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Effect of soaking temperatures on milling and cooking quality of paddy (PS-5)

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Abstract
The research work was carried out the effect of soaking temperature on milling of PS-5 variety of paddy. After calculated of raw paddy (PS-5) moisture content, bulk density, true density, porosity. Moisture content was observed 11.07 ± 0.16%. The bulk density was observed 445.4 ± 8.0 kg/m^3. The true density was calculated 553.6 ± 4.0 kg/m^3. The porosity was also calculated ranged 19.54%. The variety of raw paddy (PS-5) was soaked in water at different soaking at (T_{50}, T_{60}, T_{70} and T_{80}) for 5 hrs and steaming at 100 °C for 10 min thereafter drying of steamed paddy is accomplished in tray dryer at 45 °C upto desired moisture content. After milling the color value and whiteness index was measured of milled rice, thereafter cooking properties were also measured of milled rice of PS-5 of different above given temperature of parboiled rice.

Keywords: Colour, cooking, milling, paddy, parboiling, quality, soaking

Introduction

Paddy (*Oryza sativa* L.) is second largest major cereal crop a member of grass family (Poaceae/Gramineae), which produces starchy seeds. Paddy is one of the stable and leading food crops in India. About 70% of the paddy produced in India was stored at farm level. Rice is a that type of food grain which is most essential for human survival of the World. India is the world's second-largest producer of rice and the largest exporter of rice in the world. About 50 to 75% of the total world population has partially or totally adapted rice as their main food. Asians meet half of their daily energy requirements through intake of rice. The paddy grain is a living matter and represents a colloidal capillary porous body. It contains large amount of micro and macro capillaries through which water can move out or inside of the grain surface.

In his process, parboiled paddy was selected and moisture content was estimated. Dehusking of the same was done in the next stage. Brown or whole rice was extracted from the dehusked sample and broken rice was isolated and only the whole grains were considered. Next polisher was used for polishing the rice grains and once more broken rice grains found during polishing was removed from the sample [10].

The efficiency of milling is decided by its HRY and whiteness other than deciding its transaction price which is also dependent on shape, size and cleanliness of the rice [8]. Head rice is capable of fetching two to three times more price than that of broken kernels. A number of studies have been focused on improving milling quality through plant breeding programs, improved cultural practices, optimization of harvesting and drying conditions [2, 1, 9, 11]. Delay in harvest has been shown to reduce HRY due to low kernel moisture contents [22], optimum moisture content for seven US varieties to harvest varied from 16% to 21.5% (db.) to achieve maximum HRY [12]. To reduce the occurrence of fissures and improve the milling characteristics research has been pursued on post-harvest management of rice along with optimizing the conditions for harvesting and drying. Increase in the bulk surface temperature of the grain during milling due to abrasion/friction induces thermal stress, leading to crack generation and ultimately results in reduction in head rice yield [17].

Material and Method
Experiments were conducted to study the premilling treatments (Parboiling), Milling and cooking characteristics of rice (*Oryza sativa* L.) studies and parboiling, milling and cooking with quality evaluation in the laboratories developed under the Agro Processing Centre at Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. Studies were also carried out to evaluate the moisture content on soaking, steaming and drying of paddy by given parboiling treatments on raw paddy, then parboiled paddy were prepared for milling and the paddy were milled on rice sheller after milling we got milled parboiled rice (head and broken), colour value of L*, a*, b*, whiteness value and we were also evaluating the cooking quality of parboiled rice in the laboratory. The setup and detailed of methodology are being described as below:

Raw material
Fresh and raw paddy was procured from the Seed Processing Center Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. Raw paddy was cleaned to from impurities like stones, trashes, dirt with the help of winnower at the Agro Processing Center, CoPHT & FP, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut. After cleaning raw paddy was parboiled with prescribed method followed by to evaluate the milling quality of PS-5 variety of paddy.

Moisture content
Moisture content (%) of all the samples was determined using AOAC, (2012) standard method.

Parboiling
The parboiling process were done with three steps viz. Soaking, steaming and drying. The soaking of paddy was done with varying soaking temperature i.e. T_{50}, T_{60}, T_{70}, T_{80} for a constant period of 5 hrs, followed by the steaming was accomplished for 10 minutes at 100 °C temperature. The steamed paddy was dried in tray dryer at 45 °C upto required moisture content for milling.

Milling of paddy
In the process of removing the husk from paddy (1000 g), force has to be applied. The dried paddy was milled using a Rice Sheller (Make: Nyagah Mechanical Engineering Ltd.), to separate the kernels from the husk. Milling characteristics of paddy were determined by using the procedure expressed by [4]. The head rice and brokens were sorted directly by both outlets of sheller. Broken rice yield was very important milling characteristics for the determination of rice quality [7]. For the determination of the broken rice yield (%) was taken from the outlet of sheller in triplicate. The grains which were smaller than ¾ of the grain length were considered as the broken grains. The milling yield (%), head rice yield (%) and broken rice yield (%) were calculated by below given equations respectively.

$$\text{Total milled rice yield(in\%)} = \frac{\text{Total Mass of milled rice}}{\text{Mass of whole parboiled paddy}} \times 100$$

$$\text{Head rice yield(in\%)} = \frac{\text{Total mass of head rice}}{\text{Mass of total milled rice}} \times 100$$

$$\text{Broken rice yield (in\%)} = \frac{\text{Total mass of broken rice}}{\text{Mass of total milled rice}} \times 100$$

Color Quest
The color values in terms of L, a and b of the rice were measured by using a Color Meter (Make: Shenzhen 3nh Technology Co., Ltd.). A higher L* value indicated a brighter or whiter sample. Values of a* and b* indicated the red-green and yellow-blue chromaticity respectively. The rice was filled in the specific container of the color meter and instrument sensor was placed on the container and mean of three replicated values of respective L, a and b were obtained (Bharti *et al.*, 2024). Whiteness of the sample were measured by whiteness meter.

Cooking Quality of parboiled milled rice
The cooking quality of parboiled rice is better in several ways: its grains stay firm, they do not stick together, and it loses less starch during cooking [3]. In cooking quality of parboiled paddy; water uptake, water absorption, volume expansion, elongation ratio was calculated in the lab with the help of some important equipment's.

Water absorption (%): The better milling technology should take care of the problems of impurities, lack of uniformity, and high percentage of broken grains that care will help to solve problems of taste, storability, cooking time, water absorption and other characteristics that are not apparent to the eye. Parboiling may be used to increase water absorption during cooking [3].

$$\text{Water absorption (\%)} = \frac{\text{Weight of cooked rice} - \text{Weight of raw ricee}}{\text{Weight of raw rice}} \times 100$$

Volume expansion (%): After cooking, the cooked sample with the beaker will weigh and the height of the cooked sample will measure [26].

$$\text{Volume Expasion (\%)} = \frac{\text{Height of cooked rice} - \text{height of raw rice}}{\text{Height of raw rice}} \times 100$$

Elongation ratio (%): The cooked samples used in the water absorption and volume expansion tests will used to determine the grain elongation ratio of the rice samples. Fifteen grains will randomly select from each replicate. The length of the cooked and un-cooked grains will measure using a digital vernier calipers [26].

$$\text{Elongation Ratio (\%)} = \frac{\text{Length of the cooked rice}}{\text{Length of raw rice}} \times 100$$

Results and Discussion
The initial moisture content of paddy (PS-5) was obtained 11.07 ± 0.16%, bulk density (445.4 kg/m^3), true density (553.06 kg/m^3) and porosity was observed 19.54% (Fig.1). The paddy was soaked in normal water at T_{50}, T_{60}, T_{70} and T_{80} upto 5 hrs. followed by steamed at 100 °C temperature upto 10 min. The steamed paddy was dried in tray dryer at 45 °C upto 2 hrs or obtained desired moisture content for milling purpose thereafter milling calculated of water absorption, volume expansion and elongation ratio also.

Effect of soaking temperatures on paddy
Parboiling process
Soaking: The aim of study is to understand of variation in moisture content of paddy due to different soaking temperature during the soaking, steaming and drying process of parboiling. The paddy was obtained moisture

after soaking at T_{50}, T_{60}, T_{70} and T_{80} temperature for 43.25, 51.08, 55.37 and 72.71% respective against the 11.07% initial moisture content of paddy (Fig:1). It seems that the moisture content of paddy after soaking was increasing with increasing the soaking temperature in normal water. The range of increased of moisture was 3.92 to 6.5 times among the various temperature. The variation in moisture content may be depended on the water absorption capacity of husk and endosperm of the paddy, moisture absorption by paddy during soaking was the major reason behind dimensional change. Starch content and size of starch granule affect the absorption of water during soaking. Soaking is a diffusion process, as a result of water absorption, the paddy swells. The water moves inside the paddy as long as the water and stop the vapor pressure inside the grain is less than that of soak water and stop when equilibrium is reached. Soaking is the result of molecular absorption capillary absorption and hydration. Initially during soaking, water penetrates the rice kernel and fills up the intergranular spaces due to capillary absorption. Some of the water molecules are absorbed by starch granules while some will enter into the lattice of starch molecules where they will be held as water of hydration [19]. The rate of soaking is also dependent on temperature of soaking. The rate of soaking is high initially but it decreases with time until bursting of the grain takes place when the soaking rate increases particularly at the temperature of gelatinization and higher [6]. In the various varieties were observed that water about 3-4 time at 70 °C temperature of soaking. Similar trends were observed by [16].

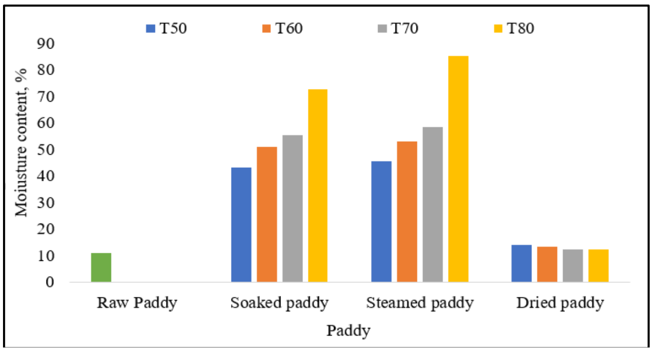

Fig 1: Changes in moisture (%) due to soaking temperatures of paddy (PS-5)

Steaming: The next step of parboiling is steaming which was accomplished at 100 °C for 10 minutes in boiled water. The moisture content of soaked paddy (PS-5) was increased 43.25 to 45.67% (T_{50}), 51.08 to 52.88% (T_{60}), 55.37 to 58.28% (T_{70}) and 72.71 to 85.20% (T_{80}) after soaked paddy during steaming. The soaking temperature was also affecting the water absorption in steaming period (Fig:1). Several studies show that the steaming of paddy upsurge the moisture content about 5.59% to 17.17% among the soaking temperature. The highest water absorption was absorbed at 80 °C soaked paddy while lowest in 50 °C soaked paddy during steaming. The similar trends were showed to raise moisture content during soaking followed by steaming also. Steaming process is used to complete the gelatinization of starch and it does not lower the moisture from the paddy while this process enhances the moisture by high heat at 100 °C during steaming, the speed of water-soluble substances inside the paddy grain which is begun during soaking is continued and increased [6]. Similar trends were observed by [16] that Suphanburi-90 paddy variety with high amylose content was soaked in hot water at temperatures of 70, 80 and 83 °C for 4.0, 3.3 and 3.2 h, respectively to get the moisture around 47-55 percent (db).

Drying: The drying of steamed paddy was calculated in tray dryer at 45 °C upto 2 hrs or the moisture content of paddy was removed fast at initial stage and thereafter decreased the rate of drying. The paddy was observed lowest moisture of the 80 °C soaked-steamed paddy, and highest 50 °C temperature soaked-steamed paddy (Fig. 1). The parboiled paddy is required to be dried to a moisture content of 14-16 percent to obtain the desirable milling and storing properties [6]. The present study was noticed that the moisture content of the steamed paddy (PS-5) was dried at above given conditions and also expressed moisture content between 12.57 to 16.27 percent (db). Similar trends about were given as well as the parboiling vessel was taken out and steamed paddy was spread on alluminium tray uniformly for sun drying for 8 hours and again dried in the tray dryer to moisture content to 13-14% on Wet basis [7].

Milling

Milling quality of rice grains is important to both, producers and consumers as the market price of rice is largely dependent on milling performance. Millers base their concept of quality upon total recovery and the proportion of head and broken rice on milling. Therefore, a variety should possess a high turn-out of whole grain (head rice) and total milled rice [27].

Milling rice yield: The range of milling yield of paddy (PS-5) was 63.11 to 74.555 among the various soaking temperatures. The highest milling yield (%) was observed in T_{80} followed by 73.01% (T_{70}), 72.85% (T_{50}) and lowest in T_{80} (63.11%). The milling yield of paddy in depending on the final moisture content of parboiling process. Paddy (T_{80}) was dried at 45 °C and recorded lower 17.07% moisture content as compared sample of paddy. Low moisture of the paddy in responsible to hardness to rice after drying (Fig. 2). Similar trends were followed by [25].

Head rice yield: Head rice yield was calculated as per yield of milled rice. Head rice yield for PS-5 variety was observed highest (89.49%) and best performance steeped at 80 °C soaking temperature while found lowest (78.64%) for 50 °C soaking temperature. Present study showed that Soaking temperature 80 °C for PS-5 is the suitable according to head rice yield after parboiling process. Soaked paddy grains of PS-5 were dried under tray drier to achieve 17.07 ± 0.03 to 16.27 ± 0.32 (db) moisture content, approximately equal to that of unsoaked paddy as well as soaked paddy (Fig. 2). Soaked paddy grains were dehusked using rice sheller to obtain brown rice, husk, broken rice and these components were expressed as a percentage of paddy weight. Percent brown rice (on paddy basis) was used to determine the head rice yield (on paddy basis) of soaked grains. Similar trends were followed by [13].

Broken rice yield: Broken percentage was very important milling characteristics for the determination of rice quality. Broken rice yield for PS-5 variety was observed the highest (21.36%) and bad performance at steeped at 50 °C soaking temperature while found lowest (10.51%) for the 80 °C soaking temperature. Present study showed that soaking temperature 80 °C for PS-5 is the suitable according to broken rice yield after parboiling and milling process (Fig. 2). For the determination of broken percentage, 21 g test weight of basmati rice [20] was taken at random from the rice samples in the triplicate. The grains which were smaller than ¾ of the grain length were considered as the broken rice grains.

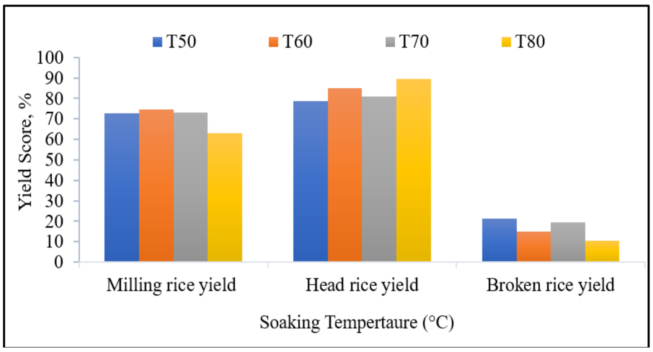

Fig. 2: Changes in milling characteristics of rice due to soaking temperatures

Colour characteristics of parboiled milled rice:
Parboiling treatment were changed color of milled rice which affected reduction of lightness value (L*) varied between 57.41 to 64.59 on soaking temperature of 60 °C, 80 °C respectively. The color value redness (a*) on the parboiled milled rice were differ to each other with various soaking temperatures. The value of parboiled milled rice was found between 1.11 to 2.73. The value of yellowness (b*) was found between 17.67 to 23.92 shown in Fig. 3.

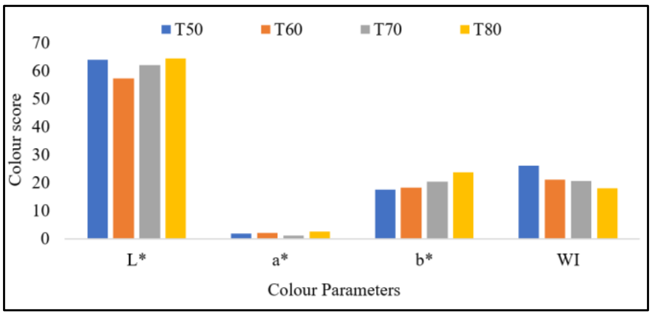

Fig 3: Changes in cooking characteristics of parboiled rice due to soaking temperatures

Similar trends were followed by [15] were measuring various de-husking states of rice and its effect on rice color, while the milled rice had color values approximately (L*, a*, and b*, respectively) 58.7, 5.1, and 24.3. This was by [23] on Ozgon rice with results (L*-66.04, a*-10.76, b*-20.09), which are similar to values of Ozgon Uchuk in this study. This research was reported by [17] that the L* values increased from 51.22 to 68.74, 41.01 to 67.87 and 52.88 to 69.5 for Swarna, ADT 37 and Pusa Basmati, respectively. This indicates, with removal of bran the endosperm was exposed and the brightness value was more or less similar for all *indica* rice. The a* values decreased from 2.99 to-0.9, 5.38 to 0.49 and 3.28 to-0.95 for Swarna, ADT-37 and Pusa Basmati, respectively. Even after 16% bran removal, the positive a* value of ADT-37 rice indicated redness in the sample, which was influenced by the red pigment in the bran, whereas, the a* values were negative implying the greenness in Swarna and Pusa Basmati rice. The b* value decreased 16.18 to 14.01 and 16.99 to 14.22. Swarna and Pusa Basmati, respectively, however the values increased from 12.26 to 13.26 for ADT 37. The decrease in the yellowness in Swarna and Pusa Basmati with progressive milling implied that bran has more pigments than the endosperm. This finding corroborates the finding of [15].
The behaviour of the whiteness index in parboiled rice under various soaking temperatures give in Fig. 3. The whiteness index of parboiled milled rice was 18.00 to 26.20 varied between different soaking temperatures. When the raw rice was subjected to steam and dry. The whiteness index of rice was decreased with increasing time and soaking temperatures. The effect of whiteness was caused by diffusion of color of rice hull to starch inside the grain kernel [21] and parboiling process such as drying temperature over 40 °C [24].

Cooking characteristics
The cooking quality of parboiled rice is expressed in terms of time of cooking, swelling capacity, expansion volume, colour, solids in gruel and pastiness [6]. The cooking quality of parboiled rice is better in several ways: its grains stay firm, they do not stick together, and it loses less starch during cooking [3]. In the present study of parboiled rice is expressed in the form to observed in water absorption, volume expansion as well as elongation ratio and discussed below.

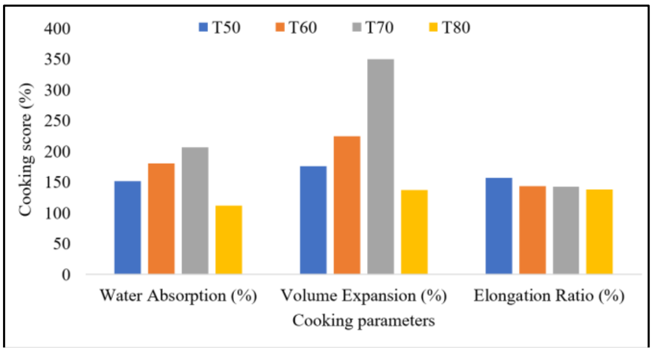

Fig 4: Changes in colour characteristics of rice due to soaking temperature

Water absorption: The water absorption for PS-5 variety on different soaking temperatures (T_{50}, T_{60}, T_{70}, T_{80}) of parboiled milled rice on the cooking is given in the Fig:4. The water absorption of PS-5 variety of parboiled rice were observed water absorption on the 180%, 112%, 206.6%, 151.2% on T_{50}, T_{60}, T_{70}, T_{80} soaking temperature respectively. The highest water absorption on PS-5 on 70 °C (206.6%) and lowest on the 60 °C (112%). Similar observation was reported by [14].

Volume expansion: The volume expansion of PS-5 variety of parboiled rice were observed water absorption on the 176.19%, 136.84%, 350%, 225% on T_{50}, T_{60}, T_{70} and T_{80} soaking temperature respectively. The highest volume expansion on PS-5 on 70 °C (350%) and lowest on the 60 °C (136.84%). Similar trends were followed by [26].

Elongation ratio: The elongation ratio of PS-5 variety of parboiled rice were observed water absorption on the 157.09%, 143.64%, 142.86%, 137.80% on T_{50}, T_{60}, T_{70} and T_{80} soaking temperature respectively. The highest elongation ratio on PS-5 on 50 °C (157.09%) and lowest on the 80 °C (137.80%). Similar research work was done by [26].

Conclusion

The paddy (PS-5) was given best result for the purpose of milling yield for paddy was soaked at 60 °C temperature while in case of highest head rice yield was found for 80 °C soaked paddy along with moisture content of 17.07% (db) in present study. Thereafter milling we were calculated color value of parboiled milled rice were calculated the values of colour L^*, a^* and b^* ranged between 57.41-64.59, 1.11-2.73 and 17.67-23.92 respectively. The whiteness index value of parboiled milled rice was observed between 18.00-26.20 on the different soaking temperature treatments of $T_{50,}$ $T_{60,}$ $T_{70,}$ T_{80}. Thereafter color values we were calculated cooking properties of parboiled milled rice as like water absorption, volume expansion and elongation ratio.

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