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Effect of microwave heating on accelerated ageing qualities of rice

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ABSTRACT

The effect of microwave heating (MWH) i.e. microwave power (540, 720, 900 W)(MWP) and exposure time (30, 60, 90 s)(ET) at a constant moisture content of 12.4±1.8 % wb of the paddy on milling and ageing properties i.e. total yield, head rice yield (HRY), cooking time, kernel elongation ratio (KER), volume expansion ratio (VER), water uptake, solid loss, gel consistency, hardness and stickiness was evaluated. These properties were determined for microwave treated and compared with freshly harvested rice and naturally aged paddy samples of 6 months storage. Head rice yield was maximum 50.67±0.17 % in microwave treated sample whereas it was 38.0 ±0.37 % in freshly harvested rice sample. Higher exposure time (90 s) and microwave power (720, 900 W) yielded lower head rice (41.50±0.42 and 43.74±0.14 %) may be due to rapid interaction of water molecules to electromagnetic field to internal fissure development of grains which caused high moisture gradient and strain in kernel and lead to more broken kernels. The cooking time of freshly harvested rice (control sample) was less (17.0± 1.52 min) compared to microwave heating at 900 W for 60 s (25.2± 0.50 min) and 6 month naturally aged rice (27.0± 0.80 min). KER of cooked rice was higher (2.87 ± 0.23) for 900 W MWP and 60s ET and VER for this case was achieved more than 3±0.37. Solid loss was less and Water uptake of rice during cooking was more towards higher exposure time i.e. 90 s and 900 W and 540 W power. The water uptake and GC values gave more or less similar results showing no definite trend. Water uptake was more in microwave treated rice i.e. 81.0±0.79 % than freshly harvested rice (65.0± 1.08 %) and six months naturally aged rice (73.00± 1.5 %). The freshly harvested rice gave a softer gel consistency (38.20±1.18 mm), whereas, MWH rice gave harder gel (GC 25.90±0.92 mm) as that of 6 months stored rice of GC 27.50±1.15 mm. Considering all these properties, microwave treatment of rice at 900 W MWP and 60 s ET has achieved better ageing qualities i.e. more cooking time, KER, VER, water uptake, harness of grain and less solid loss, gel consistency and stickiness of rice.

Key words: *Microwave heating of rice, accelerated ageing, gel consistency, water uptake, cooking time*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important cereals in the world. India is the second largest producer of rice in the world next to China. Commonly, a large amount of the rice is consumed by cooking along with a small portion (around 10%) of processed foods (Le et al., 2014). Cooking quality is one of the most important characters that influence the acceptability of rice. However, the rice from freshly harvested paddy generally leaves a thick gruel texture when being cooked. These cooking properties are not liked by consumers who prefer the fluffiness or firmness of cooked rice. This could be improved when the freshly harvested rice is traditionally stored for at least 3-6 months (Indudhara Swamy et al., 1978). By natural storage condition, the rice is stored quite a long time, which is considered as a non-economic aspect: such as storage space requirement, insect damages and high opening cost.

The quality of freshly harvested rice changes during storage. These are basically due to the physicochemical changes occurring in the paddy grains which are affected by the temperature and relative humidity of the environment or the moisture content of the grain. Rice ageing mechanism is a complicated process involving changes in different rice chemical components leading to physical and physicochemical changes, which has been not completely understood so far and dominantly explained by two main components: protein and starch. (Zhou et al., 2003; Rewthong et al., 2011).

Raw rice can be aged naturally which gives more fluffier and intact rice in cooking and does not make any paste like character. Ageing of rice is traditionally practiced by hermetically packing in specially designed underground structure for a long duration of time for at least 4-6 months to improve its cooking as well as milling qualities (Keawpeng and Venkatachalam, 2015). Storage conditions are very important on ageing process of rice. Perez and Juliano, (1981) suggested that storage of rice at 15°C ageing was most significant during the first 3-4 months. Hermetic storage of milled rice at 30°C for 3 months at 14·7% (wb.) moisture under nitrogen, vacuum or air atmosphere had positive effects on ageing of rice (Zhou et al., 2003). Indudhara Swamy et al. (1978) reported that rice during storage causes an increase in water uptake for up to 1 year, which led to the changes in amylograms of rice storage, after which water uptake decreased.

Accelerated rice aging technique is normally used to shorten the natural rice ageing process. On the other hand in comparison with parboiled rice technique that involves soaking, steaming and drying, the process of accelerated ageing gives only partial of parboiling process so that the accelerated rice process is more economical than the traditional parboiling process. So far, accelerated rice aging methods have been applied which generally used conventional heating methods. The heating treatment could be dry heat or moist heat treatment. The process at least takes minutes to several hours, even more than ten days. Heat-moisture treatment for accelerated aging of rice has been carried out using conventional air ovens or other treatment methods (Soubhagya and Bhattacharya, 2001; Rayguru and Pandey, 2009). However, there is an increasing trend toward the use of microwave applications in food processing due to the fact that microwave energy is more efficient than the traditional heating process since it ensures homogenous operation in the whole volume of substances.

Microwave energy applications in the study of heat-moisture treatments of rice for ageing have not been usually studied. Anderson and Guraya (2006) have reported microwave oven heating changes significantly the viscosity properties of waxy and non-waxy rice without altering the starch morphology and digestibility characteristics. Le et al. (2014) suggested microwave heating treatment can be applied for accelerated rice aging at different microwave powers (1000 and 2000 W), exposure time (23, 26, 31, 41, 66, and 159 seconds) applied to paddy and white rice. However, the study of microwave heating on changes of ageing qualities of rice has not been studied in detail. Therefore, the present study has been aimed to investigate the effect of microwave power, exposure time and moisture content of paddy on aging properties of rice followed with optimization of the parameters.

MATERIALS AND METHODS

Paddy sample of Lalat variety was collected from the department of Agronomy, College of Agriculture, OUAT, Bhubaneswar. It was cleaned and open sun dried up to moisture content reached to 12.4±1.8 % wb. Paddy sample of freshly harvested was kept in gunny bags for 6 months for natural aging process. Moisture content of paddy was determined by hot air oven method (AOAC, 1998). Microwave heating of rice was evaluated at three microwave power levels (540, 720 and 900 W), three exposure time (30, 60 and 90 s). The ageing characteristics of rice was ensured through milling and cooking qualities *i.e.*, head rice yield (HRY), cooking time, kernel elongation ratio (KER), volume expansion ratio (VER), water uptake, solid loss, gel consistency, hardness and stickiness.

Microwave heating of rice

All the experiments of rice were carried out with a domestic microwave oven (LG, model no: 3850W2G031A). Rice was microwave heat treated at 3 microwave power levels *i.e.*, 540,720 and 900 W corresponding to 100, 80, 60 % power levels and exposure time of 30, 60 and 90 s. After that, the samples were tested for cooking and other aging properties as per following.

Determination of milling and ageing properties of rice

Milling characteristics

Paddy samples of 100 g weight were taken and dehusked using a laboratory rice dehusker (Satake Model: TMU35B). Thereafter the brown rice was milled in rice polishing mill (Satake model JM05C) .The bran and rice was collected in two different outlets from the machine. Head rice (having more than 70% of original length of rice) and broken were separated from the polished rice by manual sorting. The head rice yield and total yield were determined by using the following formulae as per Saleh et al. (2007).

$$\text{Total yield}(\%) = \frac{\text{Weight of milled rice}}{\text{Weight of paddy}} \times 100 \quad ..(1)$$

$$\text{Head rice yield}(\%) = \frac{\text{Weight of whole kernel of milled rice}}{\text{Weight of paddy}} \times 100 \quad ..(2$$

Cooking characteristics

The amount of 2 g of head milled white rice was put in an aluminium can containing 10 g of distilled water. The container was covered by aluminium foil, and then placed in small electric cooker at temperature of boiling water of 97 ± 2°C. The small hole was made on aluminium foil during cooking to avoid the cover pushed out and also to control cooking temperature during cooking process. Each of experimental run was conducted with three containers. The process was conducted at optimum cooking time (12 min). Temperature during cooking was controlled by small electric cooker and a sensor of digital thermocouple that was set up hermetically on the container with aluminium foil. After 12 min of cooking, several kernels with chalky core were observed under two microscope glass slides. The period when the chalky core was disappeared was used as a cooking time (min). Kernel elongation ratio and water uptake were calculated using equations 3 and 4.

$$\text{Kernel elongation ratio}(\%) = \frac{X_c}{X_{uc}} \times 100 \quad ..(3$$

where, X_c - Length of the 10 cooked rice kernels

X_{uc} - Length of the 10 uncooked rice kernels

$$\text{Water uptake}(\%) = \frac{W_c - W_{uc}}{W_{uc}} \times 100 \quad ....(4)$$

where, W_c - Weight of the cooked rice

W_{uc} - Weight of the uncooked rice

Volume expansion ratio

The volume expansion was calculated by measuring the change in volume of rice after cooking (equation 5). The toluene displacement method was used to determine the volume by taking 8 g of raw and cooked rice (Sidhu et al., 1970). First 8 g rice sample was weighed and then poured in the test tube carrying toluene more than half of the volume. The initial volume of toluene was noted. Then the difference between the final volume and the initial volume gave the volume of the sample poured in the test tube carrying toluene.

$$\text{Volume expansion}(\%) = \frac{V_c}{V_{uc}} \quad ...($$

Where, V_c - Volume of the cooked rice

V_{uc} - Volume of the uncooked rice

Solid loss

The drained water/gruel from the rice cooking process was collected in a pre-weighted Erlenmeyer flask and evaporated at 105°C for 24 hours. The sample was then cooled in a dessicator for 45 minute and weighed. An increase in weight of the Erlenmeyer flask divided by the weight of the rice sample is defined as the solids loss:

$$\text{Solids loss}(\%) = \frac{\text{Increase in weight of the Erlenmeyer flask}}{\text{Weight of the rice sample}} \times 100 \quad ..($$

Gel consistency

Gel consistency of rice was found out following the method of Cagampang et al. (1973) with little modification. Rice powder 200 ± 1 mg was placed in 13 x 100 mm culture tubes wetted with 0.4 ml 95% ethanol containing 0.025% thymol blue and were shaken to suspend the starch. Four ml of 0.2 N KOH was immediately added to it and the mixture was dispersed using a Vortex Genie. The tubes were covered with glass marbles and placed for 8 minutes into a vigorously boiling water bath to reflux. Samples were then removed from water bath, set at room temperature for 5 minutes and then cooled in ice-water bath for 15 minutes. The tubes were then laid horizontally over ruled paper graduated in mms. Length of gel was measured from the bottom of test tube to the gel front after 30 min of pouring.

Textural properties

Six cooked kernels were placed on the platform of texture analyzer machine (TA-XT2, Stable Micro Systems, UK). A cylindrical probe of 36 mm diameter attached to a 50-kg load cell was used to compress the kernel to 85% of its original height at a crosshead speed of 10 mm/min. The values were reported by the mean of ten replications. Hardness and stickiness were determined as maximum and negative force value, respectively (Rewthong et al., 2011) obtained in a typical texture profile curve.

Statistical analysis

The ANOVA in one factor, critical difference (CD) test was employed for making pair comparisons between different treatments as the case has arisen. The procedure provides for a single CD value, at a prescribed level of significance (5% level), which serves as the boundary between significant and non-significant differences between any pair of treatment means (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of microwave power and exposure time on milling yield

The effect of microwave power (540, 720, 900 W) and exposure time (30, 60,90 s) at a moisture content of 12.4±1.8 % wb of the paddy on total rice yield and head rice yield was given in Table 1. The total rice yield did not follow a particular trend, and it varied between 56.5 to 76.9%, although the variation is significantly different for different combination of treatments. Head rice yield were higher at treatment combinations of 720 W, 30 s (50.67%); then 900 W, 30 s (49.33%) respectively. The head rice yield was higher at lower exposure time (30, 60 s) than at higher exposure time (90 s). Higher microwave power level and high exposure time yielded lowest head rice yield (41.5 to 45.23 %). The effect of total microwave power input (kJ) on head rice showed that, within energy level of 21.6 to 32.4 kJ the head rice yield were higher as compared to higher energy inputs. Higher input energy of microwave i.e. above 43.20 kJ the head rice yield was significantly ($P< 0.05$) lowered i.e at higher power level and higher exposure time. The reason for lower head rice yield at higher microwave power level and exposure time may be due to the abrupt loss of moisture during microwave heating that caused high moisture gradient and strain in kernel due to cracks and fissures which lead to more broken kernels (Juliano, 1981; Le et al., 2014). The head rice yield of freshly harvested rice was minimum *i.e.*, 37.3±0.37 % and it improved up to 49.33 ± 0.19 % in case of naturally aged 6 months stored rice.

Table 1. Effect of microwave power and exposure time on head rice yield of rice.

MW Power (W)	ET (s)	Energy input (kJ)	Total rice yield (%)	Head Rice Yield (%)
540	30	16.20	63.4±3.11b	42.67±0.25b
720	30	21.60	56.5±1.32c	50.67±0.17a
900	30	27.00	67.6±0.84b	49.33±0.23a
540	60	32.40	66.6±1.45b	48.67±0.54a
720	60	43.20	76.9±0.76a	43.67±0.54d
900	60	54.00	69.6±1.55a	49.00±0.22b
540	90	48.60	70.3±4.05a	45.23±0.31c
720	90	64.80	65.8±0.24b	41.50±0.42e
900	90	81.00	63.8±2.63b	43.74±0.14d
Control (untreated, freshly harvested rice)			72.1±0.58a	37.3±0.37e
6 month aged rice			69.5±0.19b	49.33±0.19b
CD (at 5%)			8.99	1.62

Effect of microwave power and exposure time on cooking quality

The effect of microwave power and exposure time on cooking and textural properties e.g. cooking time, kernel elongation ratio, volume expansion ratio, water uptake, solid loss, gel consistency, hardness and stickiness values of treated rice are given in Table 2. All these values are a confirmation of accelerated ageing process of rice which was compared with that of freshly harvested rice, untreated and 6 months aged rice in natural ambient condition. The discussion about variation of different aging properties of rice with MW heat treatment are described as follows.

Cooking time

Table 2. Effect of microwave power and exposure time on cooking quality.

MWP (W)	ET (s)	CT (min)	KER	VER	WU (%)	SL(%)	GC (mm)	Hardness(N)	Stickiness(N)
540	30	23.2± 0.50	1.80 ± 0.08	3.0 ± 0.89	75.0± 0.64	0.89±0.24	25.00 ±0.85	90.45 ±0.87	14.75±2.87
720	30	25.0± 0.25	2.18 ± 0.09	3.05 ± 0.01	80.0±0.51	0.03± 0.70	23.00 ±0.67	87.85 ±0.57	15.35±2.95
900	30	24.5± 0.50	2.56 ± 0.56	3.1± 0.06	80.0±0.89	0.08± 0.17	24.00 ±0.81	89.65 ±0.75	18.75±3.65
540	60	23.2± 0.75	2.44±0.45	3.1±0.78	80.0±0.08	0.25± 0.09	25.50±0.88	83.85± 0.95	12.45±1.97
720	60	23.5± 0.50	2.85±0.65	3.2±0.06	76.0±0.09	0.06± 0.07	25.90±0.92	80.10± 0 .65	13.95±1.77
900	60	25.2± 0.50	2.82± 0.26	3.2±0.05	77.0±0.05	0.46±0.01	24.50±0.77	91.30± 0.81	16.35±2.02
540	90	20.5± 0.60	2.2 0±0.21	3.0±0.37	81.0±0.79	0.12± 0.15	23.50±0.59	85.85± 0.58	10.95±1.09
720	90	18.3± 0.50	2.16±0.20	3.10±0.72	79.0±0.65	0.17± 0.09	25.20±0.75	86.20± 0.65	11.65± 0.51
900	90	16.76± 0.60	1.74± 0.21	3.00±0.43	81.0±0.55	0.22± 0.34	23.80±0.60	93.45± 0.71	14.70± 0.08
Control		17.0± 1.52	1.46± .105	1.50± 0.15	65.0± 1.08	0.66± 0.02	38.20± 1.18	75.75± 0 .66	12.95±0 .78
6 month aged rice		27.0± 0.80	2.67±0.04	3.20± 0.076	73.00± 1.5	0.15±0.04	27.50± 1.15	100.2± 1.89	10.5±1.64
CD at 5% level		0.52	0.12	0.15	2.72	0.06	0.609	5.28	3.10

Control = untreated (freshly harvested rice), MWP = microwave power, ET= exposure time, CT= Cooking time, KER= Kernel elongation ratio, VER=Volume expansion ratio, WU= Water uptake, SL= solid loss, GC= Gel consistency.

The cooking time at different microwave heat treatment are shown in Table 2. The cooking time of untreated freshly harvested rice (control sample) was 17.0± 1.52 min., whereas it was increased up to 25.2± 0.50 min after microwave heating. The cooking time for 6 month aged rice was higher (27.0± 0.80 min) than fresh and also microwave treated rice. For microwave treated rice, it was highest (25.2± 0.50 min) at 900 W for 60 s, which was at par with that of 6 months aged rice. Cooking time decreased with increase in exposure time (ET) for microwave heating. The cooking time of 90 s ET, irrespective of the microwave power (540, 720 or 900 W) was much lower (16.76 to 20.5 min) than that of 30 and 60 S even lesser than the control sample. The lower cooking time was due to more crack formation of rice grains since the cracks could allow water to infuse the kernels at the greater rate. On the other hand, the cooking time was also depended on chemical components such as starch and protein (Zhou et. al., 2001). The differences in rice components including the water probably caused the difference in interactions between starch and protein under MWH, which led to different changes in physical (crack or fissure) and physicochemical properties (gelatinization). The higher cracks or fissures led to the higher water penetration during cooking resulting in the sample with the lower cooking time (Le et al., 2014). There was significant ($P<0.05$) difference in cooking time for rice between two levels of microwave power. However, the cooking time difference between 900 W, 60 s; 720 W, 30 s and 900 w 30 s are non-significant ($p<0.05$). Therefore, maintaining either these three combinations of MWP and ET are sufficient to give accelerated aged rice with data comparable to 6 months old naturally aged rice.

Kernel elongation ratio

Kernel elongation ratio for different power and exposure time are shown in Table 2 and it varied from 1.74 to 2.85. Microwave heating process increased the kernel elongation ratio in all cases, higher than freshly harvest untreated (control) rice (*i.e.*, 1.46± .105) and at par with result of that of 6 months naturally aged rice *i.e.*, 2.67±0.04. Kernel elongation ratios were higher at 60 s ET at higher power level *i.e.*, 720 (2.85±0.65) and 900 W (2.82 ± 0.26). At higher exposure time it gives relatively less elongation in kernel of cooked rice (1.74 ± 0.21). This type of findings may be substituted with the result findings of lower head rice yield at higher power level and time settings due to the crack development inside the kernel. (Le et al., 2014). There is significant difference in KER values with increase in MWP and ET except at 60s. Therefore, higher microwave power heating at 720 W and 900 W and exposure time of 60 s gives the best kernel elongation ratio *i.e.*, 2.85 and 2.82 respectively.

Volume expansion ratio

Volume expansion ratio of cooked rice is an indirect indication of its swelling capacity during cooking. More the volume expansion ratio, the ageing of rice is more pronounced and generally volume expansion ratio more than two is desirable property of ageing (Rayaguru, 2009). From the results given in Table 2, it shows that microwave heating caused more volume expansion of rice *i.e.*, greater than 3.0 which come under the category of ageing whereas the freshly harvested sample gave around 1.5. Similar findings were also reported by Rayaguru and Pandey (2009), that well milled naturally aged rice achieved volume expansion ratio of 3.222 to 3.99 during 180 days of storage. Volume expansion ratio was highest *i.e.*, 3.2±0.06 for 60 s and 720 W as well as 900 W microwave heating.

Water uptake

More water uptake indicates more intact and fluffiness which an indirect measure of aging qualities. From Table 2, it is evident that water uptake of microwave treated rice was more towards higher exposure time *i.e.*, 90 s and 900 W and 540 W power (81.0±0.79 and 81.0±0.55 %). The variation of WU within different microwave treated combination of rice were more or less similar although a CD value of 2.72 ($p<0.05$) was observed. Freshly harvested rice i.e. control sample take 65.0± 1.08 % water during cooking. The six months naturally aged rice had higher water uptake i.e. 73.00± 1.5 % than fresh sample but, less as compared to microwave treated rice *i.e.*, 81.0±0.79 % .

Solid loss

Solid loss of freshly harvested rice was 0.66 %. Solid loss of cooked rice at different power levels and exposure time is presented in Table 2. It varied between 0.03 to 0.89% for different combinations of microwave treatment of rice. Solid loss in gruel was minimum at 720 w, 30 s followed with 720 W, 60 s MWP and ET respectively. At higher microwave power *i.e.*, 900 W solid losses were more as compared to lower power levels. The formation of fissures and cracks at higher microwave power during microwave treatment may lead towards more disruption of structures and more solid loss during cooking.

Gel consistency

Gel consistency (GC) is the quantitative measurement of texture changes (flakiness) of cooked rice durring aging. The GC of the rice samples have been categorized : 26-40 mm as hard gel, 41-60 mm as medium gel and 61-100 mm as soft in general (Le et al., 2014). The tendency of cooked rice that has a hard gel after being cooked seems to be harder on cooling. From the obtained result (Table 2), it is clear that the GC value of all the rice samples fall under the category of hard gel consistency. The freshly harvested rice (var: Lalat) gave a softer gel (38.20± 1.18 mm) compared to others. During natural ageing process upto 6 months stored rice sample the GC value lowered to 27.50± 1.15 mm giving harder gels and hard texture upon cooling of cooked rice. The harder GC of microwave heat treated rice indicates that it has achieved the ageing properties as that of 6 months stored naturally aged rice. Under microwave treatment, the GC values for different treatments (*i.e.*, MWP and ET) gave more or less similar results showing no definite trend, however, maximum GC was observed at 720 W microwave power and 60 s exposure time (25.90±0.92 mm).

Hardness

Hardness is the most significant characteristic for palatability and acceptability of cooked rice. It was (Table 2) that hardness of cooked rice of freshly harvested rice was 75.75 N which was increased to 100.2± 1.89 N after 6 months stored naturally aged rice. For different microwave power and exposure times, the hardness values varied from 70.10 N to 93.45± 0.71 N. The hardness values were higher for higher microwave power level 900 W and exposure time of 60 and 90 s. The 6 months naturally aged rice was found to be the highest hardness *i.e.*, 100.2± 1.89 N as compared to microwave treated and freshly harvested rice. It was also reported by Le et al., 2014 that the texture of cooked rice was depended on chemical characteristics of raw kernels such as amylose content and temperature of gelatinization. The hardness and stickiness were affected by amylose and short chain of amylopectin leached out during cooking process. This requires further detailed study for ensuring the effect of amylose or amylopectin content of respective rice samples with respect to the hardness parameter. However, the effect of microwave heat treatment on hardness value of cooked rice revealed that there exit a positive effect on increase in hardness of rice due to microwave heating, but, less hardness than naturally aged rice.

Stickiness

Stickiness is an undesirable property of cooked rice. Lesser the stickiness value more is good cooking quality. The stickiness of freshly harvested rice was found to be 12.95 N which was reduced to 10.5±1.64 N after 6 months of naturally aged. The stickiness of rice under microwave treatment in some cases was less and in most of the cases were higher than fresh rice sample i.e. specifically at higher MWP 900 W. The hardness and stickiness of rice were not only depended on physical characteristics but also, affected by chemical characteristics *i.e.*, amylose and amylopectin content of rice leached out during cooking process (Rewthong et al., 2011). Higher microwave power might result in samples with internal cracks and fissures leading to more leached out components during cooking and then resulting in higher stickiness. Therefore, microwave treated rice samples at higher power *i.e.*, 900 W produced more stickiness of cooked rice. However, at lower MW power 540 and 720 W at 90 s exposure time, the stickiness values were much lower 10.95±1.09 and 11.65± 0.51 N respectively as compared to fresh and untreated samples and at par with result of 6 months stored naturally aged rice.

CONCLUSION

Microwave heating of rice improved ageing qualities of rice such as head rice yield, kernel elongation ratio, volume expansion ratio, water uptake, less solid loss, gel consistency, hardness and stickiness of rice. Head rice yield was maximum 50.67±0.17 % in microwave treated sample whereas it was 38.0 ±0.37 % in freshly harvested rice sample. Higher microwave heating *i.e.*, exposure time 90 s and microwave power (720, 900 W) yielded lower head rice (41.50±0.42 and 43.74±0.14 %). The cooking time of untreated freshly harvested rice (control sample) was 17.0± 1.52 min., whereas it was increased up to 25.2± 0.50 min after microwave heating. The cooking time for 6 month aged rice was higher (27.0± 0.80 min) than fresh and also microwave treated rice. For microwave treated rice, it was highest (25.2± 0.50 min) at 900 W for 60 s, which was at par with that of 6 months aged rice. Kernel elongation ratio of cooked rice was higher (2.87 ± 0.23) for higher power level (900 W) and 60s exposure time. In this case the volume expansion of rice was achieved more than 3±0.37. Solid loss in gruel was least at higher power level 720, 900 W and exposure time 60 s. Water uptake of microwave treated rice was more towards higher exposure time *i.e.*, 90 s and 900 W and 540 W power. The hardness values were higher for higher microwave power level 900 W and higher exposure time 60, 90 s. But, this also leads towards more brokens and lower head rice yield due to rapid interaction of water molecules to electromagnetic field to internal fissure development of grains. The stickiness values for microwave heated rice showed, at lower MW power 540 and 720 W and 90 s exposure time, it was much lower 10.95±1.09 and 11.65± 0.51 N respectively as compared to fresh and other MWH conditions. Therefore, considering all the aging properties of microwave treated rice, it was found out that the best treatment out of the 9 combinations of microwave power levels (MWP) and exposure time (ET) was found to be 720 W and 60 s. Microwave treated aged rice was better as compared to freshly harvested rice and it was approaching the ageing characteristics of 6 months naturally aged rice with respect to kernel elongation ratio, volume expansion ratio, solids loss and harness values.

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