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Par Boiled Rice Boost its Nutritional Profile and Texture

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Abstract

Ultimately, it is the acceptability of the physical and chemical attributes of the final product that will promote the acceptance of a parboiled product. During hydrothermal treatment, the paddy undergoes some specific changes due to physical and chemical interactions. The extent of changes within the rice kernel depends on the processing variables applied during processing. Some of the major properties of parboiled rice are discussed in following headings.

Keywords: Milled rice; Water systems; Parboiled rice; Non parboiled rice; Rice kernel; Parboiling

Introduction

The water diffusion coupled with heat treatment causes the irreversible swelling of starch granules and hence the parboiled rice kernel is thicker and shorter than non-parboiled counterpart. This change was observed in the parboiling under excess water system but not in the limiting water systems such as dry heat and pressure parboiling process. The opaque white patches seen on the belly of the milled rice is the result of different cellular morphology of starch granules whereby chalky grains are packed loosely leaving some air spaces that scatter light and so look opaque. Chalkiness is a highly undesirable trait in all non-waxy rice varieties except for Arborio and Sake style rice. Due to the loose packing of starch there is more free volume within the kernel that can absorb more water than normal types [1]. The water diffusion and starch gelatinisation process during parboiling removes such air spaces and hence the reduces the chalkiness. In this respect, par-boiling increases the consumer appeal of the product. The colour of parboiled rice is different than the non-parboiled rice. Parboiled rice has a shade of amber colour possibly due to the diffusion of husk colour into the endosperm. Another cause has been reported to be the presence of an increased level of reducing sugar and free a-amino nitrogen and isomerisation of glucose to fructose suggest the likelihood of non-enzymatic Maillard type of browning for colour change in parboiled rice. The colour change in parboiled rice increases with increasing soak water temperature and increasing steaming duration as well as the increasing steaming pressure of inadequately hydrated grains. The husk colour absorption is also higher at high soaking temperature and the absorption of the coloured material from soak water also negatively affects the whiteness of the rice kernel. The parboiling temperature and duration has the significant influence on the hardness of the kernel. The hardness of the paddy decreases with the increasing soak water temperature and it increases with increasing steaming time. Parboiling also increases the ultimate tensile strength and modulus of elasticity of the rice kernel. These strength values are directly proportional to steaming duration and the degree of starch gelatinisation. The increase in strength may be the reasons why there is less breakage of parboiled rice when milled and why parboiled rice has altered texture than non-parboiled rice when cooked [2].

Discussion

The parboiling process was found to impart the increased protein, lipids and ash content of rice kernel. The chemical composition also differed due to different par-boiling processes. For example, parboiled rice produced with high soak water temperature was reported to be less in lipid content, higher in thiamine content but experienced higher starch leaching. Whereas, the increasing steaming period decreased protein, calcium, iron and sodium but increased the fat, total ash and crude fibre content in parboiled rice [3]. The chemical composition at a molecular level significantly influences the characteristics of the cooked parboiled rice that the consumer will ultimately base their preferences on. Due to gelatinisation during the heating/cooking process, starch is irreversibly swollen in the parboiled rice. It is also thermally broken down to low molecular weight products depending on the time/temperature combination during processing. The different methods of parboiling, which differ in time/temperature combinations, will have significantly different extent of starch breakdown. The effect of starch breakdown on the cooking and eating quality of parboiled rice has not been reported in detail. The total protein and amino acid content of parboiled rice does not change although the protein bodies in the kernel are ruptured during the steaming process. The protein is hydrolysed leading to increased disulphide bonds which increases the viscosity and hardness in the parboiled rice. If the ageing of rice is connected with the change in protein structure and conformations, a study of this change in double boiling parboiling process could be of significant importance because the rice produced from this method imparts the aged characteristics. During parboiling, the lipid bodies or the spherosomes of the non-starch lipids are broken and fat is released from the surface of kernel [4]. This band of lipids is diffused outwards and hence the bran of parboiled rice is more oily whereas the parboiled rice kernels are less in lipid content than brown rice. The parboiled rice is reported to retain more B-vitamins than raw rice. Parboiled rice has more thiamine and nicotinic acid than milled rice. Despite the fact that these two vitamins are lost during par-boiling, the parboiled rice is still richer in these vitamins than milled rice because the white rice loses these during polishing [5]. Thiamine content in the parboiled rice increased gradually as parboiling intensity was increased from initial soaking temperature at 30°C and steaming for 4 min to soaking at 70°C and steaming for 12 min. There was a sharp rise in thiamine when the soaking temperature was further increased to 90°C and steamed for 12 min. The gradual increase in thiamine content with the severity of heat treatment indicates the possibility of the formation of this vitamin during thermal treatment. But this hypothesis can only be concluded

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after proper investigation. Whereas, the riboflavin level showed a different pattern because it increased with parboiling with increasing temperature of soak water up to 70°C but beyond that it decreased. The loss of vitamins A and C was also observed after parboiling which was directly related to the severity of temperature. The reasons behind the increased level of B-vitamins despite some loss have been reported due to the inward diffusion of these vitamins from bran layer to endosperm during the parboiling process. But a previous study done by Rao and Bhattacharya showed that the increase in the level of thiamine did not occur during soaking but it happened after steaming. It was postulated that the gelatinisation fixes this vitamin and that is why the parboiling process strongly prevents the milling loss of these vitamins. The disagreement between the work by Subba Rao and Bhattacharya and Pauda and Juliano makes a topic of further research to determine whether the increase in the level of B-vitamins is due to inward migration during soaking or fixation or both or even the product of thermal degradation [6]. Texture of the rice grain after cooking is the principal quality attribute dictating the consumer acceptability and palatability which is expressed in terms of hardness or firmness and stickiness or adhesiveness as well as moistness to touch. The texture of the cooked rice grain is mainly affected by the genetic variability, storage duration and parboiling. The major varietal factor that controls the texture of cooked rice is amylose content. The high-amylose rice becomes flaky and dry upon cooking whereas low-amylose rice is sticky and moist. The freshly harvested rice cooks sticky and lumpy as compared to the aged samples of the same variety. Cooked par-boiled rice is more fluffy, non-sticky and free-flowing than non-parboiled counterpart. The gelatinisation, thermal breakdown of starch and the re-crystallisation of the starch with some lipid–amylose inclusion complexes are the major factors that cause the texture change in parboiled rice. The type of starch polymorphs formed during particular parboiling process is important in determining the final texture of cooked parboiled rice [7]. The gelatinisation temperature of the rice is not variety-specific, and varies due to environmental and other factors. Gelatinisation is related to cooking time and texture of the rice [8]. Knowledge of the gelatinisation temperature prior to parboiling is useful in hot-soak parboiling processes to adjust the temperature of soak water. For example, paddy with high and intermediate gelatinisation temperature can be soaked in hot water of 70°C whereas the paddy with low gelatinisation temperature will be over hydrated at this temperature if soaked for the same period as the paddy with high gelatinisation temperature. Parboiling process increases the gelatinisation temperature of rice which is proportional with the severity of the heat treatment. Viscosity provides inferences to the final texture of the cooked product. The peak viscosity, breakdown, final viscosity, set back time to peak viscosity and pasting temperature are typical parameters recorded by rapid visco-analyser to assess the pasting properties of cooked rice [9]. The viscosity curves are variable with the moisture, protein, lipid and amy-lose content of the rice samples. The increase in pasting temperature, reduction of peak viscosity, elevation of final viscosity and the reduction in the breakdown and total setback time are the major changes due to parboiling. The high-amylose starches are intensely affected by parboiling than medium- and low-amylose starches. The factors in controlling the material properties of parboiled rice are the diffusion of water and other compounds into and out of the rice grain, starch gelatinisation and retro-gradation and the protein denaturation and disulphide linkage. Diffusion is a key parameter to dictate the final quality of par-boiled rice. The diffusion properties of rice depend on a number of factors including grain structure, composition, post-harvest pro-cessing, temperature and moisture content [10]. Fick's second law of diffusion has been widely used to determine the diffusion behaviour in grains during soaking and drying. Researchers have also applied semi-theoretical models to understand the diffusion process in the rice grain.

Conclusion

Gelatinisation and re-crystallisation are the major changes in rice starch that occur during parboiling. During gelatinisation the swollen starch granules melt and the phase transition of starch occurs. And in re-crystallisation process, the starch exhibits polymorphisms which contribute the final texture of cooked parboiled rice.

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Conflict of Interest

None

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Table 1: (Source) Characteristics of food production systems with increasing commercialization **(**Summarized from Goletti, Purcell, and Smith (2003), Pingali (2001) and Pingali and Rosegrant (1995).

Characteristics	**Subsistence System**	**Semi-commercial System**	**Commercial System**
Farmer's objective	• Food self sufficiency	• Surplus production	• Profit maximization
Source of inputs	• Household generated (non-traded)	• Mix of traded and nontraded inputs	• Predominantly traded inputs
Production mix	• Wide range	• Moderately specialized	• Highly specialized
Marketing	• No or very little marketable surplus	• Larger amount of marketable surplus	• Increased concentration on production for market
Income Source	• Predominantly Agri	• Agriculture & Non Agriculture	• Predominantly Non Agriculture
Technology	• Labor intensive • Undeveloped post-harvest operations • Little agro-processing	• Intensification and increased use of modern technology • More capital intensive • Increased use of post-harvest operations • More agro-processing	• High-importance of post-production activities • Highly capital intensive
Supporting infrastructure and services	• Poor transportation infrastructure • No rural electrification • Mostly rain-fed • Weak linkages with research and extension	• Improved road infrastructure, but access difficult in many areas • Rural electrification in towns and nearby areas • Irrigation schemes • Greater role of public and private research and extension	• Good year-round road access • Rural electrification available to all farmers • Year-round irrigation • Agricultural information, technology, and inputs provided by private firms