International Journal of Agriculture and Food Science Technology.
ISSN 2249-3050, Volume 4, Number 4 (2013), pp. 325-330

http://www.ripublication.com/ ijafst.htm

Effect of Paddy Parboiling and Rice Puffing on Physical, Optical and Aerodynamic Characteristics

S. Kumar and K. Prasad*

Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Longowal – 148106, Punjab, India.

Abstract

Rice (Oryza sativa L) is the second largest important cultivated cereal. India is among major rice producing countries in world and Asia contributed 90 percent of the world cultivated area. India contributes more than 20% of paddy production in world with a figure of 152.6 MMT in 2012. Rice being invaluable alternative source of carbohydrate being easily digestible and has rare allergic reactions. Puffed rice is a whole-grain puffed product obtained from pre-gelatinized milled parboiled rice. This changed form of rice starch in resistant starch may be nutritionally important fraction as dietary starch, which may thus escapes unaffected during digestion and absorption in the small intestine. Also if it goes to large intestine in unaffected form may serve as nutrient for the gut micro-flora. The roasted form of rice as puffed rice may thus also be considered as pre-biotic foods apart from the conventional and nutritious low cost easily reach food to masses. Therefore, attempts have made for the preparation of puffed rice from the use of commercially important medium slender paddy genotype, Gurjari as raw material in our study. As per the result the expansion ratio was found in the range of 2.08 to 2.43 in the dimensional parameters. The increase in the surface area was found to be 5.01times that of the raw rice leaving the aspect ratio and sphericity unaltered, which is the indicator that the rice is puffed in all the dimension uniformly. The other physical properties found were in consistent with our earlier studies. The puffed rice has showed lighter optical colour with Lab value as 76.33, 0.66 and 0.33. The terminal velocity under the study of aerodynamic property showed, puffed rice could float with a very low air flow rate of 0.78 ms^{-1}.

Keywords: Paddy, parboiling, rice, puffing, terminal velocity.

1. Introduction

Paddy (*Oryza sativa* L.) is second largest major cereal crop a member of grass family (Graminaceae), which produces starchy seeds. Rice is used as an important staple food by the people in many parts of the world after wheat (Ghadge and Prasad, 2012). The world's major rice producing countries are China, India, Indonesia, Bangladesh and Vietnam and 90 percent of the world area under rice cultivation is in Asia. Paddy production in the world amounts to 718.35 MMT, out of which more than 90% paddy production is in Asia and India contributes more than 20% with a production figure of 152.6 MMT in 2012 (FAOSTAT, 2013). Moreover, rice is used as a source of nourishment for more than half of the world's population, thus, making it as second most important cereal grain (Bhatia et al, 2009, Prasad et al, 2010a, b, c). Further rice being rich in carbohydrates contributes to about 60 to 70 % of the daily energy needs of major chunks of the society. Also as convenience food such as breakfast cereals, multigrain flakes, puffed, popped, and extruded products rice is extensively used. The pre-gelatinized and puffed flour has also been utilized as ingredients for cakes, desserts and sweets, formulated baby foods, soups, stews, crackers, noodles, puddings, bread, fermented foods like idli, dosai, dhokla, rice vinegar, wine etc. Moreover, rice starch has been used as thickener and is the raw material for the production of various rice based food preparations (Prasad et al, 2013).

Puffed rice is a whole-grain puffed product obtained from pre-gelatinized milled parboiled rice, generally prepared from preconditioning of grains by hydrothermal treatment, followed by drying and milling. The milled grains are treated with salt water to an optimum moisture content, which is then subjected to puffing by sand roasting method. Consumption of these may thus be been linked to reduce the prevalence of disease risk (FDA, 2006). Puffed rice is used in snack foods and breakfast cereals, and is also a popular street food in some parts of the world. It is an ingredient of bhel puri, a popular Indian chaat item. It is also used in temples and gurudwaras as prasad. Absence of gluten provides additional benefit and makes rice particularly suitable as an alternative either in full form or as replacement of wheat in bakery products especially suitable for the celiac subjects (Prasad et al, 2010b). Further on the process of roasting the rice starch gets damaged, gelatinized and subsequently a portion of it is retrograded, which ultimately leads to the formation of resistant starch. This changed form of rice starch in resistant starch may be nutritionally important fraction as dietary starch, which may thus escapes unaffected during digestion and absorption in the small intestine. Also if it goes to large intestine in unaffected form may serve as nutrient for the gut microflora. The roasted or toasted form of rice as puffed or roasted flaked rice may thus also be considered as pre-biotic foods apart from the conventional and nutritious low cost easily reach food to masses.

2. Materials and Methods

Paddy variety Gurjari was procured from local market of Anand, Gujarat (Fig. 1). The initial moisture content determined and expressed on dry basis (AOAC, 2000). The procured paddy was found to have the moisture content in the range of 11.3 to 13.1%. Five kilogram of paddy is soaked in water at 70°C for 3.0 to 3.5 hrs before steamed for 20 min. Parboiled paddy were dried in laboratory for 1-2 days till moisture content reached up to 10.5 to 11% (wwb). Approximately, one kilogram of paddy was allowed to equilibrate at room temperature before shelling using rice husker (THU-34A, Satake Co. Ltd. Tokyo, Japan) in order to get the brown rice. The polished rice (5% degree of milling) was obtained further using single pass rice pearler (BS08A Satake Co. Ltd. Tokyo, Japan). The resulted milled rice was brought to room temperature and subjected to rice grader (Indosaw Industries (P) Ltd., Ambala, India) for the separation of head from broken rice. The paddy, brown rice with milled head rice samples were kept in polyethylene bags and stored under refrigerated condition.

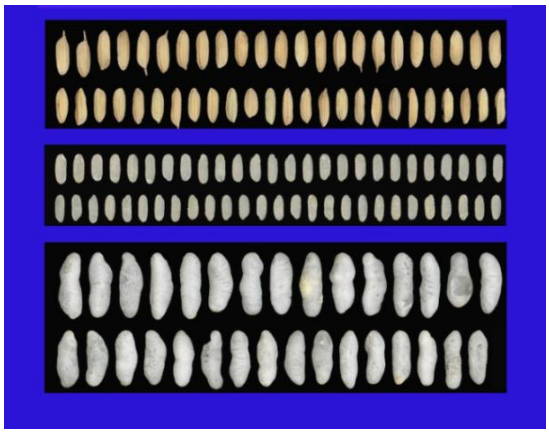

Figure 1: Experimental Setup, extraction process with carrot shreds before and after dehydration.

2.1 Tempering and Puffing

Parboiled, dried, and milled samples were conditioned to moisture level (14-14.5%) by the addition of measured amount of water containing 2% salt solution and were tempered overnight in an airtight container. Twenty gram sample was taken for puffing in a pre heated sand bath (250-280°C) containing fine sand (275 to 300 grams) maintaining a sand-to-rice ratio of 15:1 (Chinnaswamy and Bhattacharya, 1984). The parboiled tempered rice was roasted for about 10-11 second to get puffed rice (Fig. 1).

2.2 Physical Properties

The procedure for the determination of physical properties was adopted as described by Prasad *et al.* (2010c) for chickpea. The linear dimensions of the sample were measured by using three major perpendicular dimensions, length (L), breadth (B) and

thickness (T). The physical dimension were also measured manually using dial type vernier caliper (Mitutoyo Corporation, Japan) having least count 0.02 mm. Verification of dimensional characteristics of the samples was carried out using image analysis (Prasad, 2010a, c, Prasad et al, 2012) to an accuracy of 0.003 mm (Singh and Prasad, 2012, 2013). The volume expansion ratio was determined by measuring the volume of parboiled rice before and after expansion (Chinnaswamy and Bhattacharya, 1984).

2.3 Optical and Aerodynamic Properties

The optical properties of the paddy grain samples were evaluated using the Hunter Colorimeter in terms of L (luminance or brightness), a [red (+) - green (-)] and b [yellow (+) - blue (-)] values (Singh and Prasad, 2013). Terminal velocity as one of the aerodynamic properties was determined from the vertical air column designed and constructed based on the standard methods. The developed setup consisted of electrical motor, centrifugal fan, air chamber, wind tunnel and electronic measurement system. The sample was placed in the wind tunnel and air speed was gradually increased until the seeds start floating and air and speed was measured.

3. Results and Discussion

3.1 Physical Properties

The physical properties as changes with the processing levels have been represented in Table 1. The slenderness ratio or length to width (L/W) ratio varied between 2.96, which categorized the selected variety into medium slender type rice. The true density and bulk density increased on shelling and milling as the husk removal from the paddy left the starchy kernel in form of brown rice and found to have 1391.06 and 723.524 kg/m^3, respectively.

Table 1: Physical Characteristics of Gurjari paddy, parboiled rice and puffed rice.

Parameters	**Rough rice**	**Parboiled rice**	**Puffed rice**
Dimensional properties			
Length, mm	9.079±0.105	6.756±0.08	16.425±0.896
Breadth, mm	2.796±0.087	2.281±0.019	4.748±0.24
Thickness, mm	2.131±0.169	1.737±0.042	3.860±0.254
Geometric Mean Dimension, mm	3.779±0.077	2.991±0.015	6.695±0.087
Surface Area, mm^2	44.882±1.83	28.102±0.273	140.834±3.658
Aspect Ratio	30.804±1.299	33.765±0.606	28.982±2.445
Sphericity	41.739±2.183	42.227±2.788	42.763±0.888

Gravimetric properties			
Thousand Kernel Wt., g	36.367±0.077	23.207±0.178	22.277±0.158
Bulk Density, $Kg.m^{-3}$	513.576±4.859	723.524±8.897	74.525±3.135
True Density, $Kg.m^{-3}$	1044.775±16.834	1391.061±25.317	104.381±8.995
Porocity, %	50.838±0.63	49.543±4.515	46.305±4.349
Frictional properties			
Angle of repose, degree	78.579±0.481	80.679±0.244	78.443±1.1
Coefficient of friction on Glass	0.325±0.005	0.416±0.022	0.380±0.027
Coefficient of friction on GI	0.388±0.023	0.418±0.015	0.434±0.022
Coefficient of friction on ply (parallel)	0.425±0.035	0.435±0.031	0.369±0.03
Coefficient of friction on ply (perpendicular)	0.443±0.02	0.440±0.023	0.423±0.028
Optical properties			
L	69.667±4.041	43.333±3.055	76.333±2.082
A	7.667±2.082	-2.333±1.528	0.667±0.577
B	35.333±3.055	9.333±1.155	0.333±1.528
ΔE	45.250±2.757	9.000±1.732	33.140±4.652
Aerodynamic properties			
Terminal velocity, $m.s^{-1}$	2.567±0.029	2.617±0.029	0.783±0.029

Further, puffing has reduced both the true density as well as the bulk density of the puffed rice due to volume expansion in order of 13.33 times from the brown rice. During the process of puffing, the highly dense rice having the closely packed starch molecules changed in to porous and crispy puffed rice (Fig. 1) with lower moisture content and become a shelf stable. The process of making parboiled rice and puffed rice thus has accordingly affected the physical, optical and aerodynamic properties accordingly (Table 1).

The parboiled rice samples of Gurjari variety milled to 5 % and the cured form were subjected to hot sand bath maintained at 250°C and found the length expansion ratio (LER), width expansion ratio (WER) and volume expansion ratio (VER) of the puffed rice were found to be of 2.43, 2.08 and 13.33, respectively.

4. Conclusion

The physical, optical and aerodynamic properties are affected by shelling, milling and puffing, thus the properties are level of processing dependent. The volume expansion

on puffing to a level of 13.33 indicates the associated changes in the starch protein matrix of the parboiled rice make the product more appealing with desirable characteristic for finding its potential application in the development of nutritious future food products.

References

[1] FAOSTAT (2013), http://www.faostat.org.
[2] FDA (2006), Whole grain label, http://www.cfsanfda.gov.
[3] K Prasad, Anjali Anil, Y Singh and A S K Sinha (2013), Concentration dependent rheological behaviour of promising basmati and non basmati rice flour, *International Food Research Journal*, **20,** *4*, pp. 2005-2008.
[4] K Prasad, P Prakash and K K Prasad (2010b), *Rice based functional cookies for celiac: Studies on its formulation*, Lambert Academic Publishing, Saarbrucken, Germany, 128p.
[5] K Prasad, P R Vairagar and M B Bera (2010c), Temperature dependent hydration kinetics of Cicer arietinum splits, *Food Research International*, **43**, *2*, pp. 483-488.
[6] K Prasad, R, Jale, M, Singh, R Kumar, and R K Sharma, (2010a), Non-destructive evaluation of dimensional properties and physical characterization of Carrisa carandas fruits, *International Journal of Engineering Studies*, **2**, *3*, pp. 321-327.
[7] K Prasad, Y Singh and A Anil (2012), Effects of grinding methods on the characteristics of Pusa 1121 rice flour *Journal of Tropical Agriculture and Food Science*, **40**, *2*, pp. 193-201.
[8] P N Ghadge and K Prasad (2012), Some physical properties of rice kernels variety PR-106, *Journal of Food Process Technology*, **3**, pp. 175.
[9] R Chinnaswamy, and K R Bhattacharya (1984), Relationship between amylose content and expansion, characteristics of parboiled rice, *Journal of Cereal Science*, **21**, pp. 273-279.
[10] T Bhatia, R K Sharma, R Kumar and K Prasad (2009), Some studies on quality assessment of exotic promising rice cultivars on the basis of physical characteristics, *Research and Reviews in Biosciences*, **3**, *4*, pp. 153-156.
[11] Y Singh and K Prasad (2012), Rice grain quality assessment as affected by level of processing, *Crop Improvement*, **39**, *S*, pp. 1359-1360.
[12] Y Singh and K Prasad (2013) Physical characteristics of some of the paddy varieties as affected by shelling and milling, *Oryza*, (In press).