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Effect of Bran Roasting Temperature and Time on Yield and Quality Attributes of Rice Bran Oil

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Abstract. The effects of bran roasting temperature (160-200) °C and time (5-35 min) on the yield and quality attributes of 'Ofada' rice bran oil were studied so as to optimize the processing conditions for maximum oil yield with least deterioration of qualities. The physico-chemical parameters of oil studied included: yield, free fatty acids, peroxide value and colour, which were recorded as 14.50%, 5.80% (as oleic), 8.25 meq / kg and 1.51 abs, respectively. The optimum conditions were 200 °C roasting temperature and 15 min roasting time. With increasing the roasting temperature from 160-200 °C and the time 5-35 min, the oil yield and colour increased 11.31-14.50% and 1.51-1.58 abs, respectively, while free fatty acid and peroxide values decreased from 12.75-5.80% and 13.75-8.25 meq / kg, respectively.

Keywords: rice bran, roasting time, roasting temperature, rice bran oil

Introduction

Rice bran is the major by-product of rice milling process accounting for about 8.0% of the milled rice (Sereewatthanawut *et al*., 2008). Its production is about 50-60 million tons per year which is normally used as animal feed (Devi and Arumughan, 2007). This biomass is a natural source of oil, carbohydrates, proteins, vitamins, antioxidants, enzymes, dietary fibres (Luh, *et al.* 1991; Saunders, 1986).

Depending on milling procedure, rice bran contain 10.0-26.0% oil, hence this abundant biomass has considerable potential of fulfilling the global oil requirements (Prabhakar and Venkatesh, 1986). According to Yoshida *et al.* (1999) the bran contains about 18% edible oil, which has a unique complex of naturally occurring antioxidant components. Rice bran oil has vast applications in different industries (Zullaikah *et al*., 2005; Luh, 1980), low level of saturated fat (Hargrove, 1994) and cholesterol lowering activity in humans (Most *et al*., 2005). Its unique properties make it very appealing to food and pharmaceutical companies (Devi and Arumughan, 2007; McCaskill and Zhang, 1999). However, only a small portion (<10.0%) of rice bran oil is processed into edible oil (Zullaikah *et al*., 2005). The reason is the free fatty acids which are produced as a result of hydrolysis making rice bran oil unfit for edible purposes (Goffman *et al*., 2003; Westphal *et al*., 2002). Generally, rice bran oil with an excess of 10.0% free fatty acids is unfit for human consumption (Tao *et al*., 1993; Enochian *et al*., 1981). Rice is a major source of inorganic arsenic (As), a non-threshold class 1 carcinogen.

Sun *et al*., (2008) reported that rice bran and rice bran solubles contain inorganic arsenic levels of around 1 mg / kg dry weight, which is around 10-20 times the concentration found in bulk grain. Reducing the amount of total and inorganic As in the rice grain would reduce the exposure risk.

Recently, rice bran oil has been used in some developed countries as condiment oil along with sesame oil and perilla. Traditionally, these condiment seed oils are extracted using mechanical press or through solvent extraction after roasting of the seeds at appropriate temperature, for appropriate length of time. During roasting or cooking process, a pleasant aroma or taste (nutlike or peanut butter-like) develops in the seeds which gets transfered to the oil during extraction. The amount of extractable oil depends on the variety of rice bran, extraction conditions, addition of entrainer and milling procedure.

Rice bran is commercially utilized as supplement for animal feed with less attention on extraction of the oil content. Research into the potential of rice bran

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as a source of edible oil is desirable. Information on degree of influence of various parameters on quantity and quality attributes of oil recovered from rice bran is liable to increase the value of rice bran for use in the third world countries.

The objectives of this study were to observe the effects of various roasting temperature and time on the oil yield, free fatty acids, peroxide values, and colour of locally produced 'ofada' rice bran oil so as to establish optimum extraction parameters.

Materials and Methods

Materials. Rice bran used in this study was obtained from Fortune Agricultural Services Limited, Ibadan, Oyo State, Nigeria.

Methods. The samples of parboiled rice bran were cleaned manually to remove all foreign matter such as dust, dirt, stones and broken grains that can influence the oil yield and quality of extracted rice bran oil . All chemicals used were of analytical grade.

Preparation of rice bran oil. Rice bran (100 g) was roasted in an electric oven equipped with a stirrer and a temperature controller. Rice bran was roasted with constant stirring at 160, 170, 180, 190 and 200 °C for 5, 10, 15, 25, and 35 min, respectively. The roasted rice bran, after cooling to ambient temperature, was subjected to oil extraction following procedure described by Mamidipally and Liu (2004) and Hu *et al.* (1996). Each sample was soaked in *n*-hexane in a ratio of 1:5. The mixture was stirred for 45 min at ambient temperature (29 °C±2C)° and was subsequently, left to stand for 48 h at room temperature. It was then filtered through filter paper (Whatman No. 4) and the hexane residues in the oil solvent phase (filtrate) was evaporated in a rotary evaporator followed by drying in a hot-air oven at 100 °C for 30 min to eliminate residual *n*-hexane (Hanmoungjai *et al.,* 2001) and placed in desiccator for moisture removal. Unroasted rice bran was prepared by the same procedure as described above. The extracted rice bran oil was filtered to remove particles. The oil percentage per gram of sample was calculatd.

Determination of free fatty acid. AOCS (2004) official method Ca 5a-40 was used for the determination of free fatty acid content of oil. Oil samples of about 7.05 g in duplicate were put in 250 mL flask with addition of 50 mL neutralized alcohol. The mixture was titrated with 0.25 N NaOH with vigorous shaking until faint pink colour appears and persists for 60 sec. Quantity of 0.25 N NaOH (mL) used in the titration corresponding to the percentage of free fatty acids (FFA) as oleic acid may be calculated using the following equation:

$$\text{FFA (\%)} = \frac{(V - B) \times Nf \times 28}{W} \quad \text{.....(1)}$$

Where:

FFA = free fatty acids
V = volume of the NaOH consumed (mL.)
B = volume of NaOH consumed during blank titration (mL.)
W = weight of oil sample (g)
Nf = normality of NaOH factor

Determination of peroxide value. The extracted oil was analyzed for peroxide value by the method recommended by AOCS (2004). Oil sample (5.00 ± 0.05g) was weighed in 250 mL glass stoppered flask in duplicate. HOAC-$CHCl_3$ (30 mL) was added and swirled to dissolve. Saturated potassium iodide solution (0.5 mL) was added with occasional shaking for 1 min and 30 mL distilled water was added. The solution was titrated slowly with 0.1 N sodium thiosulphate ($Na_2S_2O_3$) and vigorously shaken until yellow colour disappears. Then 0.5 mL, 1% starch solution was added and titration was continued until blue colour just disappeared. Blank titration was conducted and the value obtained was subtracted from that of the sample. Three replicates of the experiment were undertaken and mean values were recorded.

$$\text{Peroxide value (milliequivalent peroxide / kg sample)} = \frac{S \times N \times 1000}{\text{sample (g)}} \quad \text{.....(2)}$$

Where:

S = mL $Na_2S_2O_3$ (sample value-blank value)
N = normality of $Na_2S_2O_3$ solution.

Determination of oil colour. The colour of oil was measured using a JENWAY colorimeter model type 6051 to measure absorbance at 540 nm wavelength (Tan *et al.,* 2004).

Results and Discussion

The result of the effects of roasting temperature and time on oil yield and quality are shown in Table 1. The percentage oil yield extracted from rice bran ranged between 11. 31-14.50%. The maximum oil yield of

Table 1. Effects of roasting temperature and time on oil yield, free fatty acid, peroxide value and colour

Roasting temp. (°C)	Roasting time (min)	Oil yield (%)	FFA (%)	Colour (abs)	PV (meq/kg)
160.00	15.00	11.31	8.51	1.51	13.75
170.00	10.00	12.59	8.90	1.53	11.85
170.00	25.00	12.68	11.80	1.53	10.20
180.00	5.00	13.08	10.60	1.54	8.50
180.00	15.00	14.45	7.10	1.54	8.25
180.00	35.00	14.24	12.75	1.58	9.30
190.00	10.00	12.71	9.60	1.55	9.10
190.00	25.00	14.33	7.20	1.57	9.15
200.00	15.00	14.50	5.80	1.58	8.50

14.50% was achieved at roasting temperature 200 °C and roasting time of 15 min. Minimum oil yield recorded was 11.31% at 160 °C roasting temperature and roasting time of 15 min. On the average, 13.67±1.06% of oil was recovered from rice bran. The oil recovered was within the range (10.0-26.0%) reported by Prabhakar and Venkatesh (1986). The difference in the results obtained may be traced to the method of oil extraction, rice varieties and type of organic solvent used. Variety and environmental variability influence chemical composition of rice bran (Luh *et al.,* 1991). Rice bran oil yield increased with increase in roasting temperature and time. The oil percentage for unroasted rice bran was low as compared to that of the roasted rice bran. A statistical analysis of the data (Table 2) showed that mean value of oil yield significantly increased as roasting temperature and time increased.

The free fatty acid value of oil ranged between 5.80 - 12.75% oleic acid. The maximum free fatty acid value determined in rice bran oil was 12.75% at roasting temperature 180 °C and at roasting time of 35 min. At roasting temperature 200 °C and roasting time of 15 min, the free fatty acid value was 5.80%, the minimum. The free fatty acid values had mean of 8.48±2.11%. The results showed that free fatty acid values begin to decrease as the temperature rises. This means that lipase, which initiates rapid hydrolytic deterioration in rice bran oil is deactivated to the maximum level. Free fatty acid value starts increasing at roasting temperature 180 °C and roasting time of 35 min, which can be attributed to the prolong roasting duration (35 min) which may accelerate hydrolysis in rice bran oil. This is in agreement with the findings of Rai *et al.* (1990) that increase of free fatty acids depends on time factor even after stabilization.

Table 2. Summary of results of the experiments

Factors	Oil yield (%)	Free fatty acid (%)	Peroxide value (meq/kg)	Colour (abs)
N	13	13	13	13
df	12	12	12	12
Minimum	11.31	5.80	8.25	1.51
Maximum	14.50	12.75	13.75	1.58
Mean	13.67	8.48	9.35	1.54
S.D.	1.06	2.11	1.68	0.02

N = number of experiments run; df = degree of freedom.

Peroxide value (PV) is one of the most widely used chemical tests for determination of fat and oil quality. Preferences for fat and oil products with fresh bland flavours and odours require quality and rancidity evaluations during development and after processing. PV is a measure of oxidation and rancidity in its early stage and shows good correlation with organoleptic flavour scores (O'Brien, 2008). The lower the peroxide value, the better the oil quality. It is known that factors such as temperature, light, moisture, metals, and oxygen affect rate of oxidation. This is a major cause of their deterioration (Salunkhe *et al*. 1992). The peroxide value determined at different roasting temperature and time for rice bran oil was minimum (8.25meq / kg) at roasting temperature 180 °C and roasting time 15 min and maximum (13.75 meq / kg) at roasting temperature 160 °C and roasting time 15 min. The oil had mean peroxide value of 9.35±1.68 meq / kg. The lowest peroxide value of 8.25 meq/kg was lower than 10.6, 9.1, and 8.5 meq/kg reported by Tan *et al*. (2002) for grape seed,

sunflower, and olive oils, respectively, but higher than 0.82 and 6.68 meq / kg reported by the same authors for refined-bleached-deodourized palm olein and canola oils, respectively.

The colour intensity of rice bran oil as rated by colorimeter ranged from 1.51 to 1.58 abs. The statistical analysis of oil colour (Table 2) showed that it has mean of 1.55±0.02 abs. It was observed that rice bran oil colour was a function of extraction time and temperature. It becomes darker with increase of extraction time and temperature, especially at high temperatures. This phenomenon might be due to the formation of oxidative materials including polymers and other oil-soluble products undergoing the Millard reactions (Liu and Mamidipally, 2005) and pyrolysis reaction. The impurities can be removed by a series of oil refining processes.

Conclusion

The analysis of the results relating to the yield and quality of extracted oil showed that individual effects of roasting temperature and time, as well as their interactive effects were significant. The optimum process parameters for the extraction of high yield, and good quality rice bran oil were roasting temperature 200 °C and roasting time 15 min, which gave 14.45% oil yield, 5.80% free fatty acid, 8.25 meq / kg peroxide value and 1.51 abs colour. It was understood that the conventional solvent extraction methods, such as hexane at ambient temperature, could not completely stabilize rice bran oil and the results showed that total free fatty acids concentration increased in the course of rice bran oil storage.

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