

# RESEARCH HIGHLIGHTS

Michigan State University Bean/Cowpea CRSP

Vol. 2 No. 6 1985

INCAP/Washington State University/Swanson

## Protein Quality and Nutritional Value of Beans

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Common beans (*Phaseolus vulgaris* L.) are the main source of complementary protein in the cereal and starchy food diets of large segments of the Latin American population. Average consumption varies between 20 and 75 grams per person per day in Central America. Thus, production, availability, acceptability, cooking qualities and nutritive value of beans are of great importance.

Research at the Institute of Nutrition for Central America and Panama (INCAP) links bean production-oriented research with scientific improvements in conservation, acceptability, cooking quality and nutritive value. INCAP research addresses factors responsible for decreased bean availability in the diets of consumers, such as microbial and insect attacks which cause post harvest losses and the hard-to-cook condition which renders beans unduly firm after cooking and lowers their nutritive value. The research programs also consider ways to increase the utilization of nutrients in beans, and ways to increase the consumption of beans through development of non-traditional food products. A number of such research efforts jointly sponsored by the CRSP, INCAP and other participating institutions,<sup>1</sup> are evolving important findings critical in responding to these problems.

A preliminary study indicated that significant losses of beans and nutrients occur during

harvest, handling, shipping and processing. Harvest losses of seeds due to threshing and handling were from 0.7 percent to 21 percent. Total bean losses, including storage and marketing, varied from 3 to 69 percent. Poor storage conditions are probably among the most important factors in production losses and underuse of beans due to poor consumer acceptance. Losses also occurred during transport, an important consideration in the marketing process.

### Hard-to-Cook Condition

A problem common to beans and some other grain legumes is known as the hard-to-cook condition. As the term suggests, these beans are hard to cook and require more fuel for prolonged cooking to make them palatable. Prolonged cooking also reduces bean nutritive value. One of our research objectives is to explain the biochemical and/or biophysical mechanisms which cause beans to become hard to cook.

INCAP research shows that two processing treatments could minimize or control bean hardening. One is the use of a moist, high-temperature treatment for a relatively short time. This process apparently alters some biochemical and/or physical functions of the grain, prolonging the storage time before the hard-to-cook condition is induced. However, the process is accompanied by a 60 percent loss in germination.

The second treatment is more effective but less practical and requires immersion of the seed

<sup>1</sup>The Washington State University/INCAP project also includes collaboration with Colorado State University, Kansas State University, Michigan State University and the University of Puerto Rico.



in a 20 percent sodium chloride solution. The sodium ion apparently penetrates cells of the seed, causing changes that delay the hard-to-cook condition from developing in storage. It has previously been suggested by Louis Rockland<sup>2,3</sup> that an increase in the ratio of monovalent to divalent ions is related to quick cooking.

In addition to these two technological approaches, research is also underway to increase the content of monovalent ions in the seed by soil or foliar fertilization.

New preliminary findings at INCAP have shown significant interaction between environmental and genetic factors and the cooking time of beans, with environmental factors having the greater effect. In studies of these factors, within certain ranges, factors which were associated with larger seed size were related both to higher yields and to reduced cooking time.

### Complementary Effect

The well-known complementary effect on protein quality which occurs when beans and cereals are eaten together has received much attention. For example, a mixture of beans and

maize in a 70/30 ratio (by weight) has a protein value 1.9 times that of beans alone and 1.8 times that of maize consumed alone. Similar effects have been noted at INCAP when beans are blended with rice, sorghum or wheat. The main reason for this is the apparently complementary effect that bean protein, high in lysine relative to that of cereals, has on the total protein digested.

An even higher bean/cereal protein value would occur if the sulfur-containing amino acids (methionine and cystine) of beans could be increased modestly by 33 percent from present levels. Beans with this enhanced methionine content would also be of high value in diets based on root crops such as cassava as a staple.

Various research indicated that bean strains vary in amounts of sulfur-containing amino acids. This suggests that methionine and cystine levels could be increased through breeding and selection of varieties with higher sulfur contents. Screening is relatively easy because the content of sulfur-containing amino acids can be determined by analyzing for elemental sulfur. Sulfur and sulfur-containing amino acids have been shown to be significantly related at the 1 percent probability level.

Sulfur-content studies show a significant interaction between variety and locality, however variety has the greatest effect on content.

<sup>2</sup>Rockland, L.B. and E.A. Metzler. 1967. Quick-Cooking Lima and Other Dry Beans. *Food Technology* 21:344-348.

<sup>3</sup>Varriano-Marsten, E. and E. de Omana. 1979. The Effects of Sodium Salt Solutions on the Chemical Composition and Morphology of Black Beans (*Phaseolus vulgaris* L.). *Journal of Food Science* 44:531-536.



1. Dr. Bressani (right), CRSP Co-Principal Investigator from INCAP, conversing at a CRSP workshop with CRSP researcher Dr. Tony Hall of the Senegal/University of California-Riverside project.



2. Bean harvest by traditional methods is one phase of post-harvest losses.



3. Maize is the staple of most Central American diets.



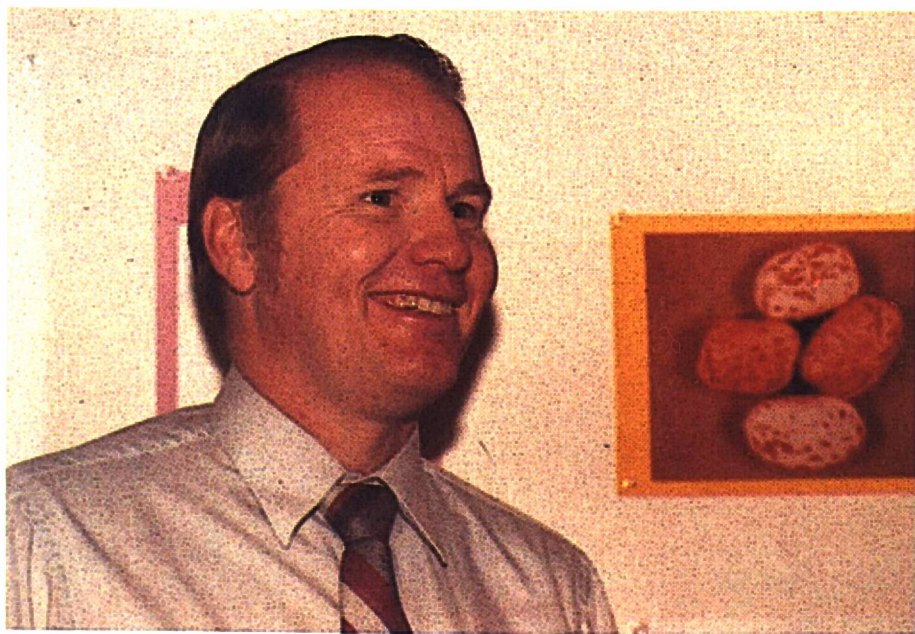
### Low Protein Digestibility

Heat applied in cooking destroys antinutritional factors such as trypsin inhibitors and hemagglutinin compounds present in seeds of most food legumes. Still, research indicates that humans digest only 55 percent of the protein in beans, or only about 13 percent of the usual 24 percent crude protein available. The reasons for this are being studied. It is known that polyphenolic compounds present in the seed coat affect protein digestibility of cooked beans. White beans contain very little or no polyphenols in the seed coats and thus have a higher protein digestibility than red or black beans. Even after protein digestibility data are corrected for the effect of seed phenolics, digestibility values are still low compared with other food components such as casein and egg albumin.

### Protein Fraction

There is recent evidence that a fraction of the bean protein, representing 15-20 percent of the total protein, has a digestibility below 20 percent. If allowances are made for this low value and the quantity of the fraction present, overall protein digestibility in beans is comparable to that of other vegetables.

The challenge is to determine if the undigestible protein fraction exists in the original seed or if it develops during storage or cooking. If the fraction is present in raw beans, it may be possible for breeders to eliminate it. However, if it comes about as part of the normal changes which occur during storage or cooking, new technology will be needed to reduce its development.



4. Dr. Barry Swanson, CRSP INCAP project Principal Investigator from Washington State University.

### Bean-Cooking Broth

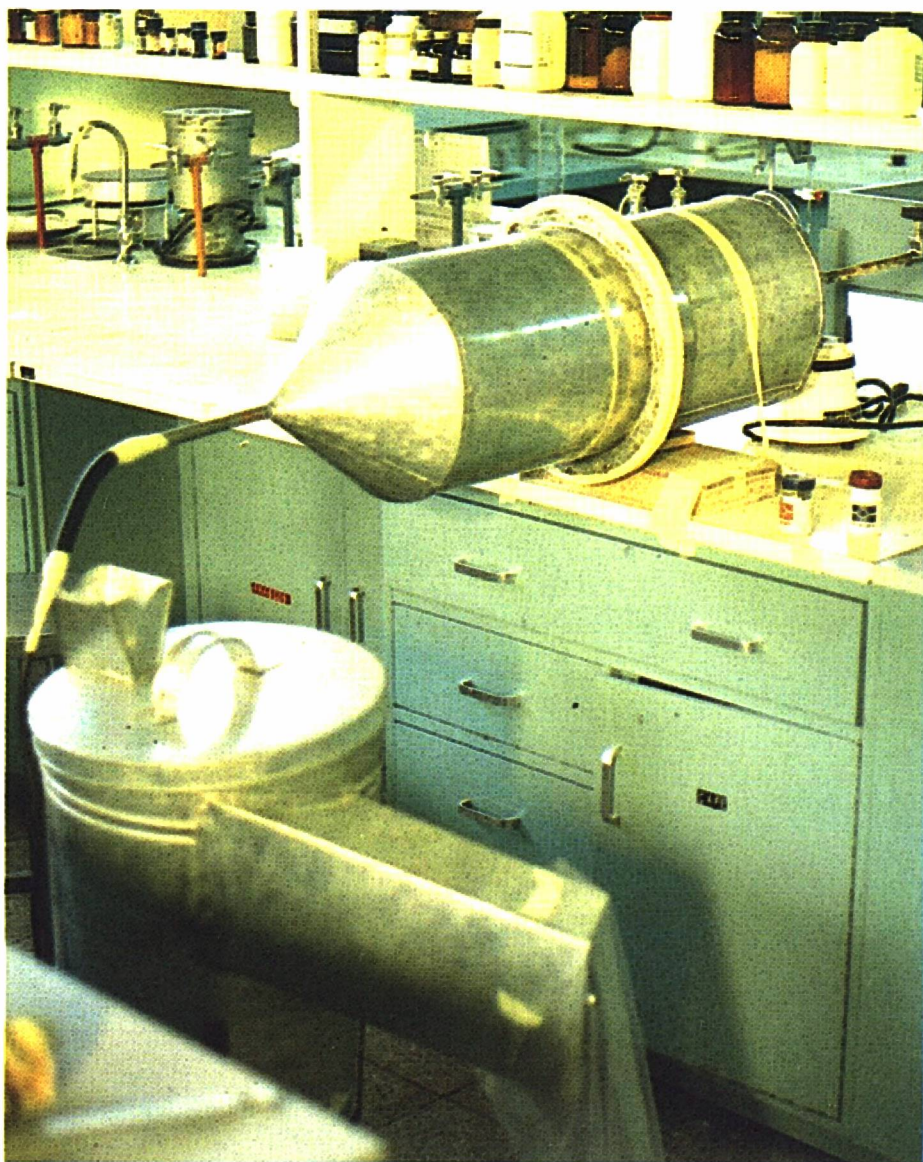
The liquid from cooked beans is sometimes consumed separately, especially by young people and infants. Nutritionally, this broth contains around 1 percent protein with an amino acid pattern reflecting that of bean protein. It contains high levels of polyphenols and potassium which reduce the quality of the protein. When fed to rats, the broth causes a decrease in weight gain and in protein digestibility in amounts correlated with the quantity consumed.

The effect on digestibility was expected due to the polyphenols present, however, the decrease in protein quality was not. The decrease in protein quality continued even when beans were supplemented with methionine, the essential amino acid which controls the biological utilization of bean protein.

Research under this project is continuing to determine whether some polyphenols are being hydrolyzed and absorbed, thus decreasing the utilization of the absorbed amino acid by unknown mechanisms.

### Future INCAP/CRSP Research

Further CRSP-supported research will build on the above findings and will provide a clearer picture of the mechanisms which act to impair the nutritive value of beans. This information will be an invaluable aid to plant breeders in choosing traits to select and strategies to use in improving bean nutrition.

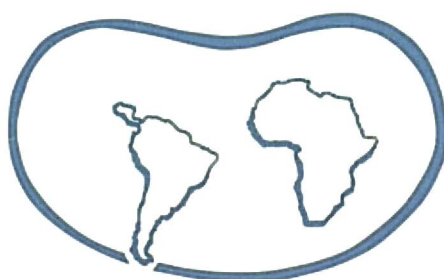


5. A granular-heated-bed dry cooker for beans developed by workers at Colorado State University.



## **THE BEAN/COWPEA CRSP**

**An international community of persons, institutions,  
agencies and governments committed to collectively  
strengthening health and nutrition in developing  
countries by improving the availability  
and utilization of beans and cowpeas**



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