

Drying Condition and Qualities of Rapeseed and Sunflower

Genta KANAI*, Hitoshi KATO, Naonobu UMEDA¹, Kensuke OKADA² and Morio MATSUZAKI

Biomass Production and Processing Research Team, National Agriculture Research Center, National Agriculture and Food Research Organization (Tsukuba, Ibaraki 305–8666, Japan)

Abstract

We examined drying condition and its effects on qualities of rapeseed and sunflower, especially on oil qualities as measured by POV (peroxide value), AV (acid value) and color of oil. Initial moisture contents for rapeseed (*Norin-48*, *Kirariboshi*) were 38.7% w.b., 31.1% and 15.1% and for sunflower (*Pioneer 63M80*, *Harurinzo*) 31.5% w.b. and 15.8%. Each sample was dried unheated in a ventilation dryer for 24 hr, dried in an oven at 45°C, 55°C or 65°C for 24 hr, or dried in a circulating dryer (capacity: 1t) at unheated-55°C for 11 hr. Samples were expressed for oil with a small expeller. The oil samples were examined for POV, AV and the color of oil. POV of rapeseed oil was from 0.8 meq/kg for 45°C drying with 15.1% initial moisture content to 10.8 meq/kg for 65°C with 38.7% initial moisture content. POV of sunflower oil was from 1.9 meq/kg for 45°C drying with 15.8% initial moisture content to 6.8 meq/kg for 65°C with 31.5% initial moisture content. The early harvested rapeseed dried under higher temperature conditions had not only low oil quality measured by POV but also a green color stemming from chlorophyll. For AV a tendency that grain with higher moisture contents had higher AV was implied. According to the results, to avoid the degradation of oil quality the grain should be mature and initial moisture contents low enough to prevent deterioration; if the harvested rapeseed or sunflower grain have high moisture content, drying at lower temperatures is better to maintain the qualities of oil.

Discipline: Postharvest technology

Additional key words: acid value, peroxide value

Introduction

Recently the area of oil crops has increased rapidly because of a growing expectation of demand for bio-fuels made from vegetable oil. Among the oil crops oil palm has a very high yield of oil producing 3,800 kg/ha, compared to rapeseed with 1,000 kg/ha and sunflower with 740 kg/ha. However, a two crop system of rapeseed and sunflower has the potential of producing half the yield of oil palm in Japan⁷. Unfortunately in some areas farmers do not have enough experience in growing, harvesting and drying rapeseed and sunflower. In Japan because of its very humid climate the drying process is inevitable for most crops but there is not enough knowledge about how to dry rapeseed and sunflower. Sometimes it is difficult to harvest the crop at an appropriately dried condition because of the weather. There have been some studies on

qualities of oils and drying condition of oilseeds^{8,9}, but research on oilseeds harvested with high moisture content⁶ is not a major topic because harvesting occurs at a sufficiently dried condition in most oilseed areas.

Here the drying condition and its effects on the qualities of rapeseed and sunflower, especially on oil qualities, were examined to clarify the appropriate conditions for rapeseed and sunflower in a machine drying. In addition, to deal with the Japanese weather conditions high moisture content grains were examined.

Materials and methods

1. Materials and initial moisture contents

Rapeseed (*Norin-48*, *Kirariboshi*) was grown with the usual cultivation methods from October 2005 to June 2006 in a field at Tsukuba City, Ibaraki Prefecture, Japan. Samples were collected three times, designated I, II and III

Present address:

¹ Bio-oriented Technology Research Advancement Institution (Saitama, Saitama 331–8537, Japan)

² Japan International Research Center for Agricultural Sciences (Tsukuba, Ibaraki 305–8686, Japan)

*Corresponding author: e-mail kanaigen@affrc.go.jp

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Table 1. Sample conditions

		Moisture content (w.b.%)*	Days after seeding	1,000 kernel weight (g) D.M.	Total fat content (% D.M.)	Seeding date	Harvesting date
Rapeseed	I	38.7	245	3.01 a	49.2 e	12-Oct-05	14-Jun-06
	II	31.1	246	3.04 b	50.5 e	12-Oct-05	15-Jun-06
	III	15.1	252	3.00 a	49.0 e	12-Oct-05	21-Jun-06
Sunflower	IV	31.5	100	49.9 c	47.6 f	10-Jul-06	18-Oct-06
	V	15.8	113	65.9 d	48.1 f	20-Jun-06	11-Oct-06

*: Values in a column followed by the same letter do not differ from each other at the 5% level of significance.

as shown in Table 1.

Sunflower (*Pioneer 63M80, Harurinzo*) was grown with the usual cultivation methods from June to October of 2006 also in a field at Tsukuba City. Samples were collected two times designated IV and V as shown in Table 1.

All samples were harvested with a combine from a field of more than 10 a. Samples were collected from well mixed bulk grain discharged from the combine. Moisture contents were measured with 10 g (grain) using a 105°C-24 hour method⁵ for three times or repetitions. The 1,000 kernel weight was measured 5 times for each sample and expressed as dry matter weight. Total fat contents were measured with the Büchi B-820, Caviezel method, for 3 times or repetitions for each sample and expressed as percent value of dry matter weight.

2. Drying settings

Samples were dried with unheated or heated air as follows; A: unheated, B: 45°C, C: 55°C, and D: 65°C to fix the best drying temperature for each moisture content. In addition, E: a circulating dryer was also examined for II and IV. The dryer is very popular in Japanese rice farming and it is expected to be utilized for drying rapeseed and sunflower.

Drying settings are shown in Table 2. For "A" a ventilation dryer (Issingo Kaneko Agricultural Machinery Co., Ltd.) was used with the burner off. The dryer has a 6.6 m² mesh deck and air flows upward from a blower (0.75 kW) through the mesh. For "B" to "D" a drying oven (Espec Convection Oven LC-123) was used. For "E" a circulating dryer was used (Iseki GA100, capacity: 400-1,200 kg for wheat). Normally the drying temperature of air is regulated by the on/off of the burner based on the moisture content and quantity of the grain. However, the dryer was not adapted for use with rapeseed or sunflower grain and we stopped the electric sensor for grain moisture of the dryer. The drying temperature was observed between the unheated condition, the same as the ambient temperature, and 55°C.

Table 2. Drying settings

	Dryer	Air temperature (°C)	Duration time of drying (hour)
A	Ventilation dryer	Unheated	24
B	Drying oven	45	24
C	Drying oven	55	24
D	Drying oven	65	24
E	Circulating dryer	Unheated - 55	11

Each sample of "A" to "D" was almost 2 kg and packed in 30 cm × 40 cm plastic mesh bags. The sample of "E" was dried as bulk grain. For each setting one sample was prepared. After drying each sample, samples were preserved under conditions of 10°C in a refrigerator.

3. Expression of oil sample

A small expeller (San-Seiki S100-200, capacity: 3.5 kg/h) was used for expression (cold press) of samples. Moisture contents of samples were 5-6% when expelled. Yield of oil was 20-30% of the input grain weight.

4. Evaluation of oil qualities

Expelled oil samples were examined for POV (peroxide value), AV (acid value) and the color of oil. POV and AV are used as indices for degradation of oil and referred to as food constituents. POV increases when the oil is oxidized, and AV increases when oil is hydrolyzed. The AV is also known as being proportional to free fatty acid (FFA). The measurement of POV and AV were held at *Japan Institute of Oil, Fats & Other Foods Inspection Foundation* based on *Standard Methods for the Analysis of Fats, Oils and Related Materials* (Japan Oil Chemists' Society) for one sample for each.

Color of oil was judged by the naked eye. In addition, for rapeseed oil the colors of the samples were

measured with a spectrophotometer (UV2550, Shimazu). The results of the spectrophotometer observation were expressed as chlorophyll density using the following conversion formula based on *Standard Methods for the Analysis of Fats, Oils and Related Materials* (Japan Oil Chemists' Society).

$$\text{Chlorophyll density (ppm)} = \frac{\{A_{670} - 1/2(A_{630} + A_{710})\}}{0.0964 L}$$

A_X : Absorbance of the wave length X nm
 L : Width of the liquid in the cell

Results and discussion

1. Sample condition

Sample conditions are shown in Table 1. For rapeseed the sample harvesting times were 245 (I), 246 (II) and 252 (III) days after seeding and moisture contents were 38.7 (I), 31.1 (II) and 15.1% (III). The 1,000 kernel weights were 3.01 g (I), 3.04 g (II) and 3.00 g D.M. (III). The kernel weights of "I and II" and "II and III" were significantly different at the 5% probability level. The kernel weight difference seemed to stem from the difference in locations of the field.

For sunflower, sample IV was harvested 100 days after seeding and had kernel weight of 49.9 g; V harvested 113 days after seeding had kernel weight of 65.9 g. The kernel weight of IV and V was significantly different at the 5% level of probability. The kernel weight difference seemed to stem from the difference in locations of the field and the difference in seeding date. IV and V had been grown in the same field but seeded at different dates.

2. Peroxide Value (POV)

Figure 1 shows POV of rapeseed dried under each setting. When the initial moisture content was 38.7% (I),

the "D" setting had the highest POV followed by "C", "B" and the lowest was "A". When the initial moisture content was 31.1% (II), the "E" setting had the highest POV followed by "D", "C", "B", and the lowest was "A". Furthermore, when the initial moisture content was 15.1% (III), "A" had a value of 0.8 and "B", "C" and "D" had values of 0.9.

The results showed that a higher drying temperature was associated with a higher POV, especially in the higher initial moisture contents of 38.7% (I) and 31.1% (II). The tendency was not clear in the low initial moisture content of 15.1% (III). However, because the samples had no repetition it is difficult to discuss the results based on the statistical analysis for the tendency.

The results also showed the effect of the initial moisture content on POV. When the initial moisture content was higher, the POV was also higher. Comparisons of POV for drying condition are as follows, in drying condition "A": I (POV = 4.9) > II (2.8) > III (0.8), in "B": I (6.1) > II (3.4) > III (0.9), in "C": I (9.7) > II (3.9) > III (0.9), and in "D": I (10.8) > II (4.7) > III (0.9). The samples had no repetition and this makes it difficult to discuss the results based on statistical analysis for the tendency. However, the tendency was analyzed statistically by treating the POV of "A"-"D" as the repetitions for each harvesting date, I-III. Based on Welch's t-test, POV of III was significantly lower than that of I and II, at the 5% and 1% probability levels, respectively.

Figure 2 shows POV of sunflower dried under each setting. When the initial moisture content was 31.5% (IV), the "E" setting had the highest POV followed by "D", "C", "B", and the lowest was "A". When the initial moisture content was 15.8% (V), "D" setting had the highest POV followed by "C", "B" and the lowest was "A".

The results showed that the higher drying temperatures had higher POV. The tendency was stronger in the

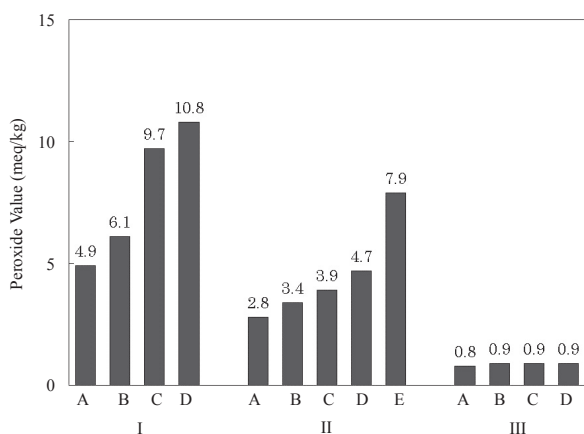


Fig. 1. Drying conditions and POV of rapeseed oil

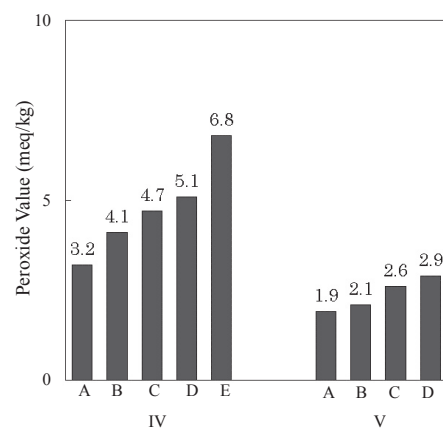


Fig. 2. Drying conditions and POV of sunflower oil

higher initial moisture content of IV (31.5%) than in V (15.8%). However, because of no repetition of the samples it is difficult to discuss the results based on statistical analysis for the tendency.

Generally oil oxidation is known to be accelerated by increased temperature¹⁰. Our study was on oilseeds not on the oil, but the tendency of the results, higher drying temperatures had higher POV, did not contradict that. For the drying of moisture conditioned grains the POV was reported to be proportional to the drying temperature from 25°C to 90°C¹, showing the same tendency.

The results also showed the effect of the initial moisture content on POV. POV of IV (31.5%) was higher than V (15.8%) in all drying conditions from “A” to “D.” No repetition of the samples makes it difficult to discuss the results based on statistical analysis for the tendency. However, here the tendency is discussed statistically by treating the POV of “A”-“D” as the repetitions for each harvesting date, IV and V. Based on Welch’s t-test, POV of V was significantly lower than that of IV at the 5% level of probability.

The POV should be under 10 (milliequivalents of active oxygen/kg oil) for edible oil obtained by cold press according to the *Codex Stan 210*². The POV of both rapeseed and sunflower oil had values fulfilling the standard.

3. Acid Value (AV)

Figure 3 shows AV of rapeseed dried under each setting. The AV of rapeseed did not show any effects of the drying condition. However, there is a report that shows higher drying temperatures had higher FFA for rapeseed with initial moisture content adjusted to 20%⁸. In the report the moisture content of grain was conditioned to 20%. In addition, the effect of field deterioration may be different every year and for every location. Those differences may be the reason that our results did not show the same tendency as the report.

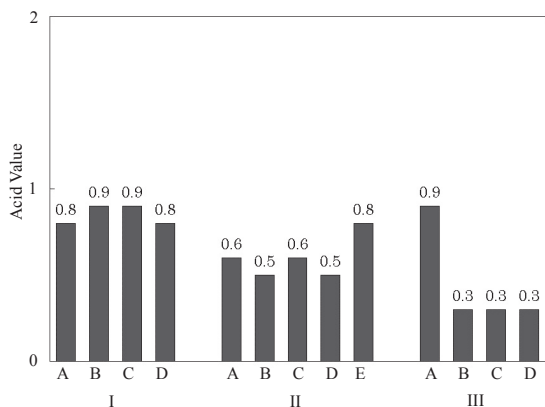


Fig. 3. Drying conditions and AV of rapeseed oil

An effect of the initial moisture content on AV was implied. Comparisons of AV for drying condition are as follows, in drying condition “A”: I (AV = 0.8) > II (0.6) < III (0.9), in “B”: I (0.9) > II (0.5) > III (0.3), in “C”: I (0.9) > II (0.6) > III (0.3), and in “D”: I (0.8) > II (0.5) > III (0.3). The tendency that higher initial moisture contents had higher AV was observed except in III-A. III-A showed strangely high AV but the reason has not been identified. No repetition of the samples makes it difficult to discuss the results based on statistical analysis for the tendency. However, here the tendency is discussed statistically by treating the AV of “A”-“D” as the repetitions for each harvesting date, I-III. AV of II was significantly lower than that of I based on Welch’s t-test at the 5% level of probability.

Figure 4 shows AV of sunflower dried under each setting. The AV of sunflower did not show any effects of the drying condition. For the drying of moisture conditioned grains the FFA was reported to be proportional to drying temperatures from 25°C to 90°C¹. The examination of grain with 15% to 43% moisture contents and dried at temperatures of 35°C to 88°C is reported to show the FFA increasing with drying temperature without statistical validity⁶. However, here the results did not show this tendency. One reason for the difference from the first case can be explained by the difference in the sample preparation for drying. In the report the moisture content of grain was conditioned to 28% by spraying grain with distilled water. In addition, the effect of field deterioration may be different every year and for every location.

The tendency that higher initial moisture contents had higher AV was observed in drying conditions “A”-“D”, IV (0.4) > V (0.3). No repetition of the samples makes it difficult to discuss the results based on statistical analysis for the tendency. However, here the tendency is discussed with statistical analysis by treating the AV of “A”-“D” as the repetitions for each harvesting date, IV and

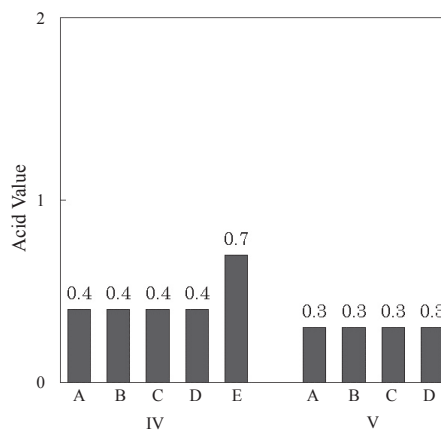


Fig. 4. Drying conditions and AV of sunflower oil

V. AV of IV was significantly higher than that of V based on Welch's t-test at the 1% level of probability but there is a report⁶ which found the opposite tendency of the FFA to initial moisture content. In the report the samples with 15% initial moisture content had significantly higher AV than that of samples with 22% to 43% moisture contents for drying temperatures of 35°C to 88°C. In this case differences in field deterioration may have occurred between harvesting of the 15% grain sample and 22% grain sample.

The AV should be under 4.0 (mg KOH/g fat or oil) for edible oil obtained by cold press according to the *Codex Stan 210*². The AV of both rapeseed and sunflower oil had values fulfilling the standard. The drying conditions did not seem to have enough effect on deterioration of grain to influence AV. It is implied that grain with higher initial moisture contents had higher AV.

4. Color of oil

According to the observations by the naked eye, the rapeseed oil color of "A", "B", "C", and "D" of I, and "C", "D" and "E" of II was slightly green. The intensity of green seemed to be proportional to the POV. However, those of "A" and "B" of II, and all of III had almost the same color of light yellow. The results seemed to indicate a relationship with the ratio of immature green rapeseed grain in each sample.

Figure 5 shows the chlorophyll density of rapeseed oil samples according to the results of the spectrophotometer observation. The intensity of green observed by the naked eye seemed to be almost proportional to the chlorophyll density. Chlorophyll is a green coloring matter and seemed to have an effect on the oil color. There was a report that grain with higher green seed ratio had higher chlorophyll density of seeds and that higher chlorophyll

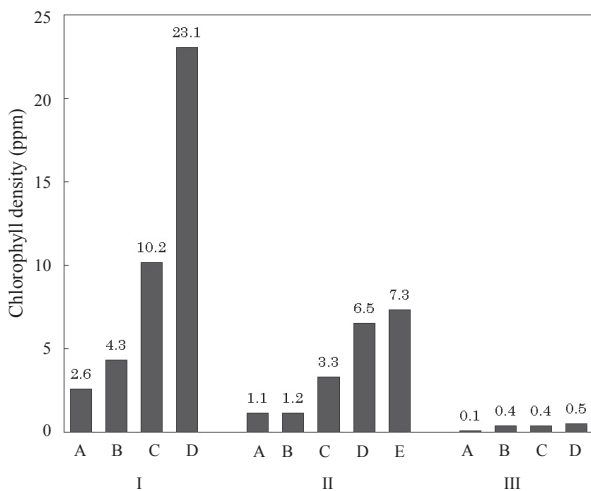


Fig. 5. Drying conditions and chlorophyll density of rapeseed

density of seeds had higher chlorophyll density of oil³.

Chlorophyll density of rapeseed oil was higher when the drying temperature was higher. The reason for the tendency could be explained by chlorophyllase activity. Chlorophyll is decomposed by chlorophyllase. In addition, chlorophyllase generally shows maximum activity at 30°C to 40°C⁴. That implies the tendency of the results can be explained by drying condition D having the highest temperature outside this range, the lowest activity of chlorophyllase and the highest density of chlorophyll, followed by C, B and A. Furthermore, chlorophyll and its derivatives in the oil have been reported to accelerate oxidation¹¹ that seemed to be related with the chlorophyll contents and were almost proportional to POV.

Based on the observations by the naked eye, the sunflower oil color of all of IV and V was almost the same color of light yellow. Chlorophyll density was not measured for sunflower oil.

Conclusions

We examined the drying condition and its effects on oil qualities of rapeseed and sunflower as measured by POV (peroxide value), AV (acid value) and color of oil. The examination includes grains with high moisture contents to deal with harvesting in rainy weather condition. The conclusions of this study are as follows.

- 1) POV of rapeseed oil was from 0.8 meq/kg for 45°C drying with 15.1% initial moisture content to 10.8 meq/kg for 65°C with 38.7% initial moisture content. POV, green color intensity and chlorophyll density seemed to increase when drying temperature increased. In addition, they also increased when initial moisture content increased.
- 2) POV of sunflower oil was from 1.9 meq/kg for 45°C drying with 15.8% initial moisture content to 6.8 meq/kg for 65°C with 31.5% initial moisture content. POV seemed to increase when drying temperature increased. Furthermore, POV also increased when initial moisture content increased. No tendency was observed here for the color of sunflower oil in any drying condition.
- 3) The drying conditions did not seem to have enough effect on deterioration of both rapeseed and sunflower to influence AV. It is implied that grain with higher initial moisture contents had higher AV.
- 4) According to the results for avoiding the degradation of oil quality, to keep POV and AV low, the initial moisture content should be low enough to prevent quality deterioration; if the harvested rapeseed or sunflower grain have high moisture contents, drying at lower temperatures is better for maintaining the qualities of oil.

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