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Quality characteristics of flood affected paddy (*Oryza sativa* L.) after milling

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Abstract
A significant element of the economy in general and the agricultural sector in particular is rice. Flooded paddy is frequently sold for a cheap price, which costs farmers money. In order to determine different milling parameters like head rice recovery, husked rice, broken rice and milling recover, the current study was carried out to examine these characteristics in flood-affected paddy in contrast to regular paddy. All of the milling quality characteristics, including the percentage of husked rice (N: 78.37% and F: 75.47%), head rice (N: 93.70% and F: 84.88%), broken rice (N: 6.28% and F: 15.10%), and milling recovery (N: 73.44% and F: 64.07%) between the normal paddy and flood-affected paddy, showed statistically significant differences at p <0.05. This shows that flood affected rice can be utilized for producing various value added products so that it can be sold at higher price and fetches good income to the farmers residing in flood affected areas. Therefore, further extensive research is needed for the utilization of paddy for the production of more feasible and convenient products in order to minimize the economic losses to the farmers.

Keywords: Flooded paddy, broken kernels, milling quality, economic losses, recovery percent

Introduction
For about half of the world's population, rice is one of the most essential staple foods, and it has an impact on the economics and way of life of several billion people. According to Suzanne, almost 154 million hectares of rice were harvested globally in 2010, with 137 million hectares (88.0%) of that total occurring in Asia. Just 48 million hectares, or 31.0% of the world's total rice harvest, were harvested in Southeast Asia. Since rice is a wet-season crop, it needs a lot of water. As a result, it is anticipated that the crop will be able to tolerate heavy rainfall and harsh watering circumstances with little impact on the rice quality. Yet, India is seeing an unusual occurrence of torrential rainfall and flooding at a time when the paddy was ready for harvesting because of climate change. Fields become inundated after five days of nonstop rain. This results in the rice crop being submerged and staying that way for four days.

Every year, floods affect more than 20% of paddy fields of India (IRRI 2010) [7]. Degradative alterations, such as low head rice yield (HRY), poor physico-chemical, nutritional, sensory, and organoleptic quality changes, occur in the paddy that has been soaked by floods. The two most crucial factors affected during milling are kernel whiteness and head rice yield (HRY). Head rice is defined as rice kernels that retain at least 3/4 of their original length following a full milling operation (USDA, 1983) [16]. The quality of milled rice is determined by these two factors, which also affect its retail price. According to Conway *et al.* (1991) [6], there is a high correlation between the size, shape, cleanliness, and whiteness of the rice and its transaction price. When compared to broken kernels, the price of head rice is nearly double or triple. Therefore, the rice milling industry's top goal is to maximize the percentage of head rice with the necessary level of kernel whiteness (Yadav and Jindal, 2008) [19]. When rice kernels have already been compromised by stress cracks (fissures) brought on by fast moisture adsorption, significant breaking happens during milling. Reduced head rice yields are the result of these cracked kernels typically breaking during subsequent hulling and milling processes. The produce of such fields is sold at low price causing small and marginal farmers to the economic loss. Moreover, rice millers prefer varieties with high milling out-turn (Merca and Juliano, 1981) [10].

An estimated 4.0 million tons of paddy are lost annually as a result of flooding in Bangladesh and India alone, which is sufficient to feed 30 million people. The physical appearance of the grains are clearly impacted by agricultural floods. This caused us to conduct a thorough investigation of milling and cooking quality of flood affected paddy.

Materials and Methods

Paddy was procured from Raavulapaalem in West Godavari district of Andhra Pradesh which is one of the flood affected areas of India. The samples of the same variety were collected from both normal paddy and flood affected paddy. In case of flood affected paddy, the samples were collected from areas which were submerged under water for almost three days at fully matured stage. These samples were studied for its milling quality characteristics. Later, the samples were taken to Post Graduate and Research Centre (PGRC), Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad to carry out the study.

Milling (Rice sheller-Indosaw) was carried out for the collected samples of both normal and flood affected paddy after bringing down the moisture content to 14%. For analyzing the quality characteristics of paddy such as husked rice percentage, head rice percentage, broken rice percentage and milling recovery percentage, milling was done which is an operation that transforms the materials by applying mechanical forces (Sahay and Singh 2005) [11]. The normal and flood affected paddy samples before and after milling are depicted in fig 1 and 2.

Fig 1: Normal paddy and normal rice

Fig 2: Flood affected paddy and flood affected rice

Results and Discussion

The quality characteristics of normal paddy and flood affected paddy after milling are given in table 1 and fig 3. Statistically significant difference at $p<0.05$ was observed between normal paddy as compared to that of flood affected paddy with regard to quality characteristics after milling. Husked rice and head rice exhibited higher percentage values for normal paddy (78.37% and 93.70% respectively). Lower percentage values were observed with flood affected paddy (75.47% and 84.88% respectively). In flood-affected paddy, the head rice percentage decreased the most, whereas in normal paddy, it decreased the least. Interestingly, paddy impacted by flooding had the highest percentage of small kernel fragments in whole milled rice but the lowest drop in head rice recovery. The development of fissures (stress cracks) in the rice kernel as a result of internal pressures brought on by drying and uneven moisture content, as well as changes in relative humidity during the rice kernel's ripening process, may be the source of the losses in head rice recovery. According to Kunze and Hall (1965) [8], significant cracks that span the grain cross-section form when humidity levels fluctuate during the milling process. Flood-affected paddy in the current study displayed the emergence of huge fissures across the grain cross-section (Fig. 1), but it also displayed the existence of tiny fissures close to the grain tip (Fig. 2). This most likely explains why the samples under study showed various milling characteristics. According to Kunze and Prasad (1978) [9], there are variations in the likelihood of cracks developing due to the grains' extreme fragmentation during milling and polishing which leads to decline in head rice recoveries.

In contrast, the percentage of broken rice was higher for flood affected paddy (15.10%) as compared to normal paddy (6.28%). This might be due to prolonged period of submergence of paddy under floods which damaged the internal structure of grains and caused breakage of kernels. When stress cracks (fissures) brought on by rapid moisture adsorption has already damaged rice kernels, significant breaking occurs during milling. According to Banaszek and Siebenmorgen (1990) [2], these cracked kernels typically shatter during hulling and milling processes, lowering head rice yields (HRYs).

Table 1: Milling quality characteristics of normal paddy and flood affected paddy

Sample	Husked rice%	Head rice%	Broken rice%	Milling recovery%
Normal paddy	78.37±0.21	93.70±1.21	6.28±1.20	73.44±1.14
Flood affected paddy	75.47±0.30	84.88±1.86	15.10±1.86	64.07±1.66
CD	0.622	3.669	3.669	3.343
SE (d)	0.218	1.288	1.286	1.172
SE (m)	0.154	0.909	0.909	0.829
CV	0.347	1.765	14.735	2.088

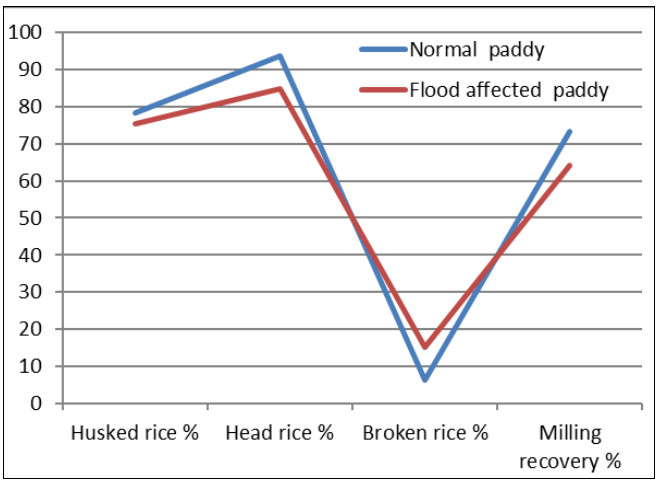

Fig 3: Milling quality characteristics of normal paddy in comparison to flood affected paddy

A close perusal of the data pertaining to milling recovery% delineate that among the two paddy samples, 73.44 percentage of milled rice was recovered from normal paddy as compred to flood affected paddy (64.07%). A number of variables, including variety, grain type, cultural practices, drying, storage, and

milling conditions, affect the milling recovery% (Adair *et al*. 1973; Witte 1972; Wasserman and Calderwood 1972) [1, 18, 17]. Different rice types are known to react differentially to moisture-induced kernel fissuring (Chen and Kunze, 1983; Bautista and Bekki, 1997) [5, 3]. Therefore, it would be beneficial to comprehend how water adsorption affects the incidence of kernel fissures in current, widely produced cultivars in order to create pre- and post-harvest recommendations for maintaining milling quality.

Brian and Terry (1999) [4] also demostrated that the environmental factors lead to shattering of rice kernels. It has been demonstrated that when milled rice kernels are subjected to specific environmental conditions, they quickly crack and eventually shatter. Depending on the temperature and relative humidity (RH) of the surrounding air, as well as the moisture content (MC) of the kernels, milled kernels quickly absorb or release moisture from their surroundings. The starchy endosperm of the milled kernel experiences compressive or tensile pressures as a result of this moisture movement into or out of the kernel. These forces can lead to kernel fissures during post-milling procedures, depending on the moisture gradient between the kernel and the equilibrium MC of the surrounding air.

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