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# Abbreviations

| | |
|---|---|
| Raw paddy | (RP) |
| Raw brown | (RB) |
| parboiled brown | (PB) |
| parboiled paddy | (PP) |
| Amylose | (A) |
| Amylopectin | (Ap) |
| Free fatty acids | (FFA) |
| Peroxide value | (PV) |
| Thiobarbituric acid value | (TBA) |
| Scanning electron microscopy | ( SEM) |
| Amino acids | (AA) |
| Essential Amino acids | (EAA) |
| Non essential Amino acids | (NEAA) |
| Gram | (g.) |

# 6. SUMMARY AND CONCLUSIONS

The present work was conducted to optimize the factors affecting production of popped and puffed rice from five rice varieties**,** namely**;** Giza 177 and Sakha 101 varieties belongs to Japonica paddy rice**,** Giza 181 and Yasmine varieties belongs to Indica paddy rice and Giza 178 variety belongs to Japonica / Indica paddy rice under a wide range of conditions**,** including temperature**,** time**,** moisture content and load. The total numbers of factors studied were 22 to 23 factors.

The resulting data were statistically analyzed to figure out the most suitable conditions required for preparation of popped and puffed rice on pilot scale basis. The popped and puffed rice were physically**,** chemically and sensory evaluated. The formulated snacks prepared from both rice products were also sensory evaluated.

The results obtained throughout this study may be summarized in the following main points:

**(a) Physical properties of rice varieties:**

1-The varieties were significantly different in their physical properties.

2-Raw paddy rice of Yasmine variety had the highest value of grain index**,** while paddy rice of Giza 178 had the lowest value. Parboiled brown varieties were significantly higher in grain index than raw paddy rice and raw brown rice varieties.

3- Raw brown rice of Sakha 101 had the highest value of bulk density**,** while Giza 178 had the lowest value.

4- All dimensions of raw brown rice are closely related to the dimensions of parboiled brown rice for each variety and the inverse was true for raw paddy rice.

5- Classification of raw brown rice according to its length indicated that Yasmine and Giza 181 varieties were a long grain type**,** Shakha 101 was a medium grain type and both of Giza 177 and Giza 178 varieties were a short grain type.

6- Dehulling process led to decrease significantly the shape value in contrast to parboiling process.

7- Classification of brown rice according to its shape value indicated that both Yasmine and Giza 181 varieties had a slender shape**,** both of Sakha 101 and Giza 178 had a medium shape and Giza 177 variety had bold shape.

8- Brown rice and shellability percentages of parboiled rice varieties were significantly higher than that of raw paddy rice varieties.

9- Parboiling process had no significant difference effect on hull thickness.

10- Hardness was significantly higher for parboiled brown rice than raw brown rice.

**(b) Proximate composition of rice varieties:**

- Varietal difference and parboiling process had significant positive effects on crude protein**,** total lipids**,** amylose**,** crude fiber and ash and had negative effects on starch content.

**( c) Effect of processing conditions on popping quality of raw and parboiled paddy rice:**

1- Variations in popping expansion ratio and popping yield between varieties were significantly different.

2- Increasing the heating temperature of each raw parboiled paddy rice varieties enhanced significantly both of popping expansion ratio and popping yields and raw paddy rice of Giza 178 variety had the highest value of popping expansion at 300$^{o}$C while the corresponding value was at 175$^{o}$C for parboiled paddy rice.

3- Expansion ratio as well as popping yields increased as the moisture content increased up to 14% moisture level**,** then the values decreased with further increase of moisture content either for raw or parboiled paddy rice varieties.

4- Expansion ratio and popping yields of raw or parboiled rice paddy increased significantly as heating time increased and up to 60 seconds of heating grain whiteness decreased with increasing heating time due to scorching and browning of the grain surface.

5- 60 seconds of heating time was considered the optimum heating time.

6- Expansion ratio and popping yields of raw or parboiled paddy rice decreased significantly as load increased from 50 to 75 and there after.

7- The optimum conditions for producing popped rice are: heating temperature 300$^{o}$C for 60 second of time**,** 50 g of raw paddy rice of 14% moisture.

8- Correlation analysis showed that expansion ratio of raw paddy rice was negatively correlation with grain index**,** length**,** shape of paddy and brown rice**,** husk**,** total lipids**,** crud fiber**,** amylose percentage and whiteness and positively correlation with width of paddy and brown rice**,** hull thickness and amylopectin percentage. The correlation with other parameters was insignificant popping yields were negatively correlated with grain index**,** length and shape of raw paddy and brown rice varieties while other parameters were insignificant.

**(d) Effect of processing conditions on puffing expansion of raw and parboiled brown rice:**

1- Puffing expansion ratio progressively improved as the heating time increased from 150 to 175. further increasing did not enhance expansion ratio.

2- Variation among varieties was significantly difference at each degree of heating.

3- Puffing expansion ratio improved as the initial moisture content raised from 10 to 20%.

4- Puffing expansion ratio increased until up to 120 seconds of heating time.

5- Giza 181 variety had the highest expansion ratio being 1.88 and 2.72 for raw and parboiled brown rice**,** respectively.

6- The parboiled brown rice always had higher value of puffing expansion ratio than raw brown.

7- Increased of load level of raw and parboiled brown rice over 50 g decreased the values of puffed expansion ratio.

8- The optimal conditions for maximum puffing expansion ratio are: parboiled brown rice of Giza 181 variety**,** at 20% moisture content and heating time of 120 seconds at 175$^{o}$C of heating time with 50 g load.

9- Correlation coefficient between physical and chemical parameters and puffing expansion ratio were not significantly correlated except for protein and starch.

**(e) Physical properties of popped and puffed rice:**

1- The shape of popped rice looks like opened flower having more porous structure and was white in colour**,** while puffed rice remains cylindrical in shape and had slightly light brown colour.

2- The density**,** whiteness and hardness values of popped rice were much lower than puffed rice.

3- Popped rice had much higher expansion ratio than puffed rice.

4- Flake size of popped rice was two folds more than that of puffed rice.

5- popped rice possesses high score of crispness and was quite tender while puffed rice had high score values of hardness**,** taste and crispness as well as overall acceptability.

**(f) Chemical composition of popped and puffed rice:**

1- Glutelins represent the major protein component in raw brown**,** parboiled brown**,** popped and puffed rice. Popping and puffing process led to

decrease significantly albumins and globulins fractions, while increased of both prolamines and glutelins as well as residual protein.

2- The following amino acids decreased slightly due to popping and puffing: threonine, methionine, isoleucine, phenylalanine, lysine, serine, glycine, proline, glutamic and aspartic acids.

3- Some lysine and methionine degradation were shown by popping which dropped their contents from 38.10 and 10.71 to 34.52 and 9.52, respectively. Puffing decreased lysine from 33.65 to 32.44, while methionine content being constant..

4- The levels of essential amino acids in rice samples were superior than these reported in FAO/WHO pattern except for lysine which was the first limiting amino acids.

5-The digestibility values of popped and puffed rice were relatively higher than those of raw and parboiled brown rice.

6- The SDS-polyacrylamide gel pattern of raw brown rice contain 6 bands of different molecular weights, while parboiled brown, popped and puffed rice proteins are having only 5 bands.

7- Scanning electron microscopy of raw brown rice showed that starch granules were polygonal in shape and compactly packed in endosperm. In parboiled rice, the outline of the starch granules was less distinct. In popped and puffed rice, the starch granules were blown up into a film, showing the characteristic of soapy bubble structure.

8- Raw and parboiled brown rice contain approximately 33.8 and 20.6% total saturated fatty acids 76.7 and 79.4% and unsaturated fatty acids, respectively. Popping decreases considerably reduced the linoleic acid and arachidonic acids content and slightly affect linolenic acid content while such effects did not observe in puffing rice.

9- The popping and puffing processes did not significantly affect the K, Ca, Na, Mg, Fe, Mn and Zn contents.

**(g) Storage stability of popped and puffed rice:**

1- Storage of popped and puffed rice for 6 months in poly propylene bags at ambient temperature significantly increased their moisture contents.

The changes occurred in free fatty acids**,** peroxide**,** thiobarbituric acid values were fairly minimal after 6 months of storage.

2- Sensory evaluation of stored popped and puffed rice showed insignificant differences in colour**,** taste and flavour scoring after 6 months of storage. Whereas**,** the changes in hardness and crispness scores were significantly affected comparing at zero time of storage. However the overall acceptability of stored were still preferred by consumers.

**(h) Sensory evaluation of popped and puffed rice snacks:**

1- Sensory evaluation of formulated snacks containing honey and marshmallow showed that Honey-popped snacks had better taste and lower texture scores comparing with that containing marshmallow.

2- Marshmallow based puffed snacks were better in colour and lower in taste scores comparing with honey based puffed rice**,** while other characters was fairly identical.

3-The overall acceptability of the four snacks were reasonably good.

**From the foregoing discussion it could be concluded that the results made possible to upgrade rice grain through production of popped and puffed rice which could be used satisfactorily as breakfast cereal, snacks or incorporated them in some food item like sweet confectionery.**