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Review Paper

SENESCENCE STUDIES ON GRAINS: REVIEW

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Abstract: Senescence of biological material is one of the typical steps between harvest and consumption. During ageing, a number of physiochemical properties occurs. Normally, during ageing of freshly harvested produce, there is an increase of volume expansion and water absorption observed. The conventional (natural) ageing of rice takes a relatively long time. This ageing method also requires much space for storage of grain, thus leading to high operating cost. Furthermore, grains undergoing ageing is susceptible to damage from insects, microorganisms and rodents. It is therefore necessary to explore the accelerated ageing techniques that can reduce the ageing time and operating cost, while at the same time can maintain the rice properties such as appearance and texture to be similar to those obtained by the conventional ageing process.

Keywords: Artificial ageing, Fluidized bed, Maize, Microwave, Rice, Senescence.

Introduction

Senescence of biological material is one of the typical steps between harvest and consumption. During ageing, a number of physiochemical properties occurs. Normally, during ageing of freshly harvested produce, there is an increase of volume expansion and water absorption observed. Freshly harvested grains, when cooked, usually becomes a sticky or pasty mass, swells only slightly and losses a fair amount of solids (starch) into the cooking water yielding a thick gruel. Upon storage for a minimum period of 3 – 4 months, the rice swells more easily with less stickiness and the gruel becomes thin, its linear elongation upon cooking is more than in fresh rice. In addition, aged grains has higher volume expansion ratio and water absorption and results in less dissolved solids on cooking. Preferences for new or old grains differ among different population. New grain is preferred in Japan, Korea, Laos and China; whereas aged grain is desired in the countries like India, Pakistan, Bangladesh and Sri Lanka.

Rice - Natural senescence

The natural ageing of rice requires much space for storage, thus leading to high operational cost. Furthermore, rice undergoing ageing is susceptible to damage from insects,

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microorganisms and rodents. Noomhorm *et al.* (1997) carried out the experiment on two Thai cultivars of ground glutinous rice (RD6 and RD8) and discovered the effects of ageing on physicochemical properties. Stored rice tends to have a lower rate of water absorption that increases proportionally with the soaking time. Samples of both rice cultivars were used to make rice crackers to study the effects of ageing on quality. The volume expansion of rice crackers from cultivars RD6 and RD8 tended to decrease during storage, which resulted in an increase in the hardness of the cookies. Faruq *et al.* (2003b) investigated to discover optimization of ageing time and temperature for four Malaysian rice varieties, Mahsuri, Mahsuri Mutant, NS 9192 and Putri (Q-50). It was also observed that the variety, temperature and time significantly influenced the ratio of elongation, proportional change, and actual elongation. Variety time interactions, variety temperature interactions and variety temperature time interactions also significantly influenced these physical characteristics of rice grain. The interaction of the temperature time did not significantly influence the elongation ratio, but this interaction influences the proportional change and the actual elongation.

Change in properties during ageing

The physicochemical and textural properties of brown and ground rice were determined using an Instron universal test machine. Steam at higher levels of moisture content increased elongation, width expansion, water absorption, cooking time and decreased solids loss. Gujral and Kumar (2003) studied the physico-chemical and textural properties of brown and ground rice. The hardness, cohesiveness and elasticity of cooked rice increased when its adhesiveness decreased. The extent to which these changes occur seems to depend on the moisture content of the rice before steaming. At higher moisture levels, the severity of the treatment increased due to increased gelatinization of the starch. The extent to which these changes are desired can be controlled by changing the moisture content of rice before accelerated ageing or by the duration of the accelerated ageing treatment. Accelerated aged rice can be prepared by this short time process to produce rice having better and more desirable cooking properties.

The enthalpy of relaxation, measured by DSC, gradually increased with the ageing time, reaching a structural equilibrium. The maximum temperature of the relaxation endotherm in the DSC thermogram increased linearly with the logarithm of the ageing time. Relaxation kinetics revealed that the relaxation rate was much slower for normal rice starch than for waxy rice starch. The storage modulus increased by ageing, but the peak height was reduced,

indicating that the mobility of the vitreous starch chain was reduced by ageing. Chung and Lim (2004) studied the physical ageing of glassy amorphous (normal and waxy) rice starches (14.5% moisture) and characterized by their thermal and mechanical properties, using a differential scanning calorimeter (DSC), thermal analyzer Dynamic (DMTA), and Instron textrometer. Water absorption and volume expansion increased during the ageing period. Similarly, the length of cooked grain was minimal in freshly ground rice; gradually increased with the storage period and obtained a maximum value after 2 years of storage. The loss of total solids in the wash water and slurry was the highest at the beginning of the experiment, which decreased significantly and reached the lowest value at the end of the studies. Ali *et al.* (2004) studied the influence of ageing on the physicochemical properties of milled rice grain Basmati rice 385. The newly harvested rice stored in a cloth bag at room temperature. Rice analysis was performed for 24 months, starting from zero to a uniform interval of one month. However, the effect of ageing on protein content, the extent of alkali and gel length was not significant. The amylose content decreased slightly during ageing but remained in the intermediate amylose group.

Rice - Accelerated senescence

Archana *et al.* (2007) carried out the experiments to study the effect of accelerated ageing on the physico-chemical characteristics of two Basmati varieties ('Pusa Basmati-1', 'Pant Sugandh Dhan-15') and two non-Basmati varieties Wet milled rice at 90 ° C and 80% RH for 2 h, and iii) treatment with steam at 50 ° C for 7 days, rice for 10 min. The ground rice of the 'Basmati' and not 'Basmati' varieties, when subjected to curing treatments, showed a significant increase in length and L / B ratio, apparent density and true density and a significant decrease in their amplitude and thickness and porosity. The weight of one thousand grains and the moisture content increased with (ii) and (iii) and decreased with (i). During curing a significant decrease in amylose content, water soluble amylose content, gel consistency and non-reducing sugar content and increase in reducing sugars were observed for both control and experimental samples of Basmati and not Basmati. Faruq *et al.* (2003a) investigated to discover the influence of ageing on four popular Malaysian rice varieties, Mahsuri, Mahsuri Mutant, NS 9192 and Putri (Q-50). In artificial ageing, the above varieties were incubated at 90, 100 or 110 ° C for 1, 3, 5, 7 or 9 h, where as in natural ageing the selected varieties were kept in a sealed container at room temperature.

Maize

Ageing caused associations between the starch granules, the protein matrix and the cell walls. During ageing, the endosperm flour areas became more corneous as endosperm hardened, strong associations were developed between the starch and the protein, causing the endosperm to fracture through the endosperm cells rather than along the cell walls, which is common for unripe corn. Physically, the hardness and density of maize and sorghum decreased due to gaps and cracks developed during the ageing process. McDonough *et al.* (2004) studied the effect of accelerated ageing on maize, sorghum and sorghum flour. The effects of ageing on sorghum flour were more pronounced than on sorghum grain, indicating that ageing affected food faster than whole grain, or the milling process after storage partially reversed some of the effects of ageing. . The solubility of the albumins and globulins decreased while the solubility of the proteins extracted by a reducing agent or at alkaline pH increased during ageing. The decrease in the solubility and functionality of starch and protein in the aged grain appears to be due to the oxidation of the protein. Gonzalez *et al.* (2010) studied the physical ageing of the starch components of corn flakes prepared with two different levels of starch fragmentation using thermal and rheological methods. In general, flakes having greater starch fragmentation absorbed more water and the percentage of water taken decreased with the ageing time. Scales with low starch fragmentation showed little or no change in water absorption during ageing.

Effect of fluidized bed drying

Soponronnarit *et al.* (2008), in a comparison study of physicochemical properties of accelerated and naturally aged rice, found that a combination of fluidized bed drying and tempering was capable of improving the properties of the rice, ratio of elongation, whiteness, volume expansion , Water absorption, loss of solids and sticking properties at levels similar to those of naturally aged paddy. Suitable conditions for accelerated ageing were at a drying temperature of 150 ° C followed by quenching for at least 90 minutes. Jaisut *et al.* (2009) used the high temperature fluidized bed drying technique in combination with the annealing stage for accelerated ageing of the rice. The quality of rice dried at temperatures of 130 and 150 ° C and tempered for 30 to 120 minutes was compared to that of rice stored at room temperature (about 30 ° C) for 7 months. The cooking and food properties of the fluidized bed dried rice, i.e. hardness, loss of solids, volume expansion and elongation ratio, were shown to change similarly to conventionally aged rice.

Effect of packaging materials

Kaur and Chand (2011) investigated the natural ageing of basmati rice. It was stored at room temperature for 5 months in three different packaging materials like lined polyethylene, high density polyethylene and low density polyethylene bags to study rice quality. Physicochemical and cooking properties like cooking coefficient, elongation, increased water absorption during the ageing of rice stored in different containers. Amylose content, cooking time, loss of solids in the gruel decreased with the ageing of the rice. Textural properties such as hardness, cohesiveness, elasticity, gumminess and mastication increased with ageing. The physico-chemical properties of the rice correlated well with its cooking and texture properties. The loss of solids in the slurry was minimal (1.29%) for storage in HDPE followed by LDPE and polyethylene bag.

Effect of microwave

Le *et al.* (2014) reported that microwave heating can be applied to accelerate the ageing of white rice and rice with two microwave powers (1000 and 2000 W) and six exposure times (23, 26, 31, 41, 66 and 159 Seconds). The yield, color and consistency of the overhead gel was determined for the untreated and microwave treated sample. The cooking time of the white rice decreased while that of rice increased compared to the control samples. The consistency of the gel increased and varied depending on the shape of the rice and the time of exposure. The effect of microwave potency and exposure time was different between rice with white rice and rice on different ageing properties of rice. Rice treatment was more effective as an accelerated rice ageing agent.

Conclusion

The cooking quality of grain is one of the important factors influencing the acceptability of consumers. Cooked grain that is generally preferred and by people in some Asian countries, including Thailand, is one that large volume and non-sticking. Such desirable properties are generally obtained by storing paddy for a certain period of time before further processing; the process that is known as ageing. The conventional (natural) ageing of rice takes a relatively long time, approximately 4-6 months. This ageing method also requires much space for storage of grain, thus leading to high operating cost. Furthermore, grains undergoing ageing is susceptible to damage from insects, microorganisms and rodents. It is therefore necessary to explore the accelerated ageing techniques that can reduce the ageing time and operating cost, while at the same time can maintain the rice properties such as appearance and texture to be similar to those obtained by the conventional ageing process.

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