New process of dehulling- cold pressing-expansion for double-low rapeseed

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Abstract

Rapeseed dehuller, twin-screw press and expander were assembled to a new process for double-low rapeseed. The technical and economic feasibility of the new process were analyzed. It can reduce conversion cost, improve quality of oil and meal and increase economic benefit. The conversion cost of new process is 142.85 RMB Yuan·t^{-1}, which is less than pre-pressing extraction process by 20%. Cold pressing oil meets the standard of the second grade rapeseed oil (Chinese national standard, GB 1536-1986). Rapeseed meal meets the Standard of the first grade Low-glucosinolate Rapeseed Meal for Fodder of standard enacted by Chinese Ministry of agriculture (NY 417-2000), which protein content is higher than 46%. The new process will achieve higher profit, which is promising in industrialization and application.

Key words: Rape, Double-low rapeseed,Dehulling, Cold pressing, Expansion, Process

Introduction

Oilseed Rape has become the third oil crops in yield all over the world (Wang, 2004). That content of glucosinate and erucic acid was decreased greatly in double-low rapeseed improved its nutritional value of oil and protein (Bell, 1982), which caused rapeseed changed from simple provider of oil to multi-purpose sources for oils, feedstuff and protein. At present, the double-low rapeseed was still processed by the traditional method, pre-pressing and extraction, which needed the hull, long time and high temperature. So obtained rapeseed meal had a lower content of protein, deep color and bad taste for fodder. Moreover, available amino acids of protein were destroyed evidently, while effected the using value of rapeseed meal seriously, and obtained crude oils had a bad quality which increased product cost and refining loss (Watrins et al., 1989; Egon, 1975; Elizabeth et al., 1991). Traditional process of pre-pressing and extraction didn't realize excellent utilization for double-low rapeseed and made source further wasted, which already had been not fit for processing of double-low rapeseed(Zheng, 2001).

For realizing high efficient processing of double-low rapeseed, a great deal of new technology of rapeseed processing were studied, such as dehulling, cold pressing and expansion were the popular study subjects(Huang, 2002). Dehulling rapeseed not only increased content of protein, effective value of feed, and improved the meal taste for feed, but also meliorate oil's quality and decreased refining cost(Ragnar, 1992; Huang et al., 2000); Cold pressing could obtain green natural good quality rapeseed oil, avoid loss of available amino acids, increased nutritional effective value of meal and observably decreased the energy expending of rapeseed processing(Huang, 2002; Rasehorn et al., 2000); Expansion could improve materiel's extraction character, speed up extraction of oil, advance yield of oil and decrease production cost(Watrins et al., 1989; Wang, 2001). At present, the key equipments had been developed, such as dehulling, cold pressing and expansion machine (Huang et al., 2000;Rasehorn et al., 2000;Watrins et al., 1989; Lusas & Watkins, 1990). On the side of new processing for rapeseed, a factory, which could produce high quality cold-pressing oils, was been built in Germany (Rasehorn et al., 2000), but obtained cold-pressing meal had a bad extraction character. In 2003, the new process of dehulling-expansion for double-low rapeseed had been practiced(Li et al., 2004), and high protein content rapeseed meal been obtained, but high oil content of expansion meal increased the burthen of extraction system and made meal a high residual oil rate. Therefore, it is still difficult to popularize for the new process, dehulling cold- pressing and dehulling-expansion.

According to Double-low Rapeseed high effect producing actuality and developmental trend, a new idea, dehulling- cold pressing-expansion were assembled to a new process for double-low rapeseed, was given. The feasibility and economy of new process were analyzed.

1 Material and Method

1.1 Experimental material

Rapeseed was Double-low Rapeseed obtained from Wuhan Zhongpai oil Inc. The water content of rapeseed was 11.32%, impurity content 2.95%, oil content 38.68%.

1.2 Processing flow

The processing flow was showed as Fig 1.

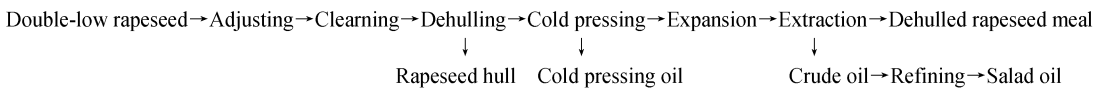

Fig. 1 The process flow diagram of dehulling-cold pressing–expansion for double-low rapeseed

1.3 Key equipments

YTTP-75 rapeseed dehuller; SSYZ50 twin-screw press; PHJZ-100 expander.

1.4 Operation conditions

1.4.1 Adjusting

Because the water content was high in new rapeseed while there was some requirement to water content in dehulling process, drying tower etc. equipment was adopted to adjust water content to 8-10%.

1.4.2 Cleanning

Dehulling-cold pressing-expansion process had high requirement in iron-excluding process. Magnetic roller was adopted to exclude iron impurity. During adjusting, double-low rapeseed was processed in vibration cleaning screen, dusty-excluding fan, and magnetic roller, in the end the rate of impurity content reached the requirement of lower than 0.5%.

1.4.3 Dehulling and separation

The appropriate moisture content for rapeseed de-hulling was 8-10%. In order to get good effect of de-hulling, rotation speed was adjusted to about 1500r·min^{-1} by transducer, and then the transducer was adjusted tinily according to observation of de-hulling rate and powder degree. Hull and kernel were separated by adjusting the wind quantity of fan, vibration speed of screen and the height of equipment of sucking hull or kernel. Hull was collected and deposited separately, and kernel was sent to next cold pressing process.

1.4.4 Cold pressing

At the beginning of press, increased feedstock gradually by adjusting frequency converter, so the press in barrel would increase gradually. Twin-screw press would work normally when current of main electromotor reached 40-50A. In pressing process, feedstock was delivered with equilibrium. If feedstock flow decreased, the pressure in barrel would fall, consequently oil yield would fall too. In the end of cold pressing process, cold pressing oil and cold pressed cake were obtained. Cold pressing oil was purified through plate filter and then was canned to get the product cold pressing rapeseed oil. And cold pressed cake was sent to next expansion process.

1.4.5 Expansion

Cold pressed cake was heated to the temperature of 90°C in cooker and then sent to expander. Feedstock flew was controlled by frequency converter to keep current between 100-120A. During expansion process, the temperature of expansion canister was adjusted directly by 0.5-0.8Mpa steam to keep it about 110°C. Attention should be paid to ensure steady feedstock flow in the process of expansion. If feedstock flow decreased or even stopped, press in expansion machine would fall and impact the expansion effect.

1.4.6 Extraction

Expansion materials were delivered to rotating extractor by a screw conveyor. The solvent infiltration speed and solvent dripping capability of expansion feedstock were better than that of pre-pressed cake, so extracting velocity was improved. Rotation speed could be increased comparatively. Oil mixture was desolventized in a series of evaporators and stripping columns. Crud oil gained by extraction was sent to refining plant and salad oil was made out through routine process of degumming, bleaching and deodorization. Wet rapeseed meal with solvent was desolventized by DT desolventizer-toaster, and then was cooled and packed to get dehulled double-low rapeseed meal.

1.5 Determining methods for physical analysis

Lipidic acidity, color and luster, peroxide value, heating test, odor and taste, moisture, volatile materials, impurity, the oil content, water, impurity of rapeseed, and crude protein, ash, crude fiber, crude fat, etc. of rapeseed meal were measured with Chinese national standard method. ITC and OZT content in rapeseed meal were analyzed by using Chinese national standard method, such as GB/T13087-1991 and GB/T13089-1991 separately. Component of amino acid in rapeseed meal was analyzed with the method of NY/T793-2004. Other process parameters were analyzed according 《Standard complication of cereals and oils. Determination methods》 SB/T10134－92 determination regulations of vegetable oil producing technique (No 1 Compiling Room of Standard Press of China,1998).

2 Results and analysis

2.1 The technical parameters of dehulling-cold pressing-expansion process for double-low rapeseed

The technical parameters of each procedure in dehulling-cold pressing-expansion process for double-low rapeseed were measured, and results were as follows:

When rapeseed was dehulled, oil contained in kernel increased to about 45%, and crude fiber content decreased a lot to 3-5%. So the phenomena of no oil out and shapeless cake would appear when present ZX18 or ZY24 single screw press was adopted. The main reason was that the dehulled rapeseed contained high oil and low crude fiber. Friction was so small that press was hard to be formed. Two screws structure was adopted in twin-screw press with a principle of combination of

joggling and non-joggling. In the press barrel, multiple-stage compression and relaxation and a thin layer of materials when pressing were applied. Compared with traditional single-screw press, twin-screw press provided high compress ratio which could reach 23 in theory, increased ratio of length and diameter of pressing obviously, and prolonged pressing time, so it could press completely. Residual oil of cold pressed cake of dehulled rapeseed which was processed in twin-screw press was about 15% which corresponded to that of hot pressed cake gained in pre-pressing process. The problem of cold pressing technology of dehulled rapeseed was solved. Compared with Germany single-screw equipment, the rate of residual oil of cold pressed cake corresponded, but the electric machine capacity of twin-screw press was only 1/3 as to the same capacity Germany equipment (Rasehorn et al., 2000).

Table 1 The technical parameters

Index	Value
Dehulling rate(%)	95.86
Residual oil of cold pressed cake (%)	15.08
Expansion rate	1:1.69
Density of expansed materials ($kg \cdot m^{-3}$)	488.56
Residual oil of rapeseed meal (%)	0.75
Capacity($t \cdot d^{-1}$)	62

PHJZ-100 expander was taken in expansion procedure for cold pressed cake. Expansed materials were porous particles with expansion rate 1:1.69 and density of 488.56$kg \cdot m^{-3}$. Feedstock was grinded, kneaded and crushed furiously in expansion machine, so cell tissue structure was destroyed completely and extraction property was improved obviously. After extraction, residual oil in rapeseed meal was 0.75% which fulfilled the requirement that the rate of residual oil in rapeseed oil should less than 1%.

2.2 Product quality of dehulling-cold pressing-expansion for double-low rapeseed

2.2.1 Quality of cold pressing oil from double-low rapeseed

Solubility of non-triglycerides component in lipid was low(Elizabeth et al., 1991), because rapeseed hull which was rich in pigment had been excluded and the temperature of cold pressing was low. Cold pressing oil gained from practical producing line was tested by Center of Quality Inspection & Test for Oil Crops Products Agricultural Ministry of China and the results were show in table 2. It was clear that the indexes of color and acidity etc. of this process were much better than that of pre-pressing crude oil. This product meeted the standard of the second grade rapeseed oil (Chinese national standard, GB 1536-1986), and could be edible when it was simply treated by filtration to exclude solid impurity. The refining processes of degumming, caustic refining, bleaching, deodorization etc. could be reduced. So, the contamination of organic chemical reagent and the appearance of trans-fatty acid could be avoided, and VE and other natural component were kept. This product could be treated as green natural healthy food, which greatly improved the economical value.

Table 2 The quality of cold pressed double-low rapeseed oil

Index	The second grade rapeseed oil	Cold pressing rapeseed oil
Color and luster (Trough thickness 25.4mm)	≤Y35 R7.0	Y35 R4.0
Odor and taste	Having the inherent flavor and taste of rapeseed oil, no peculiar smell	Having the inherent flavor and taste of rapeseed oil, no peculiar smell
Acidity(mg $KOH \cdot g^{-1}$)	≤4.0	1.1
Moisture content and volatile materials(%)	≤0.10	0.04
Impurity(%)	≤0.10	0.01
Heating test(280°C)	The color allow to be deepen and not to be darken. Trace matter allow to be separate out.	The color become deepen. No matter is separate out.

Table 3 The comparison of the quality of different rapeseed meal

Index	National I Low-glucosinolate Rapeseed Meal for Fodder	Dehulled double-low Rapeseed Meal	Rapeseed Meal
ITC+OZT($mg \cdot kg^{-1}$)	≤4000	3840	-
Crude protein(N × 6.25,%)	≥40.0	46.8	38.6
Crude fiber(%)	＜14.0	5.6	11.8
Crude ash (%)	＜8.0	7.8	7.3
Crude fat(%)	-	0.95	1.40
Moisture content(%)	＜12.0	11.2	11.5
Lysine(%)	-	2.14	1.30

Date come from Eleventh Edition Chinese Feed Database

2.2.2 Quality of dehulled double-low rapeseed meal

The quality of rapeseed meal got from dehulling-cold pressing-expansion process for double-low rapeseed was improved obviously, which meet the Standard of the first grade Low-glucosinolate Rapeseed Meal for Fodder of standard enacted by Chinese Ministry of agriculture (NY 417-2000). Due to protein content in dehulled double-low rapeseed meal increased obviously, anti-nutrition factors decreased greatly, taste was improved and had high value as fodder, all of which made the

accession amount of dehulled double-low rapeseed meal into fodder increase. This rapeseed meal could also be processed to get concentrated protein, which would increase the economical value of rapeseed meal.

2.3 Production cost of dehulling-cold pressing-expansion process for double-low rapeseed

Production cost of dehulling-cold pressing-expansion process for double-low rapeseed was shown in table 4. Power consumption of per feedstock increased for adding the equipment of dehuller and expander. However, in this new process steam consumption decreased greatly for the procedure of cooking was saved. Because the solvent infiltration property and solvent dripping capability were good, solvent content in wet rapeseed meal decreased, density of mixed oil increased. Compared with pre-pressing process, steam consumption and solvent consumption decreased greatly in the process of wet rapeseed desolventizing and mixed oil vaporizing and stripping.

Calculated the consumption of water, power, steam, solvent, refining cost, equipment depreciation and worker's salary etc., the production cost in total of dehulling-cold pressing-expansion process was 142.85 RMB Yuan·t^{-1} which decreased by about 20% compared with pre-pressing extraction process.

Table 4 The comparison of production cost(50t·d^{-1})

Index	Dehulling-cold pressing–expansion process	Pre-pressing extraction process
Power consumption(kwh·t^{-1})	70	61
Water consumption(t·t^{-1})	0.50	0.70
Coal consumption (t·t^{-1})	0.05	0.07
Solvent consumption (kg·t^{-1})	5.0	6.0
Refining Cost (RMB Yuan·t^{-1})	7	37
Equipment investment (ten thousand RMB Yuan)	500	420
Equipment depreciation charge (RMB Yuan·t^{-1})	25	21
Worker's salary (RMB Yuan·t^{-1})	12	12
Management expenses (RMB Yuan·t^{-1})	20	20
Production cost (RMB Yuan·t^{-1})	142.85	175.87

3 Discussion

3.1 Although high quality cold pressing oil was gained by process of dehulling-cold pressing for double-low rapeseed, there was still about 15% fat in cake when it was used as fodder directly. Because rapeseed kernel was pressed directly without flaking and cooking, cell tissue of cold pressed feedstock was destroyed a little(Yiu et al.,1983), fat extraction velocity was low, solvent infiltration property and solvent dripping capability of solvent were bad, and residual oil rate of rapeseed meal was high when extracted directly. Solvent consumption and steam consumption rose, which made product cost increase. Problem of producing oil by extraction from cold pressed cake remained to be solved. Though high-protein rapeseed meal was gained in dehulling-expansion process for double-low rapeseed, oil content in expansion feedstock was as high as 28% (Li et al., 2004) which affected the producing ability of extraction machine and made the resident oil rate of extraction rapeseed meal increase. what was more, producing cost increased when solvent consumption rose and burthen of evaporation and evaporation system was strengthened. In addition, the extrusion crude oil gained by dehulling-expansion process must be refined to become edible for its bad quality, which increased processing cost and decreased the economical value of double-low rapeseed oil. Dehulling, cold pressing and expansion were assembled in this experiment to build new dehulling-cold pressing-expansion process. It could not only gain high quality cold pressing oil, but also expansion process solved the problem that it was difficult to extract to gain oil from cold pressed cake. Besides high quality dehulled rapeseed meal was gained. The process of dehulling-cold pressing-expansion was proved by practice to be feasible, and was awarded as Chinese invention patient (patent number: ZL 01 1 06583.4).

3.2 In dehulling-cold pressing-expansion process, about 0.15t rapeseed hull that was new source to be used was gained from per tone double-low rapeseed. By testing, protein content in rapeseed hull was 13%~16%, which was a bit higher than that in alfalfa that was planted in home and abroad as fodder. Related experiment were being carried out to made rapeseed hull take place of alfalfa as fodder for ruminant such as cattle and sheep etc.. When planted edible fungus with rapeseed hull instead of cotton hull, product increased greatly(Huang et al.,2000). Besides Wu Mou-cheng et al. carried out study on integrated utilization of rapeseed hull(Wu et al., 1999), and they separated and extracted fine chemical products such as vegetable polyphenol and phytic acid etc.. Function and application of these products were studied farther.

References

Bell J M. Nutrients and toxicants in rapeseed meal: a review. *Journal of Animal Science,*1982,58: 996-1010.

Egon J. Effects of variation of heat treatment conditions on the nutritional value of low-glucosinolate rapeseed meal. *Journal of the Science of Food and Agriculture,* 1975,26:157-164.

Elizabeth M P, Vivekenand S V, Frank W S. Effect of heat treatments on Canola Press Oils. *Journal of the American Oil Chemists' Society,* 1991, 68(6):401-406.

Huang F H. High profit processing and multiple value-added techniques of canola. *China Oils and Fats,* 2002,27(6):9-11.

Huang F H, Zhou L X, Li W L, Wang J W, Lu S G, Cheng X Y. Study on dry dehulling technology of rapeseed. *China Oils and Fats,* 2000,25(6):48-49.

Huang F H, Zhang X J, Zhang Y B, Liu M Y, Li W L. A study of culturing mushroom with rapeseed coat. *Chinese Journal of Oil Crops Sciences,* 2000,22(4):37-39.

Li W L, Huang F H, Wang X L. Research and Application in Double-low Rapeseed Dehulling, Expansion and Extraction. *China Oils and Fats,*

2004,29(8):9-12.
Lusas E W, Watkins L R. Edible Fats and Oils Processing, Basic Principles and Modern Practices. Champaign: AOCS Press, 1990:61.
No 1 Compiling Room of Standard Press of China. Department of Standard, Bureau of Scientific and Technical Quality, Ministry of Inland Trade of the People's Republic of China. Standard complication of cereals and oils. Determination methods. Standard Press of China, 1998,23-440.
Ragnar O. Modern processing of rapeseed. *Journal of the American Oil Chemists' Society,* 1992,69(3):195-198.
Rasehorn H J, Deicke H D, Xin Y M. Theory and praxis of decortication and cold pressing of rapeseed. *China Oils and Fats,* 2000,25(6):50-54.
Wang E H. Brief introduction of expansion pretreatment in oil industry. *Sciences and Technology of Cereals, Oils and Foods,* 2001,9(3):29-30.
Wang H Z. Medium-term and long-term developing stratagem of variety improvement of China rape. *Chinese Journal of Oil Crops Sciences,*2004,26(2):98-101.
Ward J A. Pre-pressing of oil from rapeseed and sunflower. *Journal of the American Oil Chemists' Society,* 1984,61(8): 1358-1361.
Watrins L R, Johnson W H, Doty S C..Expander process for oilseeds improves extraction and reduces energy requirements. *Oil Mill Gajetteer,* 1989,94(8):30-34.
Wu M C, Yuan J H, Shao J H, Zhang Y. Studies of comprehensive processing and utilization of rapeseed. *Journal of Huazhong Agricultural University,* 1999,18(6):589-591.
Yiu S H, Fulcher R G, Altosaar I. Processing effects on the structure and microchemical organization of rapeseed and its products. 6th International Rapeseed Conference, Paris, 1983,1490-1495.
Zheng J C. Discussion of oil extraction technology for high quality rapeseed. *China Oils and Fats,* 2001,26(5):38-39.