Progress In Understanding Rice Grain Quality

Bienvenido O. Juliano

Senior Consultant, PhilRice Los Baños, Philippine

Considerable progress has been made recently in our understanding of rice cooking and cooked rice texture. Major indicators of eating quality are apparent amylose content (AC), gelatinization temperature (GT), and gel consistency (GC). The granule bound starch synthase 1 microsatellite $(CT)_n$ simple sequence repeats in noncoding region of exon 1 and G/T single nucleotide polymorphism (SNP) at intron 1 splice site associate with AC. SNP3 and SNP5 of the soluble synthase SSIIa associate with GT through the distribution of the length of short outer chains of debranched amylopectin with DP 6-24 glucose units. Hard GC in high AC rices is due to high content (>10%) of long-chain (LC) amylopectin (DP >1000 glucose units), as indexed by high RVA/Amylograph consistency and high water-insoluble "amylose" (actually LC amylopectin) in boiling water. Instrument hardness of freshly cooked, staled, and staled and reheated cooked rice may also be measured to index amylopectin staling. AC influences glycemic index, resistant starch, dietary (soluble) fiber and satiety index of cooked rice. The major aroma compound in rice, 2-acetyl-1-pyrroline, exists in both free and bound forms and associated with at least two genes. Rice bran is rich in available linoleic acid, dietary fiber, vitamins, minerals (except iron), antioxidants (including phytic acid) and anthocyanins in pigmented rices. Consumption of some brown rice with milled rice would take advantage of the nutraceuticals of rice bran. Researches are ongoing to make rice more nutritious in countries where rice is the staple food, such as higher-amylose content (>35%, high resistant starch), presence of ß-carotene (Golden Rice) and higher levels of micronutrients, iron and zinc, in milled rice.

中国におけるコメ利用の現状と将来

李　里特

中国農業大学、北京、中国

１　中国農業における米の役割

主に農耕民族の中国人の稲の栽培の歴史は 8000 年以上だと言われる。大部分の中国人は米を主食にしている。この 30 年間稲の生産は著しく成長し、1980 年の 1.4 億トンから、1997 年に約 2.01 億トンの最高生産になった、この間中国では食糧の配給制が廃止され、消費量も減り続けた。結局 2000 年以後生産量は 1.8 億トン前後に落ち、その後横ばいになっている。中国稲の総生産量は食糧のうち最も多く、1980 年には 43.05％を占めたが、2005 年には 37.31％まで落ちた。FAO の統計によると、2007 年世界精米生産量が 4.26 億トンであるが、中国は約 1.264 億トンで即ち約 30％を占める。中国の稲の品種は主に粳米（round-shaped rice or Japonica）と籼米(long-shaped rice or Indica)の二種類がある。80 年代中国の主な栽培品種は籼米(Indica)が 89.2%占め、主に南方人の好む品種で、しかし、その後嗜好傾向がだんだん変わり、北方人の好む粳米（Japonica）の消費と生産が増え続け、粳米の生産量が 1980 年の 10.8％から 2005 年には 28.7％まで増加した。つまり粘りのあるご飯の人気が増えた。

２　中国人の食卓と米食

中国人の主食は穀物で、昔から精糧と粗糧と分けて言う。精糧は米と小麦で、粗糧はトウモロコシ等の雑穀を指す。1970 年代までいわゆる食糧不足の時代は食卓の主食は精糧が 30%しかなかった。1998 年以来食卓の主食は精糧が 80%を超え、精糧のうち米が 63％を占める。大部分の中国人は米を主食とする。普通、揚子江より北方の人は小麦食が多く、揚子江流域あるいはその南方の人は米食を好む。すなわち、中国人口の大部分は米を主食として食べている。これはお米の産地は雨が多い南の地域にあるからである。しかし、この地域の人の多くは籼米(Indica)に馴染み深い。南方人はほとんどの食事のときお米は欠かせない主食で、パンや麺があっても飯を食べないと済まないといわれる。お米の消費には近年様々な変化が現れた。先ず、中国の一人当たりの年間消費量はだんだん減り続け、1990 年は 93.9kg で、2005 年には 79kg に落ちた、農村の値は相変わらず 103kg 前後であるが、都市は 67.4kg から 47.2kg に減少した。また、全国においても南方においても粳米（Japonica）の消費量が増え続け、特に東北産のお米が評判が良く、大量に全国で販売されている。

３　中国における米食の特徴

　中国の米食の特徴は以下の通りである。

⑴　食事は主食と副食があり、通常米食地域の食卓はご飯が主食で、副食が「菜」と「湯」を指す。「菜」はおかずのことで、「湯」は汁類である。家庭料理としてご飯と「三菜一湯」は普通である。「三菜一湯」は野菜を主とするおかず三種類と野菜を含む汁類である。ご飯は通常味付けはなく，おかずと一緒に食べる。朝食はご飯の代わりにお粥を食べるほうが多い。

⑵　米の食味において、今まで食事のときご飯そのものの美味しさは余り気にせず、むしろ美味しさを楽しむのはおかずである。従って、粳米にしても籼米にしてもあまり明らかな嗜好性は言えない。むしろ稲産地の大部分の人は籼米に慣れている。しかし、近年、タイ米と日本米の影響を受けて、都市の人の嗜好性は変わり始めた。粘りのある粳米が人気が増えている。普通の粳、籼米以外に中国には様々な品種の米があり、例えば、糯米、紫米黒米、紅米などである。最近色彩米が人気上昇中である。

⑶　お米の料理法が各地において様々で、様々なご飯とお粥以外に「米粉」の種類も実に多い。「米粉」は米の粉で作った麺類で食べ方も麺と似ている。糯米で作ったお菓子（餅）は年糕（ねんこう）と言い、年糕の他、米のカステラのような食べ物も沢山ある。形、色、食感などはとても美味しくて面白い。

(4)　日本のような米菓、お酒、例えば固い煎餅が余り無いが、醪糟、発酵米粉などの独特な米食が多い。

４　これからの中国の米食

　世界最大の稲生産国であり、かつ消費国である中国は米の戦略的地位が高く、輸出も規制されている。現在もいろいろな課題がある。

⑴　米の生産量はやや余るほどまでに達したが、価格が安く、農民の生産意欲に悪い影響を与えた。大都市の「高級米」は海外産が占める。消費者の嗜好に合わせ、米の生産量から品質へと重要視して研究しなければならない。

⑵　伝統米食の現代化と工業化が立ち遅れ、外国の食文化のおおきな刺激を受け、様々な危機に直面している。日本を始め東南アジアなどの地域は同じ米の食文化圏であり、お互いの交流を通じて米産業を振興する必要がある。特に日本は米食文化と米加工技術に優れ、中国が学ぶところが多い。例えば、日本における弁当を中心とする中食産業が学ぶべきことの一つだと思います。

⑶　食糧作物のうち、稲は光合成能率が割合高く、生物エネルギー源も考えられている。将来世界の食糧生産態勢の中、どのように米を合理的に利用するのかは人類の食生活だけではなく、われわれの生存環境にも最も重要な課題である。

Characteristics and Utilization of Rice in Korea

Choi Hae-Chune

Korea Rice Technical Working Group & National Institute of Crop Science, RDA, Suwon, Korea

The rice production of Korea continues to be self-sufficient since 1975, except in severely cold years. However, the self-sufficiency in cereal food supply is about 54% and that of cereal supply including live-stock feeds is only below 30%. Rice, the Korean staple food, currently provides 20% of farmer's income, 41% of agricultural income, about 35% of caloric intake per capita, and about 21% of protein intake per capita.

Continuous improvement of Tongil-type high-yielding rice in 1970s and subsequent development of high-yielding and high-quality japonica rice during 1980s～1990s played a major role not only in ensuring self-sufficiency of rice production but also in enhancing the competitiveness of rice products against free trade.

The main target of rice breeding in Korea is improvement of yielding capacity, suitability for labor-saving, low-cost and safe grain production and the marketing quality and palatability of cooked rice.

The major characteristics and utilization of japonica rice in Korea were introduced briefly. The cultivation area of specialty rice including the glutinous rice is only about 1.5% of the total rice cultivation area since its usability and processing have not been fully developed.

1. Improvement of major agronomic characteristics

The japonica rice cultivars were greatly improved in lodging tolerance through introduction of semi-dwarf gene, stiff culm, and erect plant type since 1980. The maturity of rice cultivars was also diversified from extremely early to medium-late maturing since 1970s, which largely contributed to increasing the grain yield in alpine and mid-mountainous areas, as well as, in lowland areas.

The resistance to stripe virus disease in japonica rice was introduced since 1975. In addition, high-quality japonica rice cultivars were extensively improved for resistance to major diseases and insect pests since 1980. The resistance to brown planthopper in japonica rice was introduced since 1982. Japonica rice cultivars were considerably improved in terms of tolerance to environmental stresses such as resistance to lodging, cold injury, and salt stress etc..

Improvement of grain quality gradually continue not only toward to better palatability and slow retro-gradation of cooked rice and high milling recovery and head rice ratio, but also toward wider diversification of morphological and physicochemical characteristics of rice grain for diverse food-processing utility and enhancement of hygienic functions. The grain quality of japonica rice cultivars was improved in both grain appearance and palatability of cooked rice continuously since 1980. The diversification of food-processing utility was realized by the development of specialty rice cultivars such as large kernel, chalky endosperm, aromatic, dull, colored , opaque nonglutinous, high-dietary-fiber rice, and so on.

2. Utilization of rice

The general high-quality rice is consumed mainly for cooked rice. The amounts of rice consumption for food processing is about 7.4% of total amounts of rice consumption. The rice for food processing is utilized mainly for the steamed rice cake (52.1%) and rice wines (21.4%). However, the rice wines cover approximately above 60% of money scale of processed rice food market.

The specialty rice such as aromatic, colored, and semi-glutinous rice is also mainly consumed for cooked brown rice mixing in general high-quality rice. The large kernel and low-amylose rice is suitable for both popping and brewing. The high-amylose and high-protein rice is desirable for processing rice noodle or rice bread.

The non-glutinous rice having opaque endosperm showed better rooting density of mycelia and higher saccharogenic power in *Aspergillus oryzae*- fermented rice, and higher pigment concentration in *Monascus anka*-fermented rice as compared with semi-glutinous or ordinary non-glutinous rice. It is utilized for processing the traditional rice wine.

The pigments of colored rice are very useful for traditional colored rice cakes or for brewing colored rice wine.

The high-dietary fiber mutant rice revealed a considerable "health effect" by reducing the blood glucose and insulin levels in both normal and obese or diabetic participants after feeding the rice orally. It should be an excellent candidate for processing the low-digestible, low-calorie "healthy" food products.

Since the giant-embryo rice generally exhibited 6~8 times increase in ɣ-aminobutyric acid concentration as compared with nonsoaked one when soaked for 4 hours, the soaked and/or germinated one is useful for producing various rice foods with high "healthy" elements.

Reference

Choi HC. 2002. Current status and perspectives in varietal improvement of rice cultivars for high-quality and value-added products. Korean J. Crop Sci. 47(S): 15-32.

Choi HC. 2004. Current status of varietal improvement and utilization of specialty rice in Korea. Proceedings of the World Rice Research Conference held in Tokyo and Tsukuba, Japan, 4-7 November 2004. In: Rice is life; Scientific perspectives for 21st century: 272-275(CD). Edited by Toriyama K, Heong KL, Hardy B.

日本における米利用の現状と展望

大坪　研一

新潟大学農学部

日本における一人当たりの米消費量はこの約５０年間、減少し続けている。日本の食料自給率（カロリーベース）は、約４０％と、先進国中、最下位である。水田は、米の生産のみならず、洪水の防止、自然景観の保持、バイオトープの保存、文化の起源、都会と田園地帯の住民の交流の場としても意義がある。したがって、米の消費を拡大し、水田を保持する必要がある。

日本における米消費の９０％は米飯としての主食用である。日本国民全員が米の食味に敏感である。日本では、白くてつやがあり、柔らかくて粘りのある米飯の方が、硬くて粘りのない米よりも好まれる。新潟県産コシヒカリは、日本で第１位にランクされているが、他県の人も、新潟コシヒカリに追いつこうと努力している。最近の地球温暖化は、日本にとって米の量と質との両面から大きな問題となっている。

米の食味評価には、官能検査と物理化学的測定とが用いられる。前者は基準的な方法であり、後者は客観的な方法であり、相補い合って両方が必要とされている。

主食用以外に、米は、清酒、味噌、米菓、米粉、餅、米酢などに加工される。消費者の食品表示に対する信頼性を確保し、育成者権を守るために、米および米加工品の DNA 品種判別技術が開発されている。

最近、農林水産省では、米消費を拡大するために、米粉の新規利用を推奨している。小麦と異なり、米は硬いので粉砕しにくい。米粉の場合は、水とこねてもグルテンを形成しないので、パン、麺、菓子の原料には不適とされている。これらの問題を解決するために、新潟県食品研究センターの研究者らは、優れた米粉製造方法を開発した。二段階製粉や酵素処理技術により、米から微細粉を製造することが可能となった。米粉パンや米粉麺を製造する技術もまた、新潟県で開発された。

高アミロース米、低アミロース米、香り米、色素米、糖質米などの新形質米品種は、多様な新加工製品や機能性食品の開発にとって有望である。

高圧加工、発酵、発芽、高圧加熱押し出し等の先端技術の導入は、米の新規有望食品の開発にとって有益と考えられる。

U.S. Rice: Enhancing Human Health through Research

Elaine T. Champagne

USDA ARS Southern Regional Research Center
New Orleans, Louisiana

A vision of the U.S. rice industry and the USDA Agricultural Research Service (ARS) is to improve human health through the development of germplasm and technologies for products that capture the unique nutritional benefits of the rice grain. This presentation will give an overview of research conducted at ARS directed at developing new technologies for health-promoting foods and ingredients. Research aimed at using traditional breeding tools to enhance the health-beneficial properties of germplasm will also be discussed.

In 2007, the U.S. produced 8.98 million metric T of rice on 2.75 million acres in six states: California, Arkansas, Louisiana, Texas, Missouri, and Florida. Arkansas produces roughly 50% of the U.S. rice crop (4.33 million metric T), 92% of which is long grain rice. California is the second highest producer at 1.97 million metric T with 83% being medium grain rice. Approximately, 1.6 million metric T of rough rice, 371,300 metric T of brown rice, and 2.3 million metric T of white rice are exported. The remaining 7.4 million metric T of rough rice is milled to yield 62,000 metric T of brown rice, 2.6 million metric T of white rice, and 506,660 metric T of bran that go into the U.S. domestic market.

This year brown rice has taken on new life as a whole grain food. In May, 2008, the Food & Drug Administration announced that it has extended the existing whole grain health claim *"Diets rich in whole grain foods and other plant foods and low in total fat, saturated fat and cholesterol may reduce the risk of heart disease and some cancers"* to include brown rice. This is a positive public health development that will help consumers increase their whole grain consumption. Brown rice, however, has marketing challenges. It has a short shelf life of 3-6 months due to lipolytic hydrolysis and oxidative rancidity. The rice takes 45-50 minutes to cook and has a mealy texture and sticky, gummy surface. ARS scientists have invented a process for quick-cooking brown rice. Brown rice is blasted with parboiled rice flour to create microperforations in the waxy layer. The result is a product that cooks in 15-20 minutes, has texture similar to white rice, and retains all of the nutritional value of untreated brown rice. The process has been patented (U.S. patent 6,585,036) and licensed.

In recent years, brown rice has been introduced to the U.S. consumer in ready-to-serve packages, entrees, and packaged rice mixes.

ARS breeders have developed new specialty rice cultivars in recent years with specific health benefits. Lavaca is a long grain rice that cooks with increased cooked volume. This cultivar has potential use in reduced calorie rice dishes (appears to be more rice than there is). Neches, a long grain waxy cultivar, has potential to serve as a fat replacer in yogurt, salad dressing, etc. IAC 600, a black aromatic rice developed in Brazil and planted in the U.S. through collaboration, has high phenolic content and high antioxidant activity. ARS scientists are also focusing on stacking new traits (vitamin E, iron, zinc) into Golden Rice and conducting basic research on new factors influencing mineral bioavailability from this rice.

Rice, in brown and white forms, is found as an ingredient in cereals, baby foods, chips, snack bars, crackers, and pasta. Dairy alternatives that are lactose-free (beverages, ice cream) can be produced with rice. Rice protein is hypoallergenic and gluten-free. Rice starch has the mouthfeel of fat allowing these products to be formulated as low or no fat. ARS scientists have developed, patented, and licensed a technology for a low-oil uptake, gluten-free rice batter that, in addition to excellent adhering and frying properties, absorbs 60% less oil than a traditional wheat batter when applied to chicken and fish.

Rice bran contains numerous phytonutrients with health-benefits. ARS research has shown that rice cultivars with purple and black bran have phenolic and antioxidant activity many times higher than rice with light-colored bran coats. Defatted rice bran has been shown by ARS to markedly slow down fat oxidation in hamburger patties. Full-fat rice bran requires stabilization. ARS scientists have identified cultivars with very low esterase activity resulting in bran markedly more stable to rancidity. Rice bran wax, which contains healthful policosanols, was shown by ARS to form a film with pullulan that has superior moisture-resisting properties and can be used as coating barriers or as carriers of flavor and nutritional additives. Industry has developed uses for rice bran extracts as food processing aids and markets components as nutraceuticals.

The future is promising for the development of more health-benefiting rice products.