As part of China’s 10th “five-year plan,” which began in 2001, a series of national key scientific and technological projects on downstream (i.e., “further” or “value-added”) processing of agricultural products was initiated. Downstream project initiatives included research on China’s main agricultural products, such as rice, wheat, corn, legume, and yam, as well as the comprehensive utilization of agricultural by-products. After five years of efforts, great progress was made in developing techniques for the downstream processing of cereal grains. What follows is a review:

Progress with Rice

A number of breakthroughs were made in the development of techniques for the further processing of rice. For example, healthy food concepts made from rice bran nutrients and nutritional fiber were developed. Rice bran nutrients contain high quality proteins, fatty acids, vitamins, soluble dietary fiber, and minerals. Nutritional fiber made from rice bran is a high-quality dietary fiber that also contains significant levels of protein. Development of these new food products helped to increase the use of rice bran and realized a tenfold increase in the value of rice bran.

Microporous starch of milled, long-grain, nonglutinous rice was developed successfully with an open porosity of more than 99% and an oil absorption capacity of 1.3 mg/g. By transforming this product, the value of the milled, long-grain, nonglutinous rice was also increased tenfold. The initiative produced what we believe is the world’s first rice germ beverage, with a unique nutritional function, flavor, and mouth feel. One ton of rice germ could produce eight tons of rice germ beverage, which can increase the end-product value of the rice germ by 15-fold.

By employing biological, high-performance physical separation and ultramicro porphyrization (i.e., mortar grinding) techniques, new products such as effervescent tablets of rice bran nutrients, hypolipidemic capsules of rice bran, rice bran polysaccharides, γ-aminobutyric acid, and rice milk were developed, thereby fully utilizing rice bran’s components.

Progress with Wheat

A process to produce monosodium glutamate from wheat starch was developed and improved. A new method was developed to improve the efficiency of wheat starch processing, thereby increasing the downstream value of the wheat. A breakthrough was achieved in the liquefaction, saccharification, and filtration of wheat starch, with 97% of the starch converted to sugar. Through chemical and physical mutagenesis, combined with cell fusion techniques, a high glutamic acid producing strain of Corynebacterium glutamicum FM00-187 was selected. The breakthrough came from being able to produce glutamic acid from wheat starch sugar through fermentation. A new technology involving the continuous isoelectric extraction of glutamic acid at high temperatures was developed. The method increased the extraction yield of glutamic acid to 90%. A number of other important techniques were developed to improve the production of glutamic acid and monosodium glutamate. These included wheat starch saccharification, fermentation, continuous isoelectric extraction of glutamic acid at high temperature, crystal transformation (i.e., α-type glutamic acid crystal was transformed into β type), and the continuous crystallization of monosodium glutamate. Fermentation yields for glutamic acid reached 15 g/100 mL, extraction yields reached 90%, and total yields after refining were more than 1.116. (In glutamic acid refining, it is necessary to add a crystal seed into the fermentation product. As a result, the total yield of refining will exceed a value of 1.0.)

High yields of gluten, containing 75% protein, were obtained from wheat, with the yield of wheat starch reaching 82%. The water absorption capacity of the resulting gluten exceeded 170%. Five types of modified gluten and two types of instant vegetarian food product were developed from this process. Additional technologies for the preparation of nutrient supplements, iron, and vitamin A were developed and the resulting nutrients were deemed to be of as good quality as their imported counterparts. Both wheat germ and bran were transformed into higher-value products, such as wheat germ rich in glutathione and pentosan, and wheat bran rich in xyl-o-oligosaccharides, thus significantly increasing the value of the wheat germ and bran fractions.

Developments in Corn Refining

Through enzyme technology, it was possible for the first time to produce food-grade, crosslinked, acetylated pregelatinized starch and crosslinked hydroxypropylated starch from waxy corn starch in China. Equipment for the production of modified starch through dry processing was developed independently, and a 20,000 ton/yr production line was constructed at Zhu Cheng Xing Mao Corn Developing Co., Ltd., Shandong Province, Zhucheng. This technology helped to settle the environmental pollution issues historically associated with the modified starch industry and also promoted water conservation. Breakthroughs in catalyst selection and alcohol separation techniques enabled organic alcohol to be produced from corn on an industrial scale for the first time. A 20,000 ton/yr poly-alcohol production line was set up at Dacheng Industrial Group, Jilin Province, Changchun. The purities of the ethylene and propylene glycol products were 99.5% and 99%, respectively.

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Looking Toward the Next Five-Year Plan

Instant, leisure, and healthy food products based on rice, wheat, and corn are a key trend in food manufacturing in China. China’s food industry grew 20% annually for the last five years. In the coming 10 years, it is predicted that cereal-based food products will account for 50% of all foods, providing a huge market potential. Healthy, nutritious, instant, and leisure food products, such as instant rice, instant rice noodles, cereal breakfast, baked food made with rice or wheat, rice milk, rice germ, wheat germ, and corn germ will likely become more and more popular in China.

Rice Technology

To meet demands for healthy and instant staple food products, work will be directed toward developing healthy, hygienic, safe, and convenient instant- and easy-to-cook rice products. For nutritional balance, high-quality broken rice kernels can be used to produce instantized nutritional rice products in combination with soybean powder, amino acids, vitamins, and minerals. Such products can be produced through grinding, mixing, cooking, extruding, shaping, and drying techniques.

Since the processing and edible quality of early long-grain nonglutinous rice is poor, it can be used to produce parboiled rice. The rice bran could be used to develop rice oil, protein, and dietary fiber products. The broken parboiled rice could also be used to develop rice protein or rice starch sugar ingredients.

Manufacturers of children’s food products have demonstrated a particular interest in using isolated protein from rice, due to its high bioavailability and low allergenicity. Research will focus on the industrial isolation of starch and protein from rice, the large-scale production of rice protein isolates, modification of rice protein isolates, preparation of granular rice starch, and its application as fat substitutes.

Wheat Technology

First, research and production of various types of flour, such as bread flour, all-purpose flour, and enriched flour, is still in its early stages in China. Food additives that offer the potential to improve the quality of flour will be investigated. Quality standards and compositions of wheat flour for use in instant noodles, steamed bread, dumplings, and noodles will be established. New food additives to replace potassium bromate will need to be developed as soon as possible.

Second, at the moment, China has only limited, poor quality varieties of premixed flour ingredients. To improve the situation, ingredient and processing technologies to develop premixed flour systems for use in multi-cereal, healthy steamed breads, including those with oat hulls, cakes, breads, and pizza need to be developed as soon as possible.

Third, nonfermented quick-frozen flour is not available in China today. There is a need to study the relationship between rheological characteristics, gel properties, gluten quality of flour, and the quality of quick frozen food products. By employing starch and dough modification, combined with the selection of modifying agents and quick frozen techniques, it is important to establish quality standards for nonfermented, quick-frozen flours. Flour and quality improvers that can be used to produce high-quality, quick-frozen foods will be developed in order to avoid quality defects, such as cracking, shrinkage, and the degradation of products using nonfermented, quick-frozen wheat products during production, storage, and sale.

Fourth, to improve efficiency and energy consumption, food stability, food safety, and the hygiene of fermented and nonfermented bakery food production, we will focus on breeding and selection techniques to develop low temperature-tolerant yeast, modify starches and dough, and develop quick-freeze technologies. Also needed are technologies to improve stability and recoverability in predough mixes for quick frozen foods, especially improvements in malleability, retentiveness, springiness, gas holding capacity, flexibility, and shape retention.

Finally, work will be undertaken to make full use of wheat by-products, such as wheat protein, wheat germ, and wheat bran product.

Corn Technologies

In pursuit of healthier foods, we will develop slowly digestible starches and other modified starches that have low hypoglycemia indices and help to prevent obesity. Technologies that deal with microencapsulated oils and emulsified essences are also of interest. By the enzymatic reverse-synthesis of different glycosyl branched cyclodextrins, and derivatizations thereof, a series of cyclodextrin ingredient derivatives will be developed.

Since the production of starch-derived sweeteners is at a low level and since there is currently a huge demand for these products within the Chinese market, this is a good opportunity to develop high fructose corn syrup, crystalline fructose, ultra-high maltose, and whole powdered sugars of high quality.

In sum, the development of downstream processing technologies for cereal grains comprises a very important national scientific research objective as part of China’s 11th five-year plan. Of special interest are the objectives of developing high-value and modern manufactured foods that are in high demand.

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