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Development and Use of a Low-Cost Extruder for the Rice-Oil Stabilization[1]

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米糠安定化를 위한 저렴 Extruder의 개발 및 이용

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Abstract

A simple and low-cost autogenous-type extruder with a capacity of about 400*kg/hr* for rice bran-oil stabilization was developed. Specific energy consumption of the extruder was 0.060-0.070 *KWH/kg* of rice bran during extrusion. Rice bran was easily extruded to form flakes or pellets with an increase of bulk density. And also the desired extrusion temperature of 95°C to 150°C could be easily obtained without any water addition when the rice bran was properly parametered with feed rate. The moisture content of bran was reduced and peroxidase was significantly inactivated after extrusion. The rice bran stabilized by the extrusion process was excellent in storage stability without considerable increase in free fatty acids.

Introduction

Currently, Korea imports over 200 thousand tons of edible oil and more than 500 thousand tons soybean for food and feed industries. On the other hand, it is roughly estimated that about 600 thousand tons of rice bran could be produced each year in Korea, much of it being underutilized.(1) At present, only 30 percent of rice bran produced from paddy crop is utilized as a source for oil extraction, while the remaining 70 percent is simply wasted in the farm yard manure.(2) More efficient utilization of rice bran would definitely stimulate food and feedstuff industries and save considerable amounts of foreign currency.

Rice bran is a by-products of rice milling industry and it contains 18-25 percent oil. If profer techniques on pretreatment and extraction could be applied to the rice bran from the total paddy milled in Korea, 10 thousand tons of high quality oil could be obtained annually. However, the problems associated with processing of rice bran make it difficult to obtain good quality oil economically. A major problem is the rapid deterioration of rice oil in the bran due to the presence of lipolytic enzymes which are activated during the milling process.(3) By the action of lipolysis, the oil is split into free acids and glycerol. The enzyme action is so active that within a day or two after milling 15 percent of the oil could be deteriorated and the oil is no longer economically recoverable as an edible oil.(4)

Two basic attempts to solve the problems have been carried out for many years. The one is to extract the oil immediately after milling before the enzyme causes serious deterioration of the oil. Unfortunately, the scattered location and small size of mills makes it difficult to collect suitable amount of fresh bran for production of

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edible oil on economic scale.[5] The other is stabilization of the bran, at elevated temperature, to retard the action of enzyme sufficiently to permit storage of bran without increase in free fatty acid for a reasonable length of time.[6-8] Among the stabilization process developed to date, only the process based on the drying after steam treatment appears to have been in pratical use as a commercial scale.[16] But the steam is not available at all mills in most of rice producing countries.

The extrusion-cooking process has been considered as a potential means of stabilization of rice bran oil. Williams and Bear[9] showed that the pressure extrusion of procooked rice bran caused inactivation of the enzyme to permit the production of high quality oil by simple solvent extraction technique. Viraktamath[10] found that in laboratory scale trials the frictional heat developed by the screw press was sufficient to elevate the temperature to the required level for inactivation of enzyme.

The present study deals with the development and use of a low-cost extruder for the rice bran oil stabilization at local mills in Korea. In this paper, the basic performance of developed extruder for rice bran stabilization is described and also the characteristics of extruded bran are discussed.

Materials and Methods

Material and Extrusion Stabilizer

Fresh rice bran produced from *Yushin* variety was collected within 8 hr after milling from a local mill and stored at cold room (-20°C) in polyethylene film bag. The proximate composition of raw rice bran was 13.8% moisture, 21.6% crude fat, 11.3% crude protein, 8.4% crude fiber and 9.4% ash. The free fatty acid content of raw bran oil was 8.2% as oleic acid.

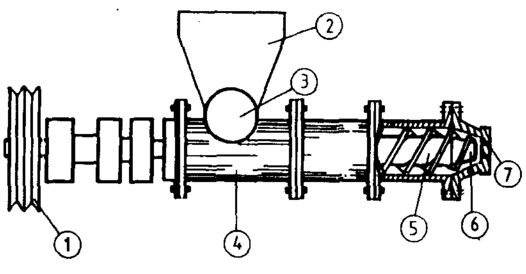


Fig. 1. KAIST-Extruder (K-E03030-100) developed for rice bran stabilization
1) Drive pulley, 2) Hopper, 3) Feed screw, 4) Barrel, 5) Main screw, 6) Screw top, 7) Die plate

Fig. 1 is the KAIST Extruder (K-E03030-100) developed for rice bran stabilization. This extruder is an autogeneous type unit with capacity of 400*kg/hr* designed to install at local mill. This extruder has a 100*mm* diameter single screw with constant channel depth and width, and is housed in 4 parallel splined barrel without any cooling or heating jackets. To control the feed rate, a feed screw having a stepless changeable rotation rate range of 0-100*rpm* is arranged at the bottom of a hopper and in a cross position above the main screw, thus the raw bran in the hopper can be fed into barrel accurately. In the barrel the bran is heated only by the heat generated from the friction of the surface of main screw and bran.

Methods

The raw bran was fed continuously into the barrel at a predetermined feed screw speed and number of die nozzle opening. After 10 *min.* of start-up, the extruder reaches steady state condition with the temperature and electric power consumption being recorded. Timed samples were taken according to the determined production rate for the analyses of moisture content and peroxidase activity.

Extrusion temperature was determined by attachment of T-type thermocouple at the inner part of die nozzle and assembled to thermocouple temperature indicator (Model 4340 Yellow Spring, Instrument Co.). Electric power was measured by using the Hidki clamp Ampere Tester 3010 and Volt-meter attached to the main motor. Specific energy consumption was determined by dividing the power input by the production rate. Bulk density of the product was determined by Narain et al.[11] and peroxidase activity was determined according to Bergmeyer's method.[12]

Results and Discussion

Operation Data

Table 1 shows the general operation data on the feed rate, extrusion temperature and specific energy consumption during rice bran extrusion. Fresh rice bran can be easily extruded through extruder and no water addition was required.

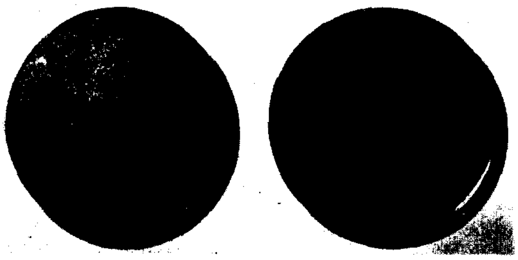
Extrusion temperature was decreased with increase

Table 1. Operational data on the feed rate, extrusion temperature and specific energy consumption during rice bran extrusion*

Feed rate (*kg/hr*)	Extrusion Temp. (°C)**	Specific energy consumption (*KWH/kg*)
300	95	0.0546
280	110	0.0591
250	120	0.0608
188	131	0.0654
145	145	0.0698
110	150	0.0713

* Three orifice die nozzle with a 4*mm* dia.

** Temperature at discharge end (around die plate)



RAW BRAN EXTRUDED BRAN

Fig. 2. Comparison of raw bran and extruded bran

in the production rate and the specific energy consumption was increased with increases in the extrusion temperature. Specific energy consumptions were measured at the range of 0.060-0.070 *KHW/kg*. It was considered that the input-energy was dissipated into a viscous heat to elevate the temperature.

Physical Properties of the Extruded Bran

As shown in Fig. 2, rice bran was formed into pellet by extrusion. Extrusion resulted in an increased particle size caused considerable bran agglomeration as shown in Table 2. Rice bran was also extruded with singificant increase in the bulk density from 0.313*g/cc* of raw to 0.618*g/cc* of extruded bran and with decrease in the moisture content from 13.8% to 6-9% depending on the extrusion temperature as shown in Table 3. The moisture of the bran was in the superheated state when the bran was placed in a high pressure of the barrel. Then it was vaporized immediately after extrusion into the atmosphere.

Residual Enzyme Activity and Storage Stability

With the reduction of moisture content, peroxidase activity of the extruded bran was considerably decreased as shown in Fig. 3. Residual peroxidase activities after extrusion at over 130°C were found to be less than 16% in comparison to that in fresh rice bran. To evaluate residual lipase activity and the formation of

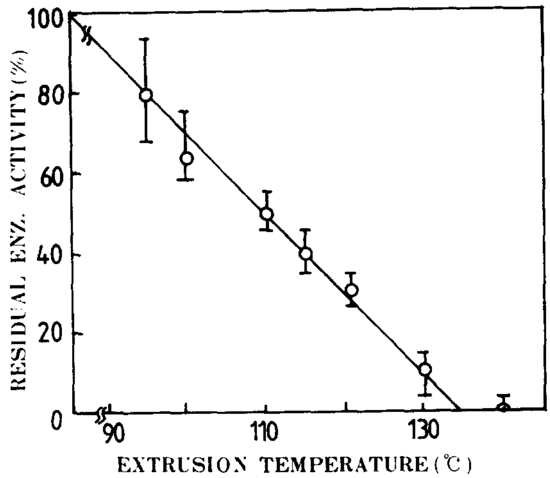


Fig. 3. Residual peroxidase activity of rice bran after extrusion with KAIST extruder
peroxidase activity in raw bran was considered as 100 percent

Table 2. Particle size distribution of extruded rice bran **ribution of extruded rice bran**

Sieve size mesh (*mm*)	Raw bran	Bran extruded @ 145°C	Bran extruded @ 110°C
+6(2.00)	0.16	31.49	68.01
-6/+9(1.18)	5.71	25.09	20.31
-9/+32(0.50)	7.09	22.22	8.01
-32/+48(0.30)	18.66	18.69	3.67
-48/+60(0.25)	37.17	2.20	—
-60/+100(0.15)	28.99	0.31	—
-100/+150(0.106)	2.16	—	—
−150	0.06	—	—

Table 3. Moisture content and bulk density of rice bran extruded at various temperature

Extrusion Temperature (°C)		Moisture (%)	Bulk density (g/cc)
Raw bran		13.08	0.313
Bran extruded at	95°C	10.41	0.526
	110	9.01	0.563
	120	8.74	0.601
	131	7.08	0.580
	145	6.68	0.523
	150	6.03	0.526

free fatty acids, the extruded bran was stored at 32°C and 80 percent relative humidity for 9 weeks. As shown in Fig. 4 it was noted that there was a substantial increase in free fatty acids of the raw bran, whereas the extrusion cooking at 130°C reduced considerably the formation of free fatty acids. At the end of 9-week storage, the bran extruded at above 120°C had less than 15% of free fatty acid in oil. It is generally recognized that the processing of the crude rice bran oil with more than 15% free fatty is not economically feasible.[4] The bran extruded at temperature above 130°C had an excellent storage stability without significant increase of the free fatty acids.

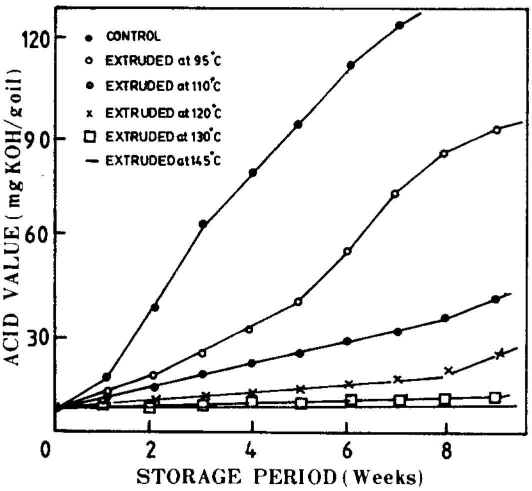


Fig. 4. Effect of extrusion temperature on free fatty acid development in rice bran during storage at 32℃ and 80 percent relative humidity

요 약

국내도정공장에 간단히 부착운용할 수 있는 미강안정화 처리용 저렴 Extruder (K-E3030 - 100, 처리능력 시간당 400kg)를 개발하였다. 부산된 미강을 그대로 안정화기로 처리하면 pellet형으로 성형된 안정화 미강을 얻을 수 있다. 안정화 처리온도는 원료투입속도를 조절함으로써 95 - 150℃ 범위에서 조절이 가능하며, 이때 전력소모량은 원료미강kg당 0.060 - 0.070KWH이었다. 안정화 처리미강은 처리온도에 따라 용적밀도가 원료미강의 0.313g/cc에서 0.526 - 0.601g/cc로 증가하였고, 수분함량은 13.08%에서 10.41 - 6.03%로 감소하였다. 그리고, 처리온도가 120℃ 이상인 경우에는 하절기의 기후 조건하에서 9주간 저장하여도 유리 지방산의 함량이 15%를 넘지 못하였다.

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