Effect of vacuum and polybag packing on simple and microwave heat treated Parboiled rice bran

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Parboiled rice bran is a by product of the milling process, after hydrothermal treatment of rice within the husk before milling. It contains more oil and low in vitamin B than raw rice bran. It's also rich in proteins, fiber, minerals. It is mainly used in feed formulation for livestock and poultry. High content of oil in parboiled rice bran is susceptible to rancidity caused by hydrolytic and oxidation activity during storage. So the effect of vacuum and poly bag packaging on the production of free fatty acids (FFA) in simple and microwave heat treated parboiled rice bran was examined. Freshly milled parboiled rice bran was subjected to microwave heat treatment and simple heat treatment. Remain was used as control. Both heat stabilized and control samples were packed in vacuum packages and Poly bag packages. They were stored in incubator at $28^{0}C$ for 8 weeks. Samples were taken for proximate analysis at 1 and 8 weeks, and at 1-week intervals for FFA determination. FFA content was increased with storage in all the samples. Lipase activity was affected by heat treatments. Reduction of free fatty acid production by microwave heat treatment was significant. Nutrient composition including protein, fat, fiber, ash and moisture were not affected by packaging methods. There is significant effect on rancidity level of vacuum and polybag packed parboiled rice bran during storage. Packaging methods and heat treatments have the effect on extending shelf life.

Key words: Free fatty acids; Heat stabilization; Parboiling rice bran; Rancidity; Vacuum and poly bag packaging.

Introduction

Rice bran is mainly used in feed formulation for livestock and poultry. Normally the 70% of total production cost goes for feed cost in livestock industry. As an animal feed ingredient rice bran has high demand and can be found in most of the areas in Sri Lanka. As raw material parboiled rice bran is relatively cheap. Because of that it is used by most of livestock feed manufactures. During storage parboiled rice bran has high chance of getting rancidity. Because of that effective storage methods are highly important to get rid of this problem.

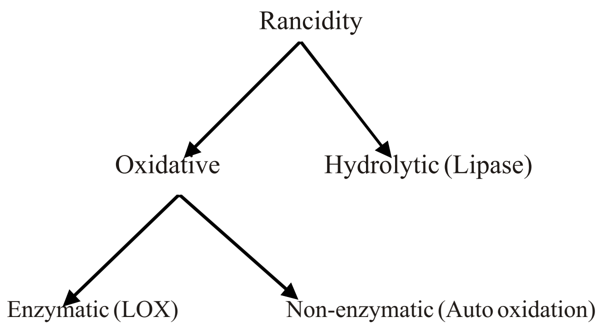
Parboiling is a hydrothermal treatment of rice within the husk without disturbing its size and shape, before milling. Paddy first hydrated, then heated to cook the rice and finally dried. Parboiled rice is the major staple throughout South Asia, where over 90% of world's parboiled rice is produced and consumed. Most of the parboiled rice produced in Sri Lanka, Bangladesh and India (Champagne, 2004).

Rice bran is a by product of the milling process. It coresponds to 5-8 % of the total rice grain. Rice bran consists of aleurone layer, embryo cell walls and parts of endosperm (Silva et al, 2000). It is rich in nutrients with 14%-16% protein, 12%-23% fat and 8%-10% crude fiber. It is also a good source of B vitamins and contains minerals such as iron, potassium, calcium, chlorine, magnesium and manganese (Saunders, 1985 cited in Malekian et al, 2000).

Parboiled rice bran contains more oil and low in vitamin B like thiamin and riboflavin. Parboiling increases oil yield by disrupting oil bodies in the aleurone and germ, this results in a band of oil migrating outward in the bran layers. Parboiled rice bran with higher oil content is “oily” and tends to clog sieves during milling. It is tends to have larger particles than does white rice bran.This differences are due to the degree of millng and conditions used in parboiling. (Juliano, 1985 cited in Champagne, 2004).

Rice bran contain oil more than 20 % of its weight. Rice bran's high lipid content limit its use, particularly if the grain has not been parboiled and rancidity occurs soon after production (Da Silva et al, 2000). The main factors for deterioration of rice bran during storage are microbial, moulds, insects and enzymatic activity. Rice bran lipases are a major cause of deterioration of oil in bran. Lipase catalyses the hydrolysis of glycrides with FFA formation.

Rancidity means breaking down lipids into FFA and production of off flavors by undergoing lipid hydrolysis and subsequent oxidation during storage. It occurs very rapidly at room temperature. Rancidity in rice bran can be categorized as hydrolytic rancidity and oxidative rancidity (Malekian et al, 2000).



Oxidative rancidity means reaction of oxygen with unsaturated lipids involves free radical initiation, propagation, and termination processes (Frankel, 1984 is cited in Malekian et al, 2000). It accelerated by free radicals, metal ions (Fe, Cu, Co), light and radiation, lipoxygenase (LOX) enzymes, fatty acid composition, storage temperature and packaging conditions.

Hydrolytic rancidity means during the milling operation, this physical separation is disrupted, and lipase enzyme comes into contact with neutral fat, causing hydrolysis of fat to FFA and glycerol in the bran. It's catalyzed by lipases and microbial enzymes activity. The hydrolysis of lipids in parboiled rice bran becomes apparent in several ways: off-flavor such as a soapy taste, increased acidity, reduced pH, changes in functional properties, and increased susceptibility of fatty acids to oxidation. The FFA undergoes further decomposition (oxidative rancidity) and result not only in free radicals but also bad taste as well as loss of nutritional values (Malekian et al, 2000).

Rice bran lipases are a major cause of deterioration of oil in bran. Lipase catalyses the hydrolysis of glycrides with FFA formation. Parboiled rice bran is resistant to hydrolytic rancidity because of the inactivation of its lipase, but it is rather prone to oxidative rancidity (Houston et al, 1954 is cited in Champagne, 2004).

Rice bran must be stabilized immediately after milling, by minimizing its FFA content to extent the shelf life. It can be done by inactivation of lipase and peroxidase enzymes using different heat treatment. Depending on the type of heat treatment, the lipase may be either reversibly inhibited or permanently denatured. The most effective classical methods include, dry heat, moist heat, moist heat stabilization. Other method includes the use of chemical products, such as hydrochloric acid, acetic acid, irradiation and stabilization by microwave. Use of chemicals and irradiation has been unsatisfactory and impractical. Most of the treatments to reduce rancidity in rice bran are not effective and economical in commercial level. The best stabilization method of rice bran in commercial level is giving heat treatment at 60 ^{0}C for 15 minutes (Malekian et al, 2000).

Most of the processes involve dry or moist heat treatment. The drawbacks common in all heat treatment methods are severe processing conditions capable of damaging valuable components of bran, substantial moisture removal and complete and irreversible inactivation of enzyme not achieved.

The use of microwave energy is an important new means of heating and is forecast to be used to a greater extent in the future. Microwave heating is efficient, economically superior, and shorter in processing time and has little effect on the original color of the rice bran. It's also had little effect on nutritional quality (proximate analysis) and functional property (water and fat absorption capacity, emulsification and foaming) of rice bran (Malekian et al, 2000).

Parboiled rice bran contains more oil than raw-rice bran. It is also generally stable to development of FFA. Proper drying and fumigation prevent FFA development. The original FFA in the bran after milling also is lowered by parboiling (Champagne, 2004).

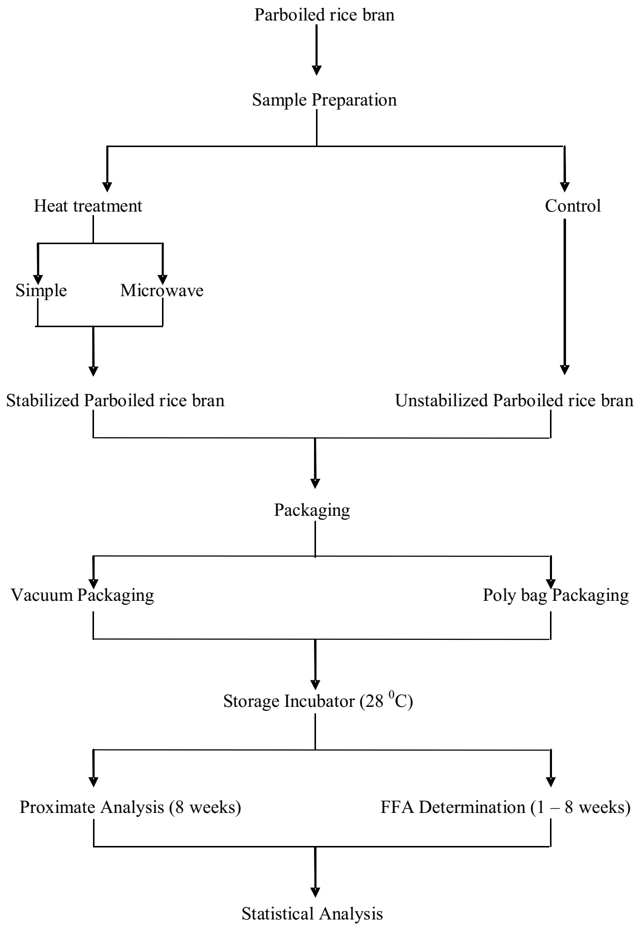
Storage of parboiled rice bran is affected from rancidity and insects. So the effective storage methods will help to keep its quality as well. Vacuum packaging and polybag packaging are also used for the purpose of parboiled rice bran storage. Vacuum packaging is a method in which foods are stored in an airless environment where rancidity and microorganism growth are prevented. It is commonly used for long term storage. Most of the time farmers and feed manufactures used polybag packaging for the storage of parboiled rice bran. It requires less cost and those packaging materials are highly available.

The primary goals of this investigation were examine effective methods to minimize the rancidity of parboiled rice bran during storage, by using different heat treatment and different packaging methods.

MATERIALS AND METHODS

Sample collection

Parboiled rice bran from the variety "BG 358" was used. Parboiled rice were dehusked and milled separately by locally available normal milling system. Samples were taken in to Livestock and Avian Science



laboratory of Wayamba University of Sri Lanka. All the samples were divided in to three portions for subjected to microwave and simple heat treatment and remain used as control.

Stabilization methods

Microwave oven operating at 850W was preheated for 4 minutes prior to loading a portion of parboiled rice bran. A part of parboiled rice bran sample was heat treated using pan roasting at 80^0 C for 10 minutes as simple heat treatment. The parboiled rice bran was removed and cooled to room temperature after the both heat treatments.

Packaging and Storage

Portions of microwave–heated, simple-heated and control parboiled rice bran were stored in polyethylene bags and vaccum sealed. Remaining heat treated and control samples were stored separately in poly bag and sealed. All the packaged samples were marked. All the bags were stored incubator at 28^{0}C until ready for use. Samples were taken for proximate analysis at 1 and 8 weeks and at 1-week intervals for FFA determination.

Fat Extraction in parboiled rice bran

Fat extraction was done by using semi auto fat analyzer and petroleum ether was used as a non-polar solvent. After one and half hours extraction the receiving flask was kept in oven for drying until it gets constant weight. Weight of the fat extracted from rice bran was taken (Soxhlet's method).

Acidity Determination

25mL of diethyl ether, 25mL of alcohol and 1mL of phenolphthalein (1%) were mixed and carefully neutralized with 0.1M sodium hydroxide. Extracted fat was dissolved with prepared solution and titrated with 0.1M sodium hydroxide shaking constantly until the pink color that persists for 15 seconds was obtained. The volume of used sodium hydroxide was recorded and acid value was calculated using equation (ISO 660; IUPAC 2.201 method).

$$\text{Acid value} = \frac{\text{Titration (mL)} \times 5.61}{\text{Wt of sample used}} \longrightarrow \text{Formula 01}$$

Proximate Analysis

Crude Protein, Crude fat, crude fiber, moisture and ash were determined by standard AOAC method (AOAC, 1991). Percentage carbohydrate was determined by difference using the formula below:

% carbohydrate = 100 – (% protein + % fat + %fiber + %moisture + %ash).

Statistical analysis

A complete randomized block design was used. Statistical analyses were done by using Minitab software. The differences were significant at P- value <0.05.

RESULTS

1. Free fatty acids (FFA)

FFA content of vacuum and poly bag parboiled rice bran samples were tested for over an 8 weeks of storage period at 1 week intervals.

Table 1: Effect of heat stabilization and packaging methods on FFA content of parboiled rice bran during storage.

Treatment	Storage time (weeks)							
	1	2	3	4	5	6	7	8
SH-VP	15.82	21.40	29.15	32.17	33.38	33.97	34.49	34.76
SH-PB	23.11	30.35	33.87	35.97	39.73	40.83	41.22	41.80
MW-VP	10.06	14.70	15.25	16.79	19.89	20.70	22.10	24.40
MW-PB	17.73	21.24	21.26	23.08	26.45	27.43	28.92	30.22
C – VP	33.24	34.42	35.80	36.19	36.83	38.57	39.90	42.69
C – PB	27.70	33.59	36.96	37.77	40.85	43.06	45.77	45.91

SH-VP = Simple heated-Vacuum packed
SH-PB = Simple heated-Poly bag packed
MW-VP = Microwave heated- Vacuum packed
MW-PB = Microwave heated- Poly bag packed
C – VP = Control- Vacuum packed
C – PB = Control- Poly bag packed

Table 1 summarized the FFA content of the rice bran which was subjected to two different heat treatments and packaging methods. FFA content was increased with storage in all the samples.

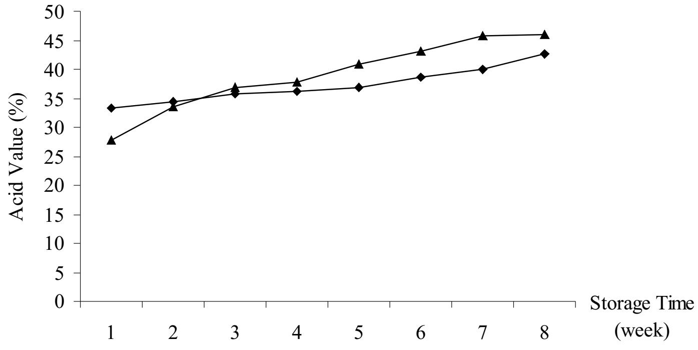


Figure 2: FFA changes in vacuum packaging (VP) and poly bag packaging (PB) on simple heat treated (SH) parboiled rice bran with storage time. Acid content of simple heat treated vacuum packed (P =0.004) and poly bag packed (P =0.001) parboiled rice bran were increased significantly with time.

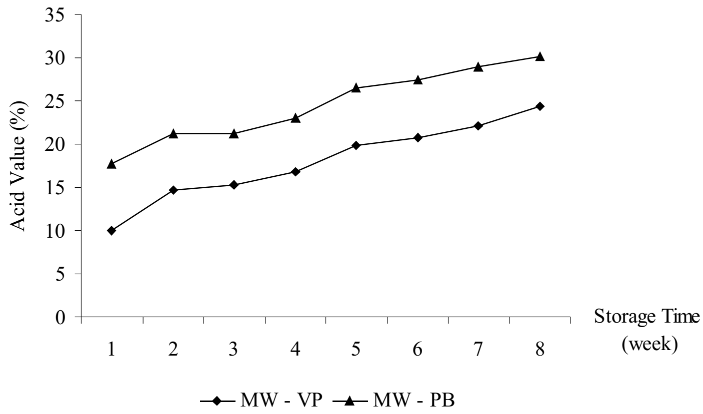


Figure 3: FFA changes in vacuum packaging (VP) and poly bag packaging (PB) on microwave heat treated (MW) parboiled rice bran with storage time. Acid content of microwave heat treated vacuum packed (P =0.000) and poly bag packed (P =0.000) parboiled rice bran were increased significantly with time.

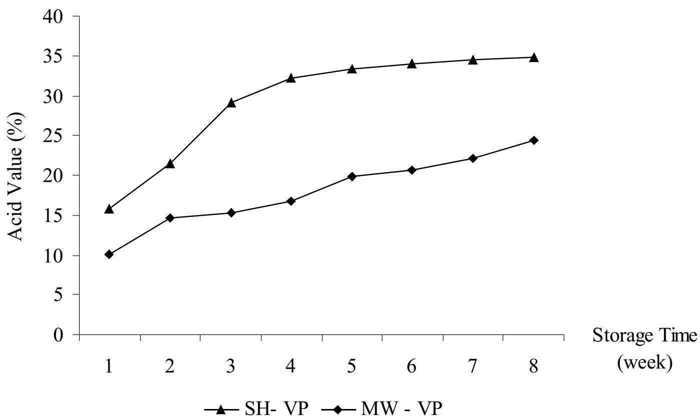


Figure 4: FFA changes in simple heat treatment (SH) and microwave heat treatment (MW) on vacuum packed (VP) parboiled rice bran with storage time Acid content of simple heat treated (P=0.004) and microwave heat treated (P=0.000) vacuum packed parboiled rice bran were increased significantly with time.

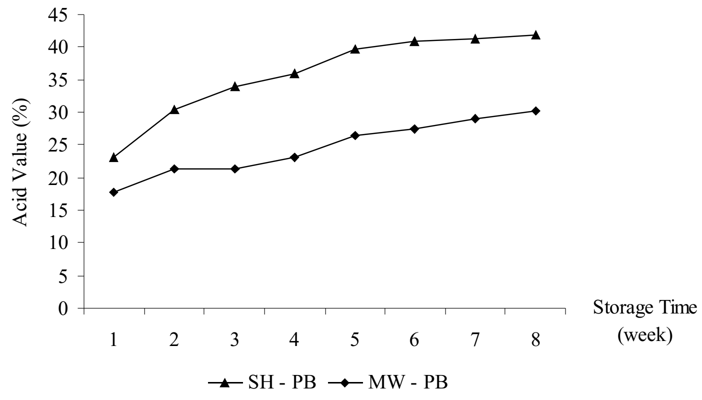


Figure 5: FFA changes in simple heat treatment (SH) and microwave heat treatment (MW) on poly bag packed (PB) parboiled rice bran with storage time.Acid content of simple heat treated (P=0.001) and microwave heat treated (P=0.000) poly bag packed parboiled rice bran were increased significantly with time. Vacuum packaging and poly bag packaging showed effect on rancidity of parboiled rice bran during storage period. (P = 0.001)

Table 2. Acid values obtained for parboiled rice bran in different packing methods.

Method	Mean	SD
VP	33.95 [a]	± 8.26
PB	39.31 [a]	± 7.53

[a] Mean values indicated by same letters are not statistically different, at a significance of 5 %, by Complete randomized block design

SD = Standard deviation

VP = Vacuum packaging

PB = Poly bag packaging

Table 3. Acid values obtained for different heat treated parboiled rice bran

Treatment	Mean	SD
SH	38.28 [a]	± 4.10
MW	27.30 [b]	± 3.99
C	44.30 [a]	± 2.48

a, b = Mean values indicated by same letters are not statistically different at a significance of 5 %, by One-way ANOVA
SD = Standard deviation
SH = Simple heat treatment
MW = Microwave heat treatment
C = Control

2. Proximate analysis

Ash, crude fat, crude protein, crude fiber and moisture percentage were analyzed for heat stabilized and non heat stabilized vacuum and poly bag parboiled rice bran samples.

Table 4. Composition of vacuum and poly bag packed parboiled rice bran subjected to different heat treatments.

Treatment	Ash [b] %	Fat [b] %	Fiber [b] %	Moisture %	Protein [b] %	Carbohydrate [b] %
SH-VP	7.38	13.58	8.80	4.90	13.20	52.14
MW-VP	9.73	19.30	9.27	4.45	13.16	44.09
C-VP	9.83	10.65	9.65	10.02	15.30	44.55
SH-PB	8.69	15.25	9.01	5.86	13.22	47.97
MW-PB	9.34	13.28	10.53	6.77	13.24	46.84
C-PB	9.39	12.32	10.49	7.30	4.20	46.30

Dry basis weight
SH-VP = Simple heated-Vacuum packed
MW-VP = Microwave heated- Vacuum packed
C – VP = Control- Vacuum packed
SH-PB = Simple heated-Poly bag packed
MW-PB = Microwave heated- Poly bag packed
C – PB = Control- Poly bag packed

Nutrient composition including protein (P=0.576), fat (P=0.629), fiber (P=0.164), ash (P=0.800) and moisture (P=0.884) were not affected by packaging methods.

DISCUSSION

Acid content of vacuum packed (P = 0.000) and poly bag packed (P = 0.000) parboiled rice bran were increased significantly with time. FFA level increase was greater in the poly bag-packed samples (Figure 1). Also FFA content of both simple and microwave heat treated vacuum packed samples were increased comparatively low than poly bag samples (Figure 2 and Figure 3). Vacuum packaging and poly bag packaging showed effect on rancidity of parboiled rice bran during storage period (P = 0.001). But there is no significant difference between two packaging methods to minimize rancidity (Table 2). As parboiled rice bran prone to oxidative rancidity during storage of polyethylene bags- vacuum packaging and removal of air and oxygen by vacuum processing activates anaerobic microorganisms. Those anerobic organisms cause microbial enzymatic rancidity. Oxidative rancidity accelerated by light , radiation and packaging conditions. Also ploy bag packaging can be further infestations and microbial growth during storage period and it cause microbial enzymatic rancidity. So those two packaging methods have not significant difference to minimize the FFA level during storage time.

Acid content of vacuum and poly bag packed, simple heat treated samples were increased comparatively higher than microwave heat treated samples (Figure 4 and Figure 5). There is significance difference of microwave and simple heat treatment to minimize rancidity. But there is not significance difference of simple heat treatment and unstabilized samples to minimize rancidity (Table 3). Microwave-heat stabilized parboiled rice bran samples packed in vacuum and poly bag stored at room temperature had much higher LOX activity than simple heat treated rice bran kept under the same conditions. This could be because of the lack or loss of antioxidants present in price bran samples during microwave heating. During the microwave stabilization, lipase and lipoxygenase enzyme as well as bacteria and mold destroy more efficiently .Therefore rancidity development can be delayed. Microwave heating is efficient, economically superior, and shorter in processing time and has little effect on the original color of the bran. (Malekian et al, 2000). Additional advantages of heat inactivation are that can simultaneously kill bacteria, moulds and insects eggs that cause further spoilage.

Nutrient compositions were not affected by packaging methods (Table 4). So both vacuum and poly bag packaging methods are suitable for storage of parboiled rice bran without changing nutritional composition.

CONCLUSIONS

Packaging methods and heat treatments have the effect on extending shelf life. There is significant effect of vacuum and poly bag packaging on rancidity level of parboiled rice bran during storage. But can't suggest best packaging methods. Stabilized parboiled rice bran has excellent keeping quality if adequate protection from microbial and insects attacks is made.

Careful selection of raw paddy and equally careful handling, parboiling and storage of parboiled rice bran would minimize problems of rancidity.

REFERENCES

1.AOAC,(1990).Official Methods of Analysis, Official Method for Ash. Method No.936.03. Association of Official Analytical Chemists, Washington, DC.

2.AOAC,(1990). Official Methods of Analysis, Official Method for Fat extraction. Method No.920.85. Association of Official Analytical Chemists, Washington,DC.

3.AOAC,(1990).Official Methods of Analysis, Official Method for Moisture. Method No.925.10.Association of Official Analytical Chemists, Washington, DC.

4.AOAC,(1990). Official Methods of Analysis, Official Method for Protein. Method No.920.87. Association of Official Analytical Chemists, Washington,DC.

5.Da Silva, M.A., Sanches, C. & Amante, E.R. (2006). Prevention of hydrolytic rancidity in rice bran. Journal of Food Engineering[On line].75(4).p.487-491. http://www.sciencedirect.com/science?_ob=ArticleURL &_udi=B6T8J-4GPW9MT1&_user=5026921&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000061525&_version=1&_urlVersion=0&_userid=5026921&md5=bf146b2da7f053e574ce501f5f20bb7b [accessed 10 February 2009]

6.Champagne,E.T.(Ed).(2004).Rice:Chemistry and Technology(3rd ed). Minnesota, U.S.A:American Associationof Cerial chemists,(pp.98-374).

7.Kirk, R.S.and Sawyer, R. (1991).Pearson's Composition and Analysis of Food (9th ed). England: Longman Singapore Publishers, (pp. 638-641).

8.Malekian,F.,Rao,R.M.,Prinyawiwatkul,W.,Marshall,W.E.,Windhauser,M.and Ahmedna,M.(2000). Lipase and Lipoxygenase Activity, Functionality and Nutrient Losses in Rice Bran during Storage, (pp.4-40).

