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Production of Aromatic Instant Rice and Effect of Storage Condition of 2-Acetyl-1-Pyrroline

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Abstract

Aromatic instant rice is preferred by consumers all over the world due to its flavor and palatability that has been precooked and dehydrated so that it cooks more rapidly. Although large number of them is available, little analysis of the genetic diversity has been done at molecular level so far. The invention provides a process for the preparation of quick cooking rice having natural appearance and smooth mouthfeel. The rice is produced by manipulating wet rice at moisture content from more than 17 to 32% wt/wt, by wet milling the rice to remove bran, followed by drying. The wet milling results in a product with quick cooking properties, superior cook yield and eating properties. The mechanically manipulated wet rice can also be instantized after the wet flexing step to produce instant rice. The stability of flavor component of 2-acetyl-1-pyrroline in aromatic rice depends on the storage condition at 4 C.
Key words : Instant aromatic rice, Parboiling, 2-acetyl-1-pyrroline, Appearance, Storage condition.

Rice (*Oryza sativa* L.) is one of the leading food crops of the world, growing in over 1.5 billion hectares of land having overall world wide production of 596 million tons per annum (FAO 1999). Rice is a staple food for more than one half of the global population. India alone produces nearly one fourth (22%) of the rice in the world, next only to China (1). It is one of the very few crop species endowed with rich genetic diversity which account over 100,000 landraces and improved cultivars and makes it one of the most researched crop with wealth of scientific literature on all its aspects. Most of the information we have so far is about common varieties, and our knowledge on aromatic rices is still incomplete. An ever increasing global demand for aromatic rice has been noted in the recent times. Chaudhary et al. (2) have discussed the economic aspects of aromatic rice detailing current trends, consumption pattern and global market demands as because consumers have become more quality-conscious toward the rice that they consume. The mature rice grain is harvested as a covered grain, called paddy or rough rice. On removing the outer cover, brown rice is obtained. On suitably polishing brown rice, milled rice is obtained which is consumed by the people after cooking. The rice grain consists of a large amount of starch, protein, fat, minerals, fibrous matter and water soluble B vitamins. Therefore, the requirement to improve the quality of rice leads linking farmers to consumers. About 90% of the worlds' rice farmers and consumers are in Asia where rice provides up to 75% of the dietary energy and protein (3). The most effective economical means of improving grain quality without any adverse effect on the yield of rice is the variety improvement (4—6). In addition to variety, agronomic condition such as location and season year may affect quality. Cultural practices also can affect quality. Proper post harvest handling of the crop in terms of threshing, drying and storage can also maintains the quality and reduces the losses of stored produce.

Nutritional Quality of Rice

Rice is the principal source of energy and protein in the diet of people in tropical Asia. Rice-starch more specifically, its amylose-amylopectin ratio is the major factor involved in cooking and eating quality. Milled rice protein has one of the highest quality proteins among the cereal proteins. The protein content of brown rice and milled rice is affected by both variety and environment (7). Applied nitrogen fertilizer has been found to be an environmental factor that also affects the protein contents of rice (8). About 80% of the non-starch lipids of brown rice is present in bran (9). The mineral composition of rice depends on the availability of soil nutrients during the crop growth period. Generally, minerals are present in higher levels in brown than in milled rice (10). Milled rice is also an important source of B vitamins in the diet. Season, variety and degree of milling affect the vitamin content and parboiling increases availability of vitamin B_1 in milled rice.

Types of Rice

Aromatic rice varieties are popular in South and Southeast Asia (11, 12) and have recently gained wider acceptance in the United States, Europe, and East Asia, especially in China. Because of their characteristic aroma and flavor, they are highly favored and command high prices in markets. The leading aromatic fine quality rice in the world trade, popularly known as Basmati, is traditionally grown in the North and North-Western parts of India (13). The total area presently under cultivation of Basmati rice is about 776,000 hectares in India and its production estimated at about 1196,000 tonnes during 1998-99. There is a substantial increase of basmati in traditional basmati growing areas.

With growing demand for aromatic rice in international market, high emphasis was placed till now on improvement of Gobindobhog rice. The improvement of indigenous small and medium grained aromatic rice, which possesses outstanding quality like aroma, kernel elongation after cooking, fluffiness and taste were neglected as they lacked export value. Almost every state of the country has its own qualitative aromatic rice that performs well in native areas. Aroma, elongation and taste of short grained aromatic rice are known to be superior to basmati types. Little attention has been paid to their improvement except for sporadic reports on germ plasm evaluation and genetics of some quality trait. As such there is very little information available on genetic diversity of traditional non-basmati indigenous aromatic rice. With introduction of high yielding varieties, the land races that include aromatic quality types are moving out of cultivation. Therefore, these varieties have to be collected and evaluated for their exploitable genetic variability and conserved. Further, management of the indigenous aromatic rice genetic resources by way of characterization and documentation helps in protection of these unique bioresources in accordance with the provision laid out in the 1992 meet on Conservation of Biological Diversity (CVT). A large collection of aromatic rice is available at several national and international Institutes including Central Rice Research Institute, Cuttack, India.

The rice millers prefer varieties with high milling and head rice out-turn, whereas consumers consider quality (14). Yields of head rice vary depending on many factors such as variety, grain type, chalkiness, cultural practice, drying, storing and milling conditions (15—17). To attract the consumers' attention, appearance of rice is important which depends on the shininess and chalkiness of the kernel. Size and shape are also important factor to consumer. Preference for grain size and shape vary form one group of consumers to another (18). High income group of people in Bangladesh prefer long slender grain, where as, lower income group prefer bold grain (19). The amylose content of rice is considered as the main parameter of cooking and eating quality (20). Amylose content, volume expansion, water absorption influences many of the starch properties of rice (21, 22). Cooking time is important as it determines tenderness of cooked rice as well as stickiness to great extent (19). Higher the imbibitions ratio of rice lower will be the energy content per unit volume or weight of cooked rice, as they will have more water and solid materials (23). High volume expansion of cooking is still considered to be the good quality by the working class people who do not care whether the expansion is lengthwise or crosswise. Urban people, on the other hand, prefer the varieties that expand more in length than in breadth (24).

Fine rice may be graded as export quality rice with normal nutritional quality. Under these circumstances, lots of studies have been undertaken to analyse and evaluate the physico-chemical and cooking properties of fine instant rice varieties.

Instant rice, also known as minute rice, is rice that has been precooked and dehydrated so that it cooks more rapidly. Regular rice requires approximately 20 min to cook while instant rice needs anywhere between 5 and 10 min. Because it has already been cooked, all that is necessary to prepare instant rice is to simply re-hydrate it with hot water. Instant rice is most commonly used by the industry to make quick meals for consumers. It is typically mixed with seasoning and may be mixed with instant beans or vegetables to produce nutritive palatable rice.

Most of the studies emphasize processes for the preparation of quick cooking and instant rices. A conventional manufacturing process for making packaged rice includes freeze-dried rice which is consumed by the consumer by adding hot water. In the free dried process rice was washed with water to remove bran, and a predetermined amount of water was added to wash rice. The mixture was then heated to gelatinize cooked rice, and in order to remove pasty materials such as dextrin, and to separate cooked grains from each other, the cooked rice is subjected to large water flows and the pasty materials were washed away. Then a mass of wet grains of rice is subjected to a freeze-drying treatment, and the resultant freeze-dried (FD) rice is packed under vacuum in a package. The conventional FD rice manufacturing method is defective in that dextrin and other nutritious ingredients of rice is washed away in treating procedure for separating the cooked grains from each other. When cooked by the consumer, such rice has a reduced viscoflexibility, palatable taste, texture and lucidness or gloss as compared to ordinary cooked rice. The precooking and dehydration process creates tiny fissures and cracks in the instant rice grains, which makes it easier for boiling water to reach the center. Instant rice also cooks much faster than traditional rice because the added water reconstitutes the dehydrated grains. Some brands of instant rice can be completely reconstituted in as little as two or three minutes, but food experts suggest that instant rice should ideally take at least five minutes to prepare for maximum flavor.

Some other methods to prepare instant rice has also been studied where the paste material, or water soluble ingredients, are not washed away and the drying procedure for drying wet rice at a high temp is abolished, so that on cooking the packaged fast cooking rice the rice retains the original ingredients of the original raw material rice and retains good taste, flavor, lucidness as ordinary cooked rice, and the product can be easily and economically preserved for a long time. In this method, the raw material is washed to remove bran there from and is soaked in water for a predetermined time. Then the water is removed and a predetermined water of the washed rice is subjected to a heating treatment so that the β starch of the raw material rice is changed into α starch and at the same time the gelatinized rice grains may have a water absorptivity, and the resultant grains of rice are impregnated with an additive liquid so that swelled grains of rice in a loose non-sticking conditions are obtained. Thereafter a mass of the resultant grain is packaged by sealing the rice in an air evacuated package (25).

Another method of preparing a quick-cooking rice, consisting essentially of the following steps : Rice grains having all of its bran and germ layers intact were collected, rice grains were parboiled to gelatinize the starch in the grains, it was followed by partially drying the rice grains to a moisture content of about 17 to 35% by weight, then was followed by a milling process of milling the rice grains at a rice grain moisture content of about 17 to 35% by weight to remove substantially all of the bran and germ from the rice grains, whereby during the milling process the rice grains were mechanically manipulated in order to flex the rice grains, the flexing causing disruption of the individual rice grain's intracellular structure, resulting in a plurality of uniform weblike micro fissures on at least a portion of the surface of each grain, and then parboiled rice grains was dried to produce a quick-cooking rice that has a water absorption level greater that 230 g of cooked rice per 100 g of dry rice after cooking in excess water for about 8 min, wherein the individual rice grains are about the same in shape both before and after cooking as conventionally prepared parboiled rice grains appear both before and after cooking (26). A small amount of barley may be mixed with the raw material rice. The barley is composed of milled grains of pressed barley, and the rice/barley mix is then washed in water and soaked in water for a desired time and in then heated in a manner as described above.

The heating treatment for gelatinizing the raw material rice and making the same water absorptive is carried out by steam-heating, microwave heating, infra-red heating and far infra-red heating. During impregnation of the additive liquid in the heated cooked rice, the additive liquid and serve to swell the grains of the cooked rice. Cooling is done below 40C against the cooked rice grains for accelerating cooling of the heated rice.

According to US Patent No. 2438939 developed by Ozai-Durrani and stuttgart (27) rice was treated with moisture and heat in such a way as to gelatinize the starch and cause the grains to soften and swell substantially beyond their original size and then drying the swollen grains in such a manner as to preserve their enlarged size and produce a porous structure throughout the grains as a result of the shrinkage of the internal starch. The process results in a rice product comprising dried, separate, substantially gelatinized rice grains having of the order of twice their original volume and a porous structure capable of ready hydration to individual grains having the soft, palatable character of ordinary cooked rice. US Patent No. 4166868 developed by Ando (28) relates to frying compressed rice having a moisture content of 8—25% to form a puffed ready-to-eat rice product. According to US Patent No. 4233327 developed by Ando (29) relates to puffing and drying pressed rice having a water content of 8—25% by weight by hot air or high frequency dielectric heating to form an instant-cooking rice product. Although the "puffing" method results in a rice product having improved cooking times, the product has an unnatural appearance and modified mouth feel as a result of the altered shape, surface texture and size. Methods involving "extrusion" decrease the cooking time of rice by forming a pasta-like substance by extruding a mass of rice product. The above described methods are also disadvantageous since each requires at least one additional step and/or apparatus for the rice processing. The methods involving the reduction of the kernel thickness, for example, require the separate step of compressing the kernels.

Here, the rice grains are not subjected to mechanical action to modify their physical structure. Instead, molecular or internal structural modification of the chemical components of the rice grain is accomplished by the use of chemicals and heat treatment to facilitate penetration of water into the rice grains during preparation of the quick cooking rice and also during its final cooking to palatable condition.

These methods do not provide a quick cooking parboiled rice product having a natural appearance, flavor and/or mouthfeel. The natural appearance is important because, as widely accepted in culinary arts, the first impression of a food is generally visual. That is, the willingness of a person to eat a particular food depends largely on preconceptions as to appealing color and other visual cues. Appearance is an influential quality attribute pre-supposed by people to be an indicator of deteriorative changes undergone by food. Aroma and flavor can also be influential upon smelling and tasting. Thus, an irregular appearance increases the likelihood that a food will be rejected, and this phenomenon jeopardizes the acceptability of rice amongst the majority of rice eating cultures around the world. This is so to an even greater extent if the rice has a foreign flavor as a result of additives used to modify the cooking characteristics of the rice (i.e., enzymes or chemical reagents). It is desired that rice appearance be uniform and natural and that rice flavor be near bland and subtle.

Accordingly, it would be desirable to produce a quick cooking or instant rice having a natural appearance and flavor and a smooth surface texture without substantially altering the size and/or shape of the individual rice kernels and a method of making the same that does not significantly increase the cost and complexity in the manufacturing of fast cooked rice.

Besides the production of fast cooking rice, we have to look after the retention of aroma of the rice both for the qualitative aspect and consumers' acceptability. We know that, 2-acetyl-1-pyrroline, a "popcorn"-like flavor compound, was reported as a main active flavor component of aromatic rice (30). Also, this compound contributed to the "roasted aroma" of cooked beef and crusts of wheat and rye breads (31). The "aroma" characteristic of aromatic rice in sensory evaluation showed the strong correlation with its content (32). According to Yoshihashi (33), 2-acetyl-1-pyrroline is not formed either during cooking or the post harvest processes of aromatic rice varieties. Instead, it is formed in the aerial parts of rice plants while they are growing in the fields. Because this compound is present at a relatively low concentration, it can be easily lost via diffusion out from the rice. Thus, it is quite important to preserve the content to maintain its flavor characteristics during distribution of aromatic rice. Previously, 2-acetyl-1 pyrroline was analyzed using gas chromatography-flame ionization detector (GC-FID) (34) or gas chromatography-mass spectrometry (GC-MS). We also used GC-MS with a stable isotope dilution technique for its quantification (33).

Fat acidity of rice was the most commonly used as factor to determine rice deterioration during storage. Lipid oxidation is the major deterioration process during rice storage and releases free fatty acids and carbonyl compounds (35). These compounds were known to contribute to the development of the rancid flavor of rice. Lipase and lipoxygenase play important roles in determining rice quality because of the influence of their reaction products in lipid oxidation. However, the factors controlling oxidation such as genetic traits and storage conditions are still not clearly understood. Far acidity is expected to increase during the storage of aromatic rice, whereas 2-acetyl-1-pyrroline content is expected to decrease. Thus, it seems that fat acidity could be an alternative indicator for the prediction of 2-acetyl-1-pyrroline change during storage. Consequently, a quite simple and quick method for fat acidity, which is a commonly used index for rice inspection or quality evaluation, can be easily adopted to estimate probable "aroma" quality of aromatic rice under laboratory condition with a moderate level of equipment.

2-acetyl-1-pyrroline is a highly volatile and lipophilic compound. Rice lipids are known to occur in both free and starch bound forms. Free lipids adhered on the surface of starch granules are ether-extractable, even at room temperature. However, higher extraction temperatures using ethanol are required for extraction of bound lipids located inside of starch granules. Because of the lipophilic characteristic of 2-acetyl-1-pyrroline, free and bound 2-acetyl-1-pyrroline are assumed to occur. Understanding the occurrence of 2-acetyl-1-pyrroline is believed to be essential for the production of aromatic qualitative rice which will have market value.

The effect of package and temperature on 2-acetyl-1-pyrroline content in milled aromatic rice during storage was investigated. 2-acetyl-1-pyrroline content was decreased faster at higher storage temperature. However, fat acidity of rice was increased during storage and inversely correlated with 2-acetyl-1-pyrroline content at an early stage of storage.

Effect of Storage Time and Package

The content of 2-acetyl-1-pyrroline in rice for both production years was decreased during storage. This result agrees with results reported by Widjaja et al. (36), but there is no information available relating to the mechanism for changes in 2-acetyl-1-pyrroline content during postharvest processes. Authentic 2-acetyl-1-pyrroline on filter paper decreased rapidly at an early stage of storage test. 2-acetyl-1-pyrroline was reported as a highly volatile compound. Evaporation of authentic standard 2-acetyl-1-pyrroline in the same storage condition showed it to be relatively faster than that in rice. Moreover, during storage at 25 to 30 C and 75% RH, the concentration of 2-acetyl-1-pyrroline did not change significantly after 7 wk of storage. Therefore, it is suspected that there are other factors that hold 2-acetyl-1-pyrroline and slow its later release from rice. Package materials of rice affected the preservation of 2-acetyl-1-pyrroline ; however, the effect was only moderate during storage. Low density polyethylene (LDPE) did not inhibit penetration of 2-acetyl-1-pyrroline. Therefore, it is needed to test other package materials for better storage of aromatic rice.

Effect of Storage Temperature

With increased storage temperature, the content of 2-acetyl-1-pyrroline decreased even faster. Cold storage at 5 C in sealed LDPE bags preserved the contents most effectively. Generally, rice storage at low temperature retarded flavor quality deterioration caused by intermolecular reactions operating in parallel. Especially, enzyme catalyzed reactions were drastically inhibited at low storage temperature (37, 38). Because 2-acetyl-1-pyrroline is quite volatile, it is recommended that aromatic rice variety be stored and handled at a low temperature.

Effect of Milling Degree on 2-Acetyl-1-Pyrroline Preservation

The content of 2-acetyl-1-pyrroline in rice bran was higher than that in milled rice . Lower milling degree increased 2-acetyl-1-pyrroline content because of its higher recovery rate from rice bran. However, 2-acetyl-1-pyrroline content was relatively unchanged after 6 wk of storage. These results suggested that 2-acetyl-1-pyrroline in rice bran evaporated faster than that in rice kernel, where bound 2-acetyl-1-pyrroline was released with difficulty, even after a long storage period.

Effect of Extraction Temperature on 2-Acetyl-1-Pyrroline Recovery and Its Relationship with Gelatinization

We have reported that the optimal extraction condition for 2-acetyl-1-pyrroline recovery from milled rice sample was 2 h at 75 C, whereas the optimal extraction condition for seedlings or callus was at room temperature. This phenomenon suggested that the rice component, of which the structural conformation is changed at around 70 C, may keep or interact with 2-acetyl-1-pyrroline and be associated with its liberation from rice. Sood and Siddiq (39) reported the technique for rice aroma evaluation using alkaline solution or boiling, which induced starch gelatinization in milled rice samples. Furthermore, the gelatinization temperature of rice starch measured by using DSC was 63.7 C. In fact, extraction at 40 C was expected to liberate free 2-acetyl-1-pyrroline, which did not form a complex with starch. On the other hand, at a higher extraction temperature, the majority of 2-acetyl-1-pyrroline was believed to be extracted from milled rice (40, 41). The gelatinization process has resulted in collapses of starch structure and its complex with 2-acetyl-1-pyrroline. Therefore, it can be expected that starch-bound 2-acetyl-1-pyrroline in milled rice is liberated during starch gelatinization processes, such as during alkaline extraction or boiling.

Conclusion

The most accepted method for the production of aromatic instant rice is rice grains were parboiled to gelatinize the starch in the grains that was followed by partially drying the rice grains to a moisture content of about 17 to 35% by weight, whereby during the milling process the rice grains were mechanically manipulated in order to flex the rice grains, the flexing causes disruption of the individual rice grain's intracellular structure, resulting in a uniform weblike micro fissures on at least a portion of the surface of each grain, and then parboiled rice grains was dried to produce a quick-cooking rice that has a water absorption level greater than cooked rice after cooking in excess water for about 8 min, wherein the individual rice grains are about the same in shape both before and after cooking. 2-acetyl-1-pyrroline content in milled rice was decreased during storage. Hence, postharvest processes like drying, milling, and storage are particularly important for aroma and flavor preservation of aromatic rice. Therefore, it was assumed that storage and handling at low temperature would inhibit not only the generation of off-flavors but would also minimize volatilization of 2-acetyl-1-pyrroline from rice. 2-acetyl-1-pyrroline on filter paper decreased faster than that present in rice.

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