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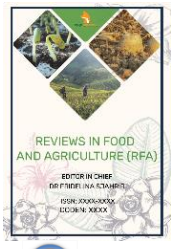

REVIEW ARTICLE

IMPACT OF POSTHARVEST OPERATIONS ON RICE GRAIN QUALITY: A REVIEW

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ABSTRACT

An efficient postharvest system aims to minimize the loss and obtained the good quality rice gain. This review summarizes the information regarding the postharvest processing published by various authors and outline the evidence that support the impacts of the postharvest handling on rice grain quality. Grain quality, includes a summary of the physical and chemical characteristics of rice grain. It has many components such as nutritional value, appearance, cooking and eating quality. Drying of rice mainly affects the milling quality, as most breakage of rice occurs because of grain fissuring. Rice ageing occurs during storage is responsible for the changes in pasting properties, color, flavor and chemical composition such as starch, protein, lipid etc. that affect rice quality. Therefore, research on various drying methods, storage conditions and milling methods should be maximized and maintain the desired rice grain quality. This review may contribute to understand the impacts of postharvest processes on grain quality and can increase the head rice yield.

KEYWORDS

drying, milling, storage, rice quality.

1. INTRODUCTION

Rice is the starchy seeds or grain of an annual marsh grass, *Oryzaisativai*, cultivated in warm climates and used for food. It is the most widely cultivated cereal crops and is used as staple food in many part of world, especially Asia and Africa. The production of paddy rice has reached 3.33 (tons/ha) in Nepal (2018) (http://ricestat.irri.org:8080/wrsv3/entrypoint.html). Nowadays, production of rice is decreasing day by day, due to the errors in postharvest operations that results in the postharvest loss which might be qualitative or quantitative. Rice quality refers to the characteristics of grains that are required for specific use by consumers according to their choices. More the rice quality, more is the market prices. So, proper postharvest operation should be performed to obtain good quality rice grain. In agriculture, postharvest operations is the handling of grains after harvest, including drying, milling, cleaning and storage. Several stages of postharvest handling of rice grains includes field drying, threshing, cleaning, grading, milling and storage. Postharvest processing is described in figure 1. In this review we will focus on the following postharvest operations; drying, milling, and storage.

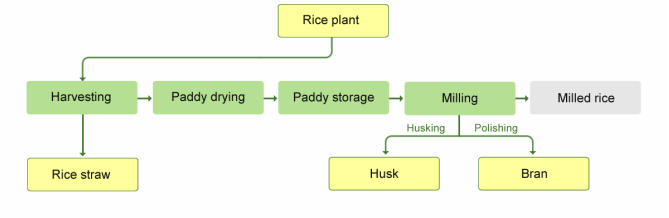

Figure 1: Postharvest operations (http://rkb.irri.org/step-by-step-production/postharvest/rice-by-products)

2. POSTHARVESTIOPERATIONS

2.1 Drying

Drying is a postharvest operation that reduces grain moisture content to a safe level for storage. It is the most critical operation after harvesting of rice. In rice, there should be 14 to 22% moisture content during harvest and the moisture content should be reduced up to 13% for storage (Mukhopadhyay et al., 2019). Storing of rice grains under high moisture conditions causes discoloration, increase in attack of pest, molds, insects etc. Paddy drying method include traditional and mechanical systems and technologies for either farm or commercial level.

2.1.1 Effects of Drying on Rice Grain Quality

Drying is more efficient and costs less for removing moisture. Quality of grain may deteriorate during drying due to overheating at high temperature and rapid moisture loss. The type of dryer greatly affects milling, cooking and eating quality of rice (Inprasit and Noomhorm, 2001). Milling quality is decreased by the uneven or over drying. Most breakage in the rice occurs because of grain fissuring before milling, which is caused because of readsorption of moisture by low moisture grains. High moisture content during harvesti and controlled drying process leads to the paddy fissure and causes breakage of rice (Alhend et al., 2019). Kernel fissuring during the milling causes breakage of grains and there by decreases the value of rice. Kernel fissure means fracturing of rice grain which is developed on either the inner or outer layers of kernel endosperm, that causes the kernel more likely to breakage (Tong et al., 2019). When kernels is dried to ≤15% moisture, then kernel fissures increases due to rapid adsorption of moisture (Sater et al., 2017). Moreover, the formation of fissure may also be variety dependent. Therefore, to decrease the grain fissuring and increase the milling quality,

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there should be strategies of proper drying and tempering based on varieties (Tong et al., 2019).

Another factor affected by drying is the appearance quality of rice. The important parameter to determine the appearance quality of rice is rice color. The temperature has a great impact on the discoloration of rice grains, i.e. drying of the rice for longer period with the high temperature causes yellowing of rice (Haydon and Siebenmorgen, 2017). The discoloration of the kernel increases with the increasing temperature and duration during drying. Therefore, kernel discoloration can quickly develop in high moisture content rice.

Drying affect the cooking, and eating quality of produced rice. The kernel length of different rice varieties with different whiteness and different moisture content changes after cooking. The elongation of rice during cooking is different due to difference in variety. The elongation property rice at certain moisture content for one variety may not be same for another variety at same moisture content and the elongation of cooked rice is about 60% more than the uncooked rice (Alhendi et al., 2019). The quality of produced rice can be evaluated by the increasing length of rice after cooking (Wang et al., 2007). With increase in drying temperature, the fatty acid content of rice decreases which results in a higher degree of rice ageing and reserve starch gelatinization during rice cooking. The main ingredients of rice that determines taste are protein, starch, lipid, and moisture. The chemical changes seen after rice ages is the conversion of neutral lipid into fatty acid and it produce a particular odour that is undesirable in taste. As paddy drying temperature increases, there is an increase in fatty acid content in rice. The taste value of rice decreases as the moisture content of rice is dropped to below15%, so in order to preserve rice taste quality, a drying temperature below 45 degree Celsius is recommended for drying paddy (Zheng and Lan, 2007).

2.2 Milling

Milling is a process in which rice grains in converted into the suitable forms for human consumption. The main purpose of rice milling is to produce edible grains by removing husk, brans layers and all other impurities. It is generally performed for grinding of the grain so that it can be easily cooked and rendered into an attractive food stuff. Total milled rice contains whole grains or head rice and broken rice grain. A rice milling system can be a simple one or two or a multi stage process.

2.2.1 Effect of milling on rice grain quality

The milling yield and quality of rice is dependent on the quality of paddy, the milling equipment used and the skill of the mill operator. Color of rice is imperative for sensory, as white rice or completely milled rice has more consumer acceptance as well as market value. The variation in color of rice depend upon the number of brans present in rice kernel and their rate of bran removal is depend upon the color intensity of rice grains and color intensity of bran varies with different varieties. With the increase in degree of milling, the lightness value and intensity of color of different rice varieties increases (Lamberts et al., 2007). Thus, the color of rice obtained is dependent on the degree of milling. Milling process bring changes in chemical composition such as composition of sugar, amino acids, vitamins, minerals and fats along with the changes in biological activities such as amylase or peptidase activities. The concentration of nutrients is generally affected by the concentration of nutrients. Degree of milling refers to the degree to which bran has been removed from kernel surface. The degree of milling affects the composition of various compounds such as sugar, amino acid, vitamin, minerals etc (Puri et al., 2014). Rice is composed largely of carbohydrates, with little protein, minerals, fatsi, etc. and about 84.2% of the kernels proteins are concentrated in outer endosperm, upon milling, further the concentration of protein decreases (Lamberts et al., 2007). The researchers also found that most of the minerals are present in bran fraction of the kernels where as starch is concentrated in the inner core of the endosperm of kernels. During milling operations, these nutrients decreases. Lipid are also concentrate on the bran layer of rice, but the bran decreases as the degree of milling process increases.

Cooking quality is another parameter influenced by milling degree. The milling process removes the bran layer which facilitates the movement of water into the core of rice kernels during cooking. Water uptake and length expansion of rice are generally influenced by degree of milling. The rice having high water binding capacity during cooking generally gives soft textured rice (Mohapatra and Bal, 2006). Parboiled rice (rice which has been partially boiled in husk) on cooking retained good shaped which result in low solid loss in cooking and its also found to be less sticky. Rice which is milled to lower degree are less adhesive and cohesive as they are hard and they take more time in cooking as well as yield low volume and length expansion as compared to rice milled to higher degree (Mohapatra and Bal, 2006). The rice milled to lower degree has more consumers acceptability as they are being more health conscious nowadays. Therefore, more emphasis should be given on DOM for acceptable physicochemical properties and desired eating quality during rice milling.

2.3 Storage

Grains are stored to minimize the loss. It is the important step of postharvest operations of grains. The purpose of storing rice is to store the rice grains under safe conditions to prevent the loss of grains from excessive moisture, birds, insectsiand other microorganism like bacteria. The storage of rice under optimum condition increases the shelf life of a grains. Rice storage facilities take many forms depending on the quantity of grains to be stored, the purpose of storage and the location of the store. Storage systems can be through bag, bulk, or hermetic containers (i.e. an air tight container).

2.3.1 Effect of storage conditions on rice grain quality

Moisture content, storage temperature and storage time are the key factors influencing the chemical, physical and functional qualities of rice during postharvest storage. During storage, a number of physiological changes occurs and these changes include pasting properties, color, flavor and composition that affect rice quality (Zhou et al., 2002). Color plays an important role in the acceptability of rice grains by the consumers. The color of rice varieties is significantly affected due to treatment and storage. Color of rice grains turned yellowish during storage at all the storage temperature; however, discoloration of rice is accelerated at slower rates when the rice varieties is stored at the lower temperature (Butt et al., 2008). Some researcher found that during postharvest storage, as the red rice often changed to a darker reddish brown hue, which results in changes of preexisting chemical species especially the decreasing polyphenol content and oxidative degradation of proanthocyanidin pigments (Hayash and Yanase, 2016). Various researchers have found the changes in color of rice with different storage condition. The percentage of discolored kernels was high when rough rice was stored with high moisture content (Trigo, 1994). The kernel postharvest discoloration found during storage may also include fungal involvement which may damage the grain. Thus, the rice grain should be stored in optimum temperature condition to obtain the good quality grain. Temperature is an important a biotic stress that can affect the rice quality during storage. The rice grains stored at the high temperature can increase the infestation of fungi, pestietc. That decreases the rice grain quality. Some of the researchers have identified that the low temperature during storage can minimize feeding, reproduction, development and survival of insect, pests and fungi. The storage of rice under normal room temperature resulted in significantly higher levels of infestation by rice weevil and greater probabilities of detection of *Alternaria spp., Nigrospora oryza and Fusarium spp.* than the cooling or freeze storage method (Kamara, 2019). The total field fungi observed was significantly higher for rough rice stored at 14 and 18% than at 22 and 26% moisture content (Trigo, 1994). Thus, storing the rice grain in low temperature can increases grain weight and head rice yield.

Cultivated rice is typically consumed as a cooked rice with only a small amount being used to make ingredients for processed foods. This pattern of usage results in the need to store rice over varying period. The textured of cooked rice grain become harder and less sticky in aged rice than cooked fresh rice and also the aged rice show more increased in volume expansion and water absorption during the cooking process (Noomhorm et al., 1997). The conceptual model of rice ageing is described in figure 2. Rice cooking properties are largely related to the gelatinization properties of starch granule. During the cooking process, starch granules become swollen and release exudates of starch molecules. Hardness, adhesive and cohesivess are the important parameters for the evaluation of the texture of cooked rice grains and the storage of rice under higher temperature resulted in significant increase in hardness and decrease in adhesiveness compared to lower temperature storage (Zhou et al., 2007). The higher hardness and low adhesiveness are likely associated with the lower hydration process of starch granules in aged rice grains stored at higher temperature and the protein content was inversely related to adhesiveness (Zhou et al., 2002). The content of free amino acids increased during the storage of milled rice. Also, the alpha-amylase and beta amylase activities of rough rice decreases during storage. The changes in fatty acid profiles and increase of free fatty acid during storage have been observed in number of studies by the researchers. Grains are characterized by various phenolic acids contributed partly to the change of cooking properties of aged rice. The components of cooked rice flavor change rapidly during ageing. Carbonyl compounds, particularly hexanal, are suggested to be the major contributors to the off flavor since they increase during storage (Swamy et al., 1978).

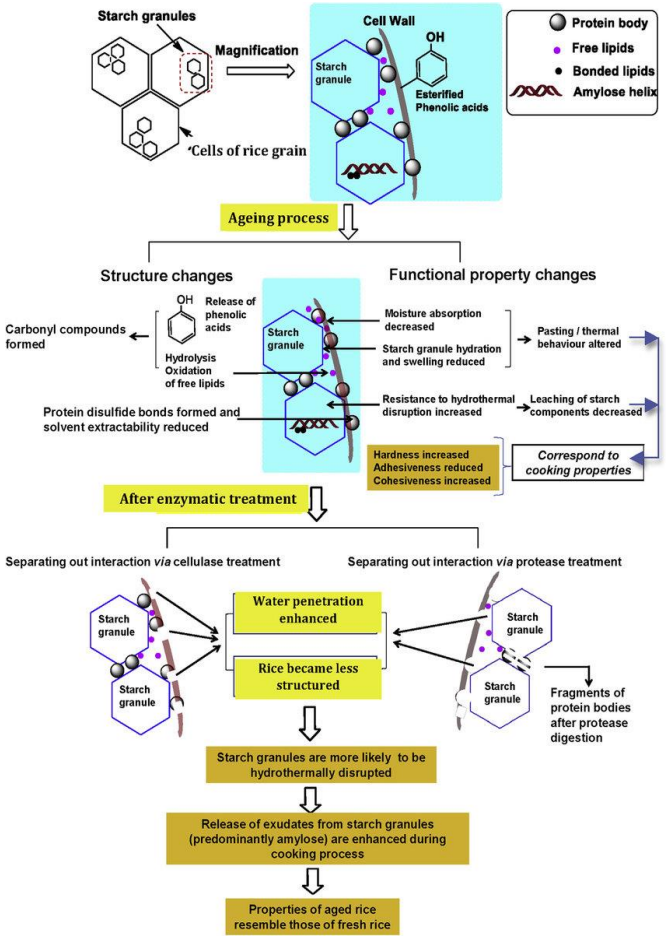

Figure 2: Conceptual model of rice ageing (Zhou et al., 2015)

3. Conclusion

Postharvest operations are the stage of crop production immediately following harvest, including drying, milling and storage based on this review, we can conclude that the various partiharvest operation such as drying, storage condition and milling method have significant impact on the appearance, cooking, eating, sensory, nutritional quality of rice. Drying temperature has negative effect on the partial quality attributes, including hardness, gumminess, chewiness, stickiness, color and flavor. Milling of rice grains with different degree of milling causes lossi of chemical of chemical composition such as sugars, amino acids, vitamins, minerals, fats, etc. water uptake and length expansion ratios of rice during cooking are also affected by degree of milling. During storage, no of physicochemical and physiological changes occur, this is usually term aging. There changes include pasting properties, color, flavor composition that affect rice quality. Although the composition of rice ageing is not fully clear, but these changes during storage is important in the evaluation of milling, cooking and eating quality.

Various authors have published of articles regarding the effect of postharvest processing of rice on its quality. However, the information regarding this topic is not sufficient for the people to produce high value rice grains. During the milling of the rice should be lowered to produce an edible, white rice kernel with sufficient nutritional quality. For rice storage, further studies should be done to understand about the rice ageing, so that various technologies can be develop to store the rice grain for longer period of time without losing lipid, protein, starch and other chemical composition suitable drying methods should be used to obtained good quality rice. Poor postharvest handling can lead to both weight and quality loss. So, rice processing operation should be fully mechanized to minimize deterioration.

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