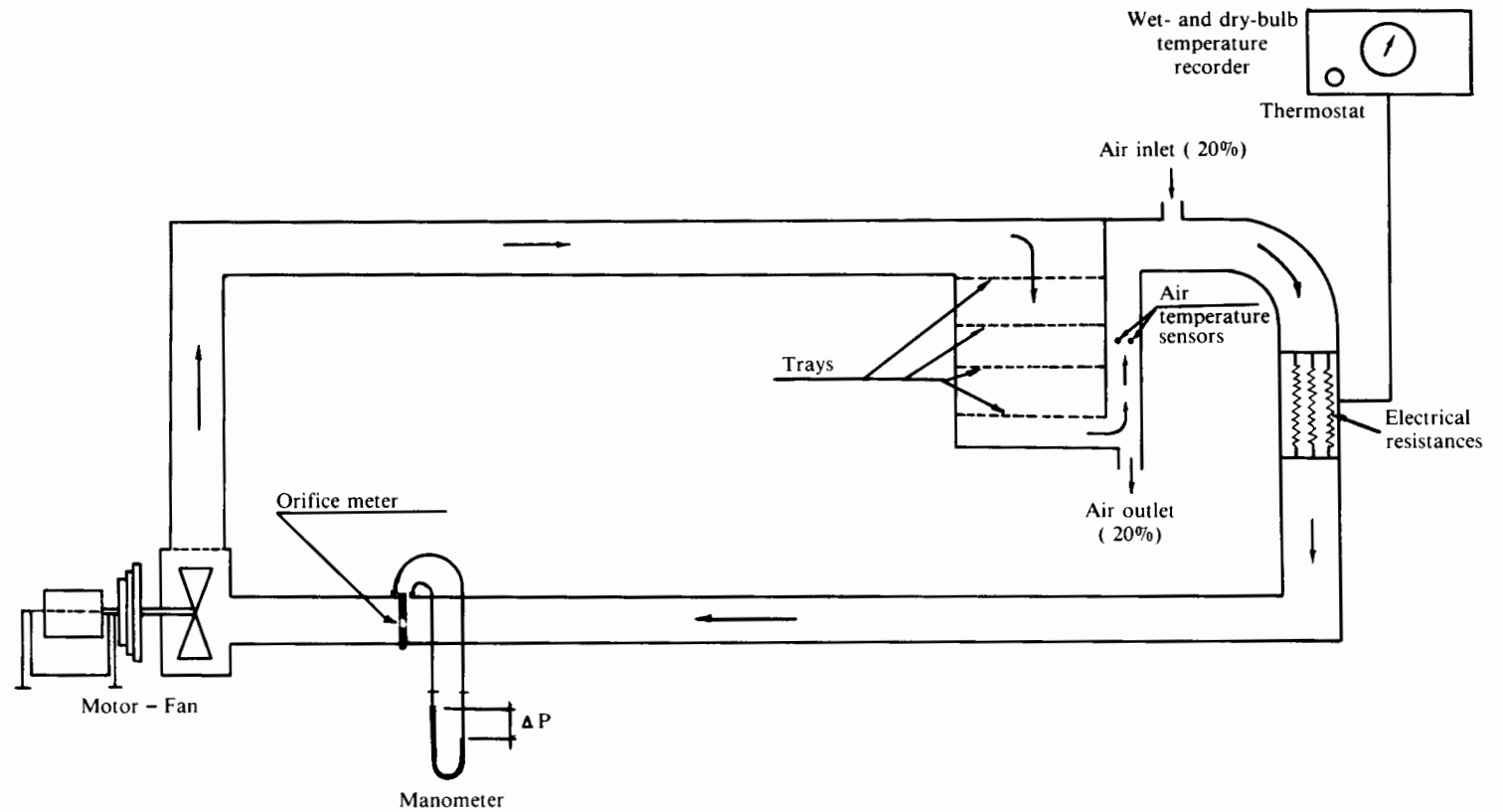


Fig. 1. Diagram of the tray laboratory dryer.

Molina, Lima, Peru, in subcontract with the International Potato Centre (CIP), a village-level or cooperative method is being developed for processing potatoes as *papa seca* for marketing in urban and rural centres. This paper focuses on the unit operation of drying within the laboratory process developed to produce *papa seca*, under the general and specific objectives of the IDRC-UNA-CIP project.

A laboratory-level process to obtain *papa seca* has been developed for extra (> 8 cm diameter) and first-grade (6.5–8 cm diameter) potatoes. This process includes: grading, mechanical washing, abrasive peeling, cutting in strips, steam cooking, hot-air drying, grinding, and packaging. (Dried *papa seca* can be stored for 3–4 years when packed in polyethylene bags.)

Results of experimental work presented in this paper will point out the influence of product characteristics on the drying process. Correlation of temperature, humidity, and velocity of

air over the material to be dried has been discussed in detail by Van Arsdel (Van Arsdel et al. 1973).

Technical information is available on drying of potatoes (Ede and Hales 1948; Van Arsdel 1951; Gorling 1958; Saravacos and Charm 1962). However, all the results reported have been on blanched or scalded potatoes, not on the drying of cooked potatoes, where the gelatinization of starch granules and the behaviour of starch seems to be important. When the end purpose is to produce flour, freezing the product beforehand is useful, but yellow is the desired colour for *papa seca* and freezing turns it white.

The experimental laboratory dryer is shown in Fig. 1. Dry- and wet-bulb temperatures can be registered during the entire drying. A thermostat controls air temperature. It is possible to obtain four air velocities: 6, 4, 2.8, and 1.32 m/sec. (The capacity of the indirect solar dryer at the pilot stage is 2 kg/2 days.)

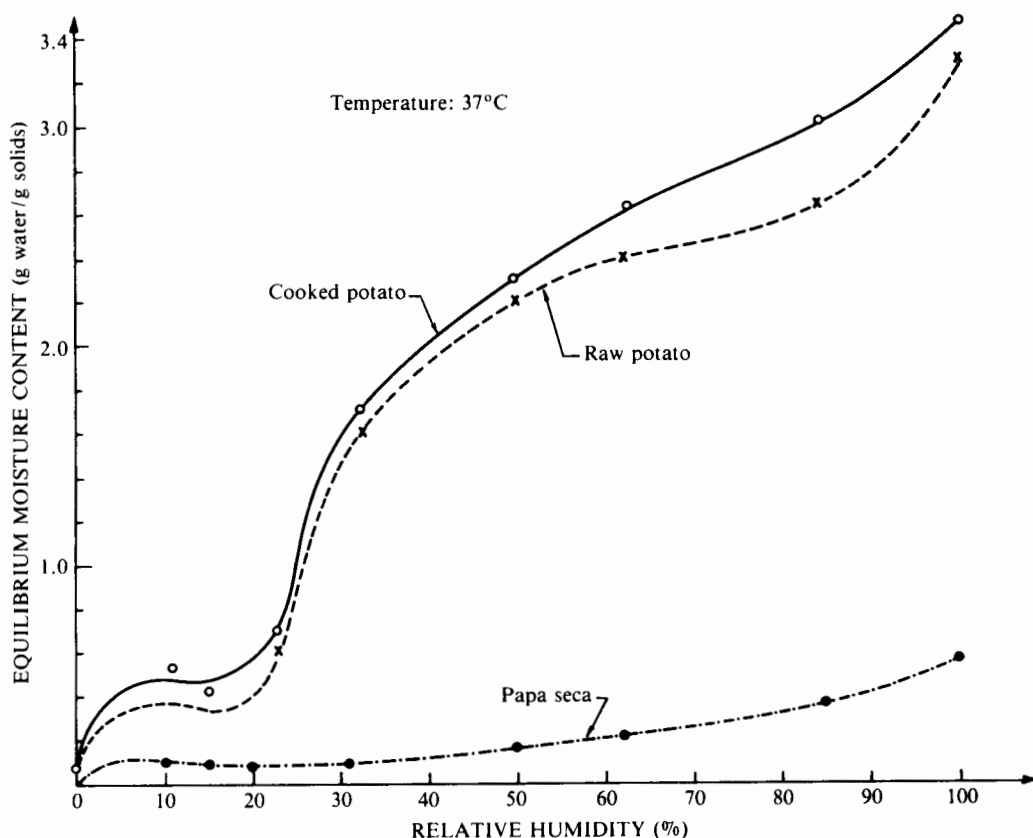


Fig. 2. Water sorption isotherms of the Yungay variety of potato (raw, cooked, and *papa seca*).

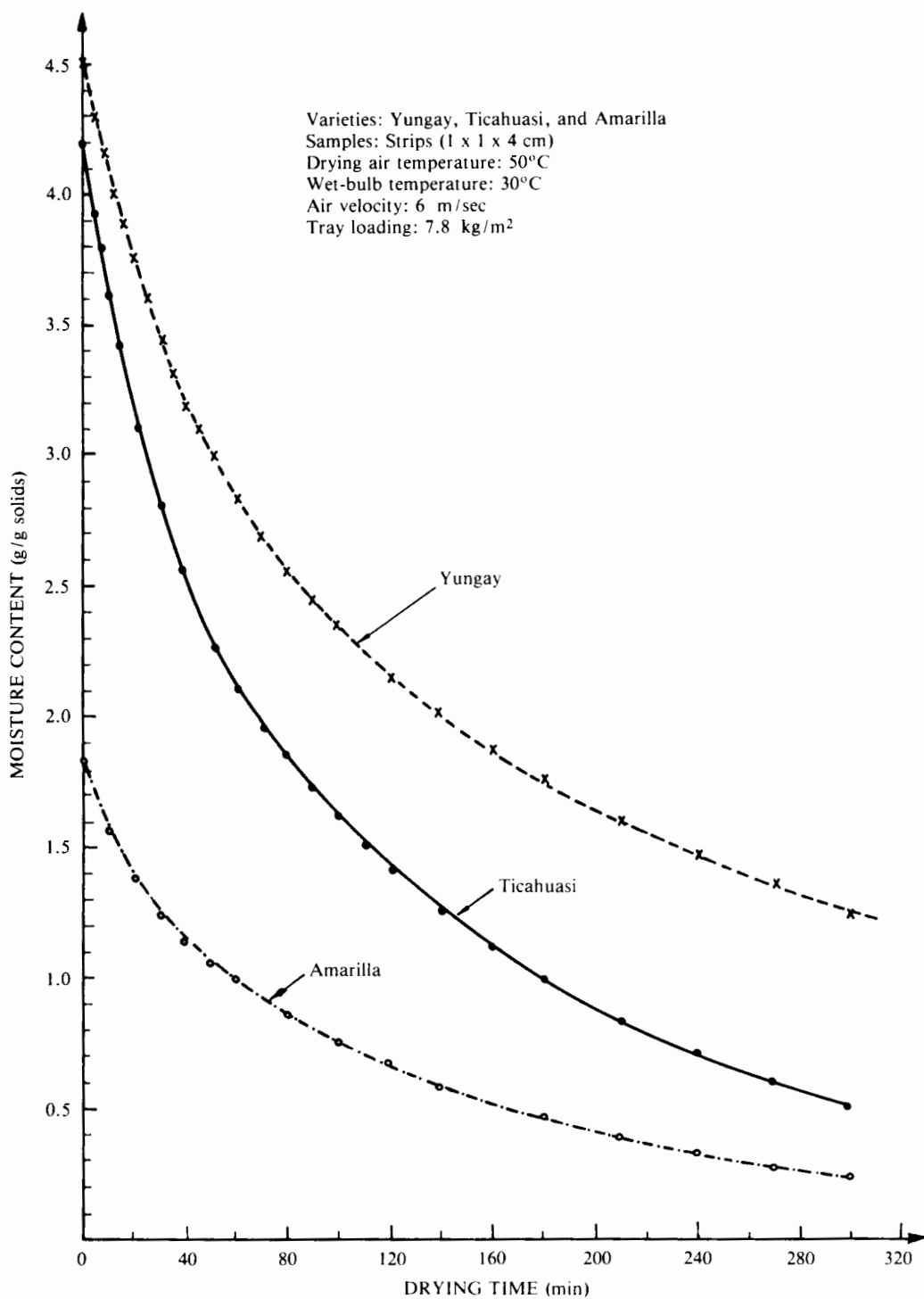


Fig. 3. *Papa seca* processing showing the influence of potato variety on drying.

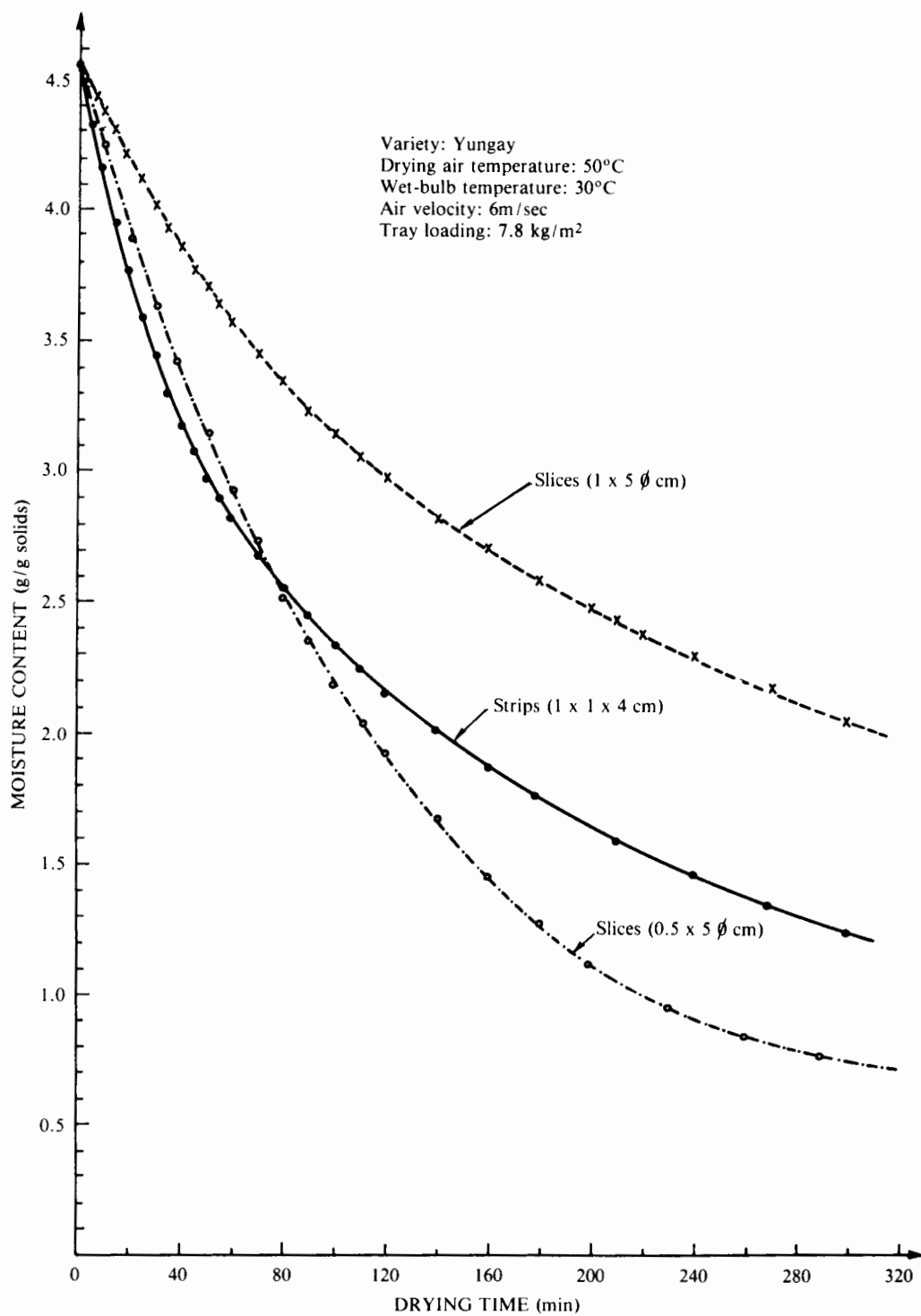


Fig. 4. *Papa seca* processing showing the influence of shape (strips and slices) and dimension of samples on drying.



Samples used in the drying tests were: Ticahuasi, Yungay, Revolucion, and Amarilla varieties; extra- and first-grade sizes; mechanically peeled by abrasion; and steam-cooked at 1.7 kg/cm<sup>2</sup> of absolute pressure for 10 min for the Amarilla variety and 12 min for Ticahuasi, Revolucion, and Yungay varieties.

## Results

An important feature is that cooked potatoes are used in making *papa seca*. Figure 2 presents sorption isotherms for raw and cooked potatoes and also for *papa seca* (Yungay variety). A marked difference is shown for the dried and undried products. The difference between cooked (steamed) and raw potatoes can be explained by the gelatinization of starch granules and changes in physical structure caused by cooking. Physical and chemical changes caused by cooking also affect rates of drying, for example, steam-cooked potatoes dry at a slower rate than raw potatoes.

The variety of potato used has proven to be an important variable in the processing of *papa seca*.

The quality of the final product is superior for potatoes with a higher moisture content (MC). The varieties with a high content of solids (native varieties) affect the structure of the final product, even though they dry faster and with less energy consumption. However, they will crumble easily, resulting in too small a particle size after grinding. After rehydration, the appearance is like a puree, without preserving the individual particle size and shape, which is a characteristic of *papa seca* of good quality. Yungay and Ticahuasi varieties have a low solids content (22.7 and 21.36%, respectively) but the Amarilla variety (29.51%) is a high solids content potato. Drying curves for three varieties of potato are shown in Fig. 3. The Amarilla variety, with a high solids content, will dry faster than the Yungay and Ticahuasi varieties. However, only the two varieties with high moisture content will produce *papa seca* of acceptable quality.

Shape and size of the product to be dried affect the drying process. Figures 4 and 5 show that strips (1 × 1 × 4 cm) will dry faster than slices of 1 cm thick and 5 cm diameter. If slices are only 0.5 cm thick they will dry faster. Figure 5 also shows that under the drying conditions of

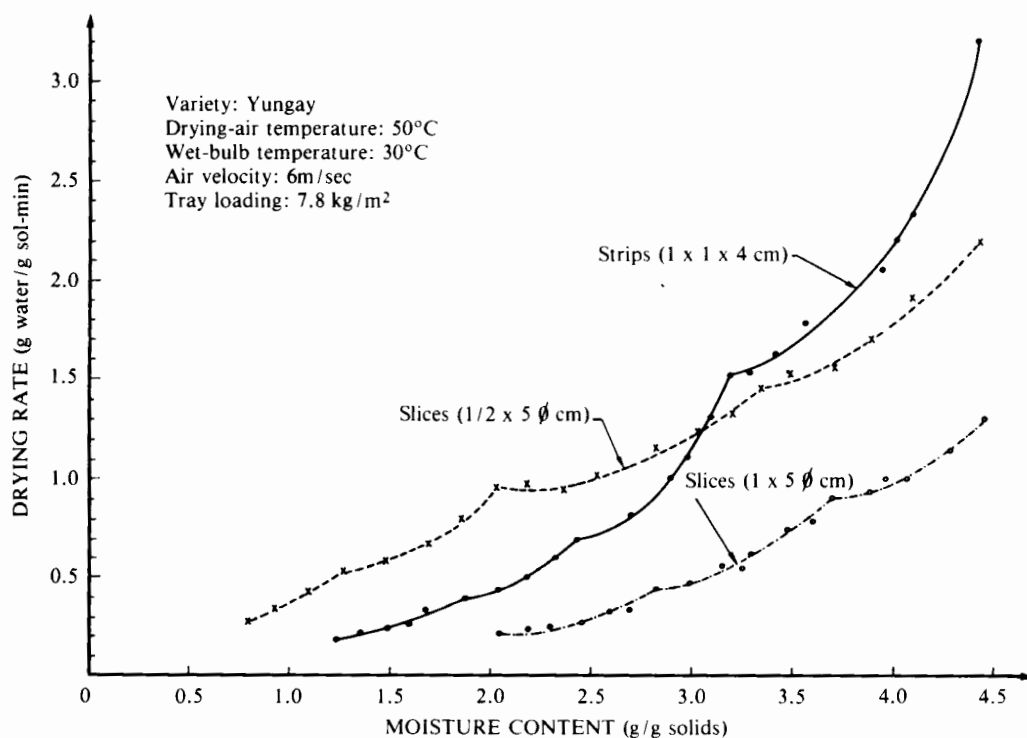


Fig. 5. *Papa seca* processing showing the influence of shape (strips and slices) and dimensions of samples on drying rates.

the test, boiled potato strips and slices present only falling-rate periods of drying, with shapes similar to the ones obtained by Gorling (1958).

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