Color Stability of Glandless Cottonseed Oil

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The color stability of oil extracted from glandless cottonseed contaminated with various levels of glanded cottonseed was studied. The rate of darkening in bleached color of cottonseed oil during storage was proportional to the original glanded cottonseed or gossypol content in the oil and to time and temperature of storage. Glandless cottonseed with 0–10% glanded seed contamination, as might be expected in commercial production of glandless cotton, yielded oil with equivalent or better color when conventionally refined and bleached after 30 days storage at 25 to 40 C than miscella refined oil from glanded cottonseed. This indicates that new oil mills for extracting glandless cottonseed need not invest in miscella-refining units in order to produce high quality oil.

Color problems encountered during processing of cottonseed oil usually are the result of difficulties in removing fixed pigments from darkly colored oils by current methods of alkali-refining and bleaching. Undesirable dark colors can become permanently fixed during storage of crude oils obtained from prime cottonseed due to gossypol which is normally present in cottonseed (1). Geneticists have developed glandless varieties of cottonseed which are low in gossypol (2). Chemical and physical analyses of oils obtained from glandless cottonseed show them to be essentially identical to oils obtained from widely-grown glanded cottonseed except for differences in pigment contents (3). However, current supplies of glandless cottonseed in commercial trade typically contain 5–10% glanded seed contamination due to cross pollination with glanded cotton. It is not known whether these levels have any practical consequences on the quality of refined and bleached oil.

MATERIALS AND METHODS

Crude oil extraction. Dehulled glandless cottonseed kernels (Rogers Delinted Cottonseed Co., Waco, Texas) were hand picked to obtain samples of 100% glandless cottonseed. Glanded cottonseed (Anderson Clayton Co., Thorndale, Texas) was dehulled and added to picked glandless cottonseed kernels to produce known levels of glanded cottonseed contamination, namely 5.0 and 10.0%. Pure glanded cottonseed samples were used as controls.

Seed samples were conditioned in a household pressure cooker. Sufficient water was added to raise the moisture content of the dehulled seed (meats) to 12%.

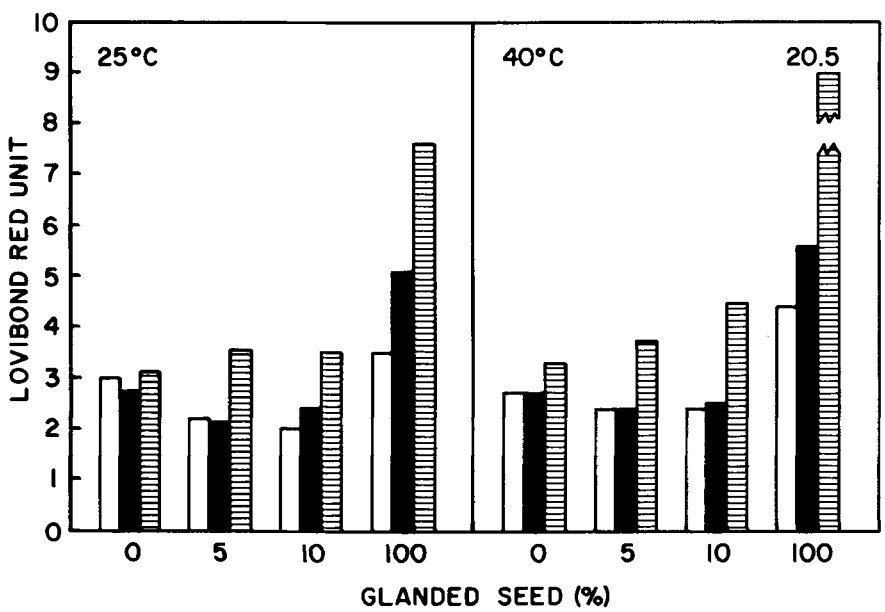

FIG. 1. Comparison of refining techniques, levels of glanded cottonseed contamination, storage time and storage temperature on Lovibond red units of bleached cottonseed oil. Bar ▭ denotes one day storage, miscella refining; bar ▬ denotes two days storage, conventional refining; bar ▤ denotes 30 days storage, conventional refining.

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TABLE 1

Gossypol Contents of Crude Oils Pressed from Mixtures of Glanded and Glandless Cottonseed Kernels

Glanded seed contamination level (%)	Gossypol content in oil (%)
0	0.0007
5	0.0050
10	0.0110
100	0.0980

Moistened cottonseed meats were heated in the pressure cooker about 30 min to 70 C and allowed to dry to ca. 9% moisture. The conditioned cottonseed meats were pressed in an Anderson Midget Expeller Screwpress (V.D. Anderson Co., Cleveland, Ohio). The screwpress was preheated with heating lamps for one hr prior to pressing seed. Crude oil was cooled immediately to 0 C as recovered.

Oil storage. In order to compare the effects of time and temperature during storage of crude oil and refined and bleached color, duplicate 500-ml lots of the four crude cottonseed oils (from 0.0, 5.0, 10.0 and 100% glanded cottonseed) were stored for three different periods of times (1 day, 2 days and 30 days) at 25 and 40 C. After storage the crude oils were refined by one of the following procedures, and then bleached.

Conventional refining. Conventional refining was simulated in the laboratory by modifying the AOCS Official Method Ca 9a-52 (4). Free fatty acid values of crude oil samples were determined by the AOCS method CA 5a-40 and found to be about 1.2 % for the glandless cottonseed oils and 1.5% for the glanded cottonseed oil. The alkali treatments of glandless cottonseed oils were calculated to be 8.1% of 14 Be′ alkali with 0.6% excess over stoichiometric. The alkali treatment of the glanded cottonseed oil was 8.3% of 14 Be′ alkali with 0.6% excess over stoichiometric. The alkali was added to 200 g of oil and mixed at speed 3 for 2.0 min at room temperature using a Sorval Omni-Mixer, Model 17150. The mixture was heated in a water bath to 55–60 C to melt the soapstock and slowly stirred at speed 1 for 10.0 min. The slurry was centrifuged at 4080 × g for 10.0 min, and the oil was decanted from the soapstock.

Miscella refining. Miscella refining was also simulated in the laboratory with miscella (20% oil) prepared by dissolving 100 g of crude-pressed oil in 400 g hexane. The miscella was concentrated to 50% oil content using a rotary evaporator and cooled to room temperature. The same amount of 14 Be′ alkali as used for conventional refining was added to the miscella and mixed for 5.0 min at 25 C using the Sorval Omni-Mixer at speed 7. The miscella was heated in a water bath to 55–60 C to melt the soapstock and stirred at speed 5 for 10.0 min. The mixture was centrifuged at 4080 × g for 10.0 min, and the miscella was decanted from the soapstock. Refined miscella was desolventized using a rotary evaporator.

Bleaching. The standard AOCS bleaching procedure Cc 8d-55 was modified to accommodate larger sample sizes. The refined oil was heated on a plate to 105–110 C, and 3% diatomaceous earth was added. The sample was stirred at speed 1.5 with the Sorval Omni-Mixer for 5.0 min while maintaining a temperature of 105–110 C. The oil was then filtered through Whatman No. 41 filter paper.

Analyses. Gossypol contents of the crude oils were determined by using AOCS method Ca 13-56. Colors of the refined and bleached oils were determined by both the AOCS Lovibond method Cc 13b-45 and the photometric method Cc 13c-50.

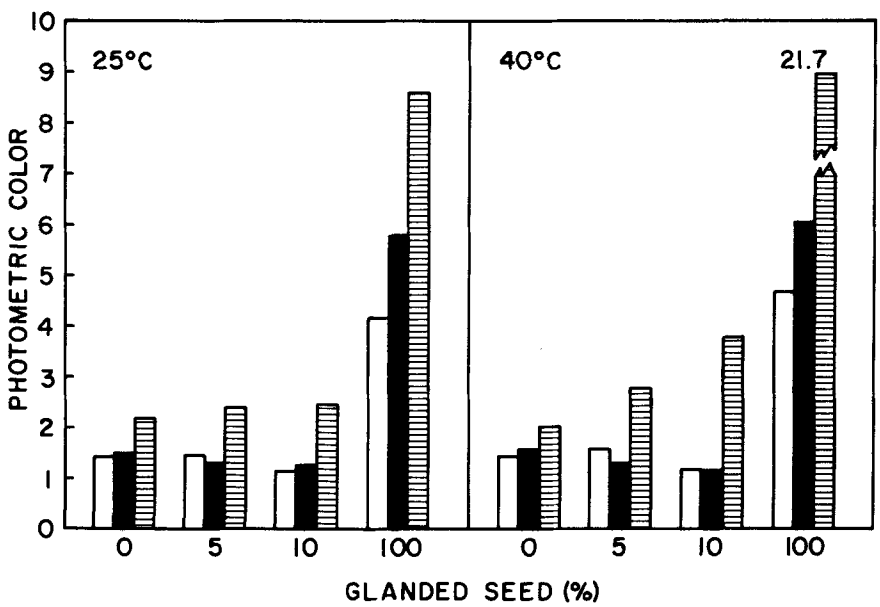

FIG. 2. Comparison of refining techniques, levels of glanded cottonseed contamination, storage time and storage temperature on photometric color of bleached cottonseed oil. Bar ☐ denotes one day storage, miscella refining; bar ■ denotes two days storage, conventional refining; bar ▤ denotes 30 days storage, conventional refining.

RESULTS AND DISCUSSION

Currently, about half of the cottonseed mills in the U.S. miscella refine immediately after extraction to produce high quality oil; the other half do not miscella refine and produce crude oils which often result in dark-colored oils upon conventional refining by the oil processor. Dark colored oils are sold at discounted prices because they are unacceptable in some applications. While it has been speculated that glandless cottonseed oil should not be susceptible to color fixation because of its low gossypol content, it is not known whether miscella refining of glandless cottonseed oil is necessary or desireable to produce refined and bleached oil with good color. It would be advantageous to oil millers and oil processors if glandless cottonseed oil could be processed to acceptable quality standards for color by conventional methods used by the oil processor. Capital investment in equipment and operating costs for cottonseed crushers would be reduced. The oil processor would not have to provide separate storage facilities for miscella-refined and crude cottonseed oils. Additionally, if oil can be stored without developing undesirable color, it may be profitable to extract gums from crude glandless cottonseed for use as food lecithin. This is not currently possible from glanded cottonseed, nor is it practical during miscella refining of glandless cottonseed oil.

The amount of gossypol in crude oil was proportional to the amount of glanded cottonseed contamination (Table 1). Crude oil from 100% glanded cottonseed had ca. 10 times more free gossypol than oil from 10.0% glanded cottonseed, 20 times more gossypol than 5.0% glanded cottonseed oil and 100 times more gossypoll than 0.0% glanded cottonseed oil.

Figures 1 and 2 show the effects of different refining techniques on bleached oil color for different levels of glanded seed contamination when stored at different temperatures and periods of time. Miscella refining of 0.0, 5.0 and 10.0% glanded cottonseed oil stored at 25 and 40 C for one day yielded few differences in bleached color. All three lower levels of glanded cottonseed contamination were much lighter in color than 100% glanded cottonseed oil. Miscella-refined, glandless cottonseed oil bleached to lighter color than miscella-refined, glanded cottonseed oil. Temperature (25–40 C) during the first day of storage prior to miscella refining had no significant effect on bleached color of any of the oils.

Conventional refining of 0.0, 5.0 and 10.0% glanded cottonseed oils stored at 25 and 40 C for up to two days yielded oils much lighter in color after bleaching than 100% glanded cottonseed oil. No significant differences in bleached colors of conventionally refined oils were noted for 0.0, 5.0 and 10.0% glanded cottonseed contamination. The temperature during the two-day storage period prior to conventional refining had no effect on bleached color. After 30 days storage, the colors of oils from seed contaminated with 0.0 and 5.0% glanded cottonseed were slightly darker than the same oils refined and bleached after two days storage. Oil from 10.0% glanded cottonseed contamination yielded acceptable color when stored for 30 days at 25 C but yielded darker oil when stored at 40 C. Oils from 100% glanded cottonseed had very high red color values, particularly when stored at 40 C. This oil was unacceptable for food applications. Conventionally refined oils from glandless cottonseed with up to 10.0% glanded seed contamination were as good in color as their miscella-refined counterparts. However, at 100% glanded cottonseed, miscella refining produced significantly better oil than conventional refining.

Conventionally refined glandless cottonseed oil with up to 10.0% glanded cottonseed could be stored for 30 days prior to refining and still yield oils lighter in color than 100% glanded cottonseed oil processed by miscella refining. In practice, crude glanded cottonseed oil is shipped from oil mills to oil processors within 10-20 days. Hence, glandless cottonseed oil extracted from seed containing as much as 10.0% glanded cottonseed contamination can be shipped to oil processors and conventionally refined to as good or better color than customary with miscella-refined, glanded cottonseed oil. Refineries can use existing conventional equipment to obtain good quality cottonseed oil from glandless cottonseed.

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