Quality analysis of rapeseed oil crushed with different extruding-expansion pretreatments

ZHANG Min[1,2], SHEN Dechao[1]

[1]*Northeast Agricultural University, Harbin 150030, China*
[2]*China Agricultural University, Beijing 100080, China Email: 777xzm@163.com*

Abstract

We designed and assembled a high-oil extruding-expansion machine which used the dry mode and studied the pretreatment of expansion in oil processing. The interaction between extruder operation parameters and oil quality was obtained by determining the changes of AV (acid values) and POV (value of peroxide) in extruded oil under different extrusion processing conditions. The stability of directly extruded oil was mensurated. The effects of the extrusion system parameters on acid values of extruded oil in turn was temperature of die noddle, diameter of die nozzle, speed of screw, moisture of material, and the effects on POV in turn was moisture of material, temperature of die noddle, speed of screw, diameter of die nozzle. The stability of oxidation of the directly extracted extrusion-expansion oil is higher.

Key words: Extrusion-expansion, Rapeseed oil, Operation parameter, Fat quality

Introduction

At present, the extruders used in rapeseed oil production are using wet mode and high oil extruding-expansion machines. The prolonged process and the energy cost were high due to the spraying of vapor and the latter drying processing. We designed a high-oil extruding-expansion machine using dry mode for rapeseed oil processing, which simplified the processing procedure, reduced equipment investment and processing cost.

The effect on oil quality in extrusion had already been attracted people's interest. Bjorck found that the stability of fat acid in the course of extrusion was greatly reduced and also found that the extrusion could promote the union between fatty acid and the starch. Mustakas had reported that the value of peroxide increased in the extrusion along with the increasing of the extrusion temperature, the water content of the material (15%-30%) as the increasing of the time which materiel stayed in the extruder. Maga also observed that extrusion may lead to cistrans isomerism of unsaturated fatty acid. Daniels thought that the reduction of fatty acid oxidation sensitivity was the form of fat peroxide.

Fig 1 Dry-single-screw extruder for high-oil-content material developed in the experiment

However it was reported very little about the research of the extrusion oil quality that obtained directly, after the oil-bearing grops extruded. We studied the influence of extruder operation parameter on extrusion oil and fat quality through the extrusion oil quality analysis which obtained to the orthogonal experiment, which is useful to determine parameters in rapeseed extruding-expansion pretreatment processing.

Material and method

The moisture of the rapeseed was 6.622% and the oil content was 40.102%. The thousand-seed weight was 3.13g and average seed diameter was 1.61 mm. After the smashing the average grain diameter was 0.85mm. The unshelled entire grain ratio was 2-7%.

The speed of screw was stepless adjustable in the range of 0-1200r/min (Figure 1). The sleeve temperature was continuously adjustable from 0 to 300°C and with the temperature number to reveal the measuring appiance closed loop automatic control system. Extruder nib aperture having steps adjustable and the productivity was 40-45kg/h.

The rapeseed extrusion-expansion pretreatment processing was:

The rapeseed→cleaning up→smashing→expanding→extracting→extracting oil
↘ Extrusion oil

The fatty acid value of oil squeezed out from extruder was determined using a method described in GB/T 5530-85 and

the fat peroxide value was determined using the sodium hyposulfite titrimetric method.

The parameters of extruder operation were listed in Table 1. The four factors and five levels were designed using tow orthogonal revolving combination to give 36 groups. Regression analysis was performed using the Reda software and found that the effect rules between influence of extrusion oil quality and the extrusion system operation parameter.

Table 1 Experimental variables and levels

	Nib diameter ϕ x_1 (mm)	Nib temperature T x_2 (°C)	Speed of screw n x_3 (r/min)	Moisture of material w x_4 (%)
-2	8	85	25	6.6
-1	10	95	35	8.6
0	12	105	45	10.6
1	14	115	55	12.6
2	16	125	65	14.6

Consequence and analysis:

Arranged the experiment of extruding-expansion rapeseed according to Table 2 and examined target for rapeseed extrusion fat acid value y1 and peroxide value y2. After disposing experiment data by Rade software package, obtained effect rules by each operation parameter of extruder to it. The regression equation was:

$$y_1=3.97+0.53x_1+0.50x_2-0.11x_3+0.33x_4+0.05x_1^2+1.16x_1x_2-0.50-0.25x_2^2-0.58x_2x_3-0.20x_2x_4-0.09x_3x_4-0.01x_4^2$$

$$y_2=2.69+0.14x_1-0.11x_2-0.10x_3+0.20x_4-0.12x_1^2+0.15x_1x_2-0.14x_1x_3-0.43x_1x_4+0.24x_2^2+0.42x_2x_3-0.19x_2x_4+0.01x_3^2-0.32x_3x_4-0.39x_4^2$$

With the test results and regression equation which were obtained according to Table 2,the factor contribution ratio of the extrusion system parameter was listed in table 3.The order of the effects of the extrusion system parameters on acid value of extruded oil in turn was:nib temperature x2(factor contribution ratio 1.75),nib diameter x1(factor contribution ratio 1.54),speed of screw x3(factor contribution ratio 0.66),moisture of material x4(factor contribution ratio 0.41); The order of the effects of the extrusion system parameters on POV of extruded oil in turn was: moisture of material x4(factor contribution ratio 2.09), nib temperature x2(factor contribution ratio1.15), speed of screw x3(factor contribution ratio 0.74), nib diameter x1(factor contribution ratio 0.41). Obviously to the acid value of the extrusion oil, the nib temperature and the diameter were playing the critical role. But the influence of moisture of material on POV of the extruded oil was far bigger than the nib temperature on it.

Tab.3 The primary and secondary turn of the effects of every factor

Review index	Parameter			
	Nib diameter x_1	Nib temperature x_2	Speed of screw x_3	Moisture of material x_4
Acid value Y1	1.54	1.75	0.66	0.14
POV Y2	0.41	1.15	0.74	2.09

Under the superior parameter combined condition (ϕ=10mm,T=105°C,n=60r/min,w=6.6%) single factor analysis result to the equation was as shown in Fig. 2.

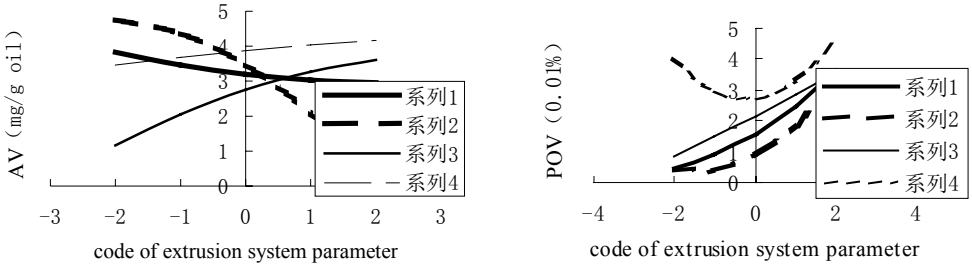
Tab2 Experiments scheme and results of characteristics of extrusion oil

Test number	x_1	x_2	x_3	x_4	AV y_1 (mg/goil)	POV y_2 (0.01%)	Test number	x_1	x_2	x_3	x_4	AV y_1 (mg/goil)	POV y_2 (0.01%)
1	1	1	1	1	3.87	2.72	19	0	2	0	0	3.46	3.07
2	1	1	1	-1	4.34	3.82	20	0	-2	0	0	3.98	3.83
3	1	1	-1	1	7.90	2.66	21	0	0	2	0	5.13	1.7
4	1	1	-1	-1	7.56	3.49	22	0	0	-2	0	3.54	3.34
5	1	-1	1	1	2.54	2.66	23	0	0	0	2	5.60	1.15
6	1	-1	1	-1	1.54	2.77	24	0	0	0	-2	3.69	0.69
7	1	-1	-1	1	2.46	3.56	25	0	0	0	0	4.13	1.20
8	1	-1	-1	-1	1.26	3.00	26	0	0	0	0	5.63	3.56
9	-1	1	1	1	2.43	3.54	27	0	0	0	0	4.58	3.03
10	-1	1	1	-1	2.06	2.65	28	0	0	0	0	4.13	3.33
11	-1	1	-1	1	2.51	2.14	29	0	0	0	0	2.14	2.81
12	-1	1	-1	-1	2.26	0.69	30	0	0	0	0	2.31	2.29
13	-1	-1	1	1	3.54	2.08	31	0	0	0	0	3.99	3.33
14	-1	-1	1	-1	3.20	2.38	32	0	0	0	0	2.25	2.38
15	-1	-1	-1	1	3.22	4.82	33	0	0	0	0	5.47	2.53
16	-1	-1	-1	-1	2.06	1.48	34	0	0	0	0	4.26	1.98
17	2	0	0	0	5.55	2.55	35	0	0	0	0	3.86	3.48
18	-2	0	0	0	4.25	3.34	36	0	0	0	0	4.86	2.32

Along with the nib temperature increasing,the acid value of the extrusion oil presented downside.The effect on the reduction to the acid value caused by high nib temperature increasing that caused the fat acid value was bigger than the low nib temperature increasing.It was because that along with the nib temperature increasing,materials flow rate in house increased

and caused the time that it stay in the high temperature sleeve reduce. Moreover as a result of heating temperature increasing,the fat viscosity reduced and also can urge the fat to be seperated from the material semifinished product in a short time. At this time,hot response time that became shortened holded the main status.The steatolysis function that caused by the temperature to the fat heating changed weakly. To this kind of effect on thecounter-flow oil, the nib temperature was higher,the effect was more remarkable.The nib diameter to the acid value of extruded oil presented the inverse correlation.when nib diameter enlarged, the friction and cutting of material which were received in house could change little, and the self-heating were few,therefore decomposition of fat being heated would reduce, and caused the acid value to reduce. Although the speed of screw of extruder increasing can cause the material flow rate to be quick,reduce dead time,and produce slightly affects to the fat decomposition.But along with rotational speed increasing,can have more intense cutting heat to the material,thus the fat decomposition speeded up and acid value heightened. This phenomenon that with the speed of screw raising caused the fat acid value to increase was more obvious when it was low speed of screw.The relation between the material moisture content and the acid value had certain effect.the high moisture content could promote the fat hydrolitic reaction to occur,so acid value increased.Because the time the material stayed in house was short,thus the scope of the acid value changing caused by the moisture content increasing was not to be big,and was also weaker for importance to effect on the acid value.

We discovered from this that in order to reduce the acid value of the extrusion,should choose the processing parameter of the high nib temperature,the big nib diameter,the low speed of screw and the low material water content as far as possible to carry on the production.



series 1- nib diameter of extruder, series 2-nib temperature of extruder, series 3-speed of screw, series 4-moisture of material

Fig. 2 Relationship between character of and extrusion system parameters

The effect on the material moisture content increasing to the POV was rising first,then to fall.As medium in chemical reaction, along with moisture content increasing, oxidation occurred in raw material intensified, peroxide in fat increased and peroxide value increased. but after the moisture content increased to a certain degree,with the moisture content continued to increase, it could displayed the characteristic that the dead time was short staying in house. Therefore the fat oxygenolysis changed weak and peroxide value reduced.When it was low nib temperature, the fat peroxide value growed slowly. Along with the nib temperature increasing,the peroxide value ingcreasing intensified.It was as a result of along with the temperature increasing,the speed of fat being heated oxygenilysis increased. The temperature was higher,the peroxide accumulation were more. Therefore the fat peroxide value increased remarkablely.The speed of screw and the extrusion oil peroxide value presented nearly the linear correlation.The influence mechanism of the enhancement of rotational speed and increasing of the temperature was the same to the fat.The rotational speed enhancing could cause the cutting hot of the material increase.This kind of function was evener and thorougher than it which the nib diameter to peroxide of extrusive oil also presented the correlation.This had direct correlation with the change of the nib diameter to the change of themeterial flow rate in house.The nib diameter was small,and the material flowing was blocked,then accumulation material semifinished product in house increased.The gun pressure which was observed from press chamber stengthened. Therefore it urged the fat to be separated from the material semifinished product as soon as possible.The probability that the fat was oxidized reduced the peroxide accumulation in fat were few.

From the single factor analysis chart between the extrusion oil peroxide value and the extrusion system parameter,we may see that in order to reduce the extrusion oil the peroxide value,we should choose the extrusion operating condition of the low or high material water content, the low nib temperature,the low speed of screw and the low nib diameter.

The index that peroxide value of the fat acted the determination initial oxidation was not only may express the fat oxidation degree in a certain extent,but also had high relevancy between the peroxide value after storage and the sense smell fetid odor and the flavor mark.In order to review the oxidation stability of the direct extrusion oil,this experiment observed the change of the peroxide value of the rapeseed extrusion oil stored in the oven at 60°C,and the peroxide value of the rapeseed extrusion oil stored,as shown in Figure 3.

In ordinary situation, when the peroxide value was higher than 0.1%,the fat appeared unhappy peppery saver and other irritant smell.In this experimental observation for 14 days time,the total peroxide content in fat had not appeared the obvious sudden change phenomenon.In the last stage of observation, peroxide value in fat was only 0.06% and was lower than the rapeseed high-quality cooking oil by 0.127% profession standard (ZBX14211-87).Not only the stability of the fat and the food including the fat had related with the existence of the unsaturated fatty acid and the resistant oxidation,but also had close correlation on way which produced oil and fat known from determination reslut of the resistant oxidation value change,rapeseed after the direct extrusion oil obtained had higher oxidation stability.

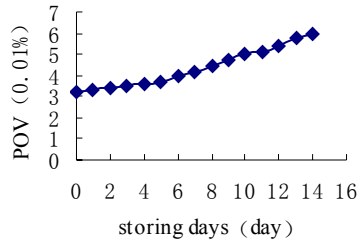


Fig 3 Storage Stability of Extruded Oil

T Wang compared the fat stability in the extrusion with unextrusion big wheat flour.The result indicated that the fat stability in the extrusion big wheat flour was lower than the extrusion sample. The proportion was lower of the unsaturated fatty acid and the saturated fatty acid in the unextrusion sample.At the same time,content of conjugation diolefine was high.T Wang proposed the extrusion-expansion desensitize activity of the lipase and the fat oxgenase, thus enhanced the stability of the soybean fat.this accorded with our test result.

4. Conclusion

The order of the effects of the extrusion system parameters on acid values of extruded oil in turn was temperature of die noddle, diameter of die nozzle, speed of screw, moisture of material,
The effects on POV in turn was, moisture of material, temperature of die nozzle, speed of screw, diameter of die nozzle.
The stability of oxidation of the directly extracted extrusion-expansion oil is higher.

Refernces

1. Liu Dachuan,Zhang Lin,Zhou Guang Sheeding the rapeseed skin,the extrusion-expansion,the new processing of extracting oil Chinese fat 2003, (1):p17
2. Zhang Fangpin,Liu Wensheng Practice on the high oil materiel with directly expanding and extracting Chinese fat 2001,26(2):p49
3. Shen Dechao,ZhangZhaoguo,Zhan Min and so on Study on the influence of the oil extraction rate of rapeseed by extrusion-expansion system parameter Agricultural enhineering journal 2004,20(6):p186
4. Zhang Min,Shen Dechao,Zhang Zhaoguo Experiment on the influence of the extrusion-expansion pretreatment to the character of the rapeseed material semifinished product. Argricultural machincal journal 2006,37(3):72-75
5. D K Bredeson Mechanical oil extraction J.Am.Oil Chem.Soc 1983,60(2):P163
6. S K Rao, W E Artz Effect of Extrusion on Lipid Oxidation J.Food.Sci 1989,54(6):P1580
7. S F O'Keefe, V A Wiley and D A Knauft Comparison of oxidative stability of high- and normal-oleic peanut oils J.Am.Oil Chem.Soc 1993,70(5):P489
8. T Wang, L A Johnson Natural refining of extruded-expelled soybean oils having various fatty acid compositions J.Am.Oil Chem.Soc 2001,78(5):P461
9. T Wang, L A Johnson Survey of soybean oils and meal qualities produced by different processes J.Am.Oil Chem.Soc 2001,78(3):P331