Efficiency of the Blanching and Electronic Color Sorting Process for Reducing Aflatoxin in Raw Shelled Peanuts[1]

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ABSTRACT

Raw shelled peanut lots produced in the United States are inspected for aflatoxin using a sampling plan designed by the Peanut Administrative Committee (PAC). The aflatoxin concentration of most peanut lots rejected by the PAC sampling plan is reduced by using a blanching process that removes the testa or seed coat from the seed and then removing damaged or discolored seeds from the lot using electronic color sorters. Comparing aflatoxin sample results on lots before and after the blanching process indicates that the two-step process is effective for reducing aflatoxin in contaminated lots. The average aflatoxin reduction among the 8911 lots blanched and color sorted over 5 crop yr (1990 to 1994) was 89.9%. The blanching process was equally efficient in reducing aflatoxin for all peanut market types and grades represented in the data base. The average total weight loss among all 8911 lots blanched over the 5 crop yr was 16.8%. Both the percentage aflatoxin reduction and the percentage total weight loss that resulted from blanching was related to the amount of aflatoxin in unblanched lots. As the aflatoxin concentration among unblanched lots decreased, the percentage aflatoxin reduction and the percentage total weight loss associated with the blanching process both decreased.

Key Words: *Aspergillus*, grading, market quality, milling, mycotoxins.

Approximately 35,000 raw shelled peanut lots, averaging about 30 t each, are processed and marketed each crop year in the United States. Each lot is tested for aflatoxin prior to shipment to a manufacturer using an aflatoxin sampling plan developed by the Peanut Administrative Committee (PAC) who administers the USDA Peanut Marketing Agreement (5,6).

Lots accepted by the PAC aflatoxin sampling plan are shipped to a manufacturer where the peanuts are prepared for consumer-ready products. Lots rejected by the aflatoxin sampling plan are indemnified by PAC who works with shellers to try and reduce the aflatoxin concentration of each rejected lot and possibly reclaim the lots for use by a manufacturer. PAC (and shellers) have several alternative processes that can be used to reclaim rejected lots: (a) rejected lots can be milled again by the sheller (remilling), (b) rejected lots can be sent to a blanching facility where the seed coat is removed from the seed and damaged or discolored seed are removed from the lot using electronic color sorters, and (c) rejected lots can be crushed for oil. PAC must decide which of the above processes has the best chance of reclaiming

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rejected lots. Decisions are based on many factors such as cost to reduce aflatoxin and the probability that the lot can be successfully reclaimed.

Since aflatoxin is associated often with small and/or discolored seeds due to mold or insect damage (2,3), the milling process includes (a) sizing seed over slotted screens so that many of the small seeds are removed from the lot and (b) color sorting seeds with electronic sorters so that many of the damaged or discolored seeds are removed from the lot.

The blanching process is a two-step process where the seed coat is removed from a seed and then the blanched seeds are sorted for discoloration using electronic color sorters (4). Electronic color sorting after removing the seed coat is believed to be more efficient for removing damaged seeds than color sorting seeds prior to blanching because of the increased contrast between the damage and a white seed background.

Since 1990, PAC has attempted to reclaim most rejected lots using the blanching process (seed coat removal and electronic color sorting). Once lots have been remilled and/or blanched, the lots are retested for aflatoxin before being placed back into commercial trade. Lots failing the aflatoxin test after blanching are usually crushed for oil.

Cole *et al.* (1) indicated that the milling and blanching processes are effective methods of reducing aflatoxin of contaminated lots. Using a single contaminated lot of farmers stock peanuts, Cole *et al.* determined that the seed sizing process (using a 18/64 by 3/4-in. slotted screen) and the electronic color sorting steps of the milling process reduced the aflatoxin concentration of the lot by 29 and 70%, respectively. Then, the shelled lot was blanched and electronic color sorted which further reduced the aflatoxin concentration by 91%.

Depending upon the severity of the aflatoxin problem, PAC may blanch and color sort several hundred to several thousand shelled peanut lots each crop year. The objectives of this study were to use PAC records to (a) measure the effectiveness of the blanching process (combined removal of the seed coat and electronic color sorting steps) as a method to reduce the aflatoxin concentration of raw shelled peanut lots and (b) determine if the percentage aflatoxin reduction achieved by the blanching process is related to the aflatoxin concentration of the unblanched lot.

Materials and Methods

The PAC uses a sequential aflatoxin sampling plan where one, two, or three 22-kg (48-lb) samples are used to accept or reject each lot of raw shelled peanuts. Since 1990, many of the rejected lots were sent to blanching facilities to reduce the lot aflatoxin concentration. After each lot is blanched and color sorted, either three or five 5.4-kg (12-lb) samples (depending on lot size) are removed from the blanched lot and tested for aflatoxin. The grade (generally relates to peanut seed size), type of peanut, aflatoxin test results before and after blanching, lot weight before and after blanching, weight of the kernels removed from the lot during the blanching process by the color sorters, and other market information associated with each lot are recorded in a data base maintained by the PAC and USDA. Presently, the PAC data base contains information about lots blanched from 1990 to 1994 crop years.

The aflatoxin concentration of an unblanched lot, B, was estimated by averaging the aflatoxin test results associated with the 22-kg samples. The aflatoxin concentration in a blanched lot, A, was estimated by averaging the aflatoxin test results associated with the 5.4-kg samples. The percentage reduction, R, in lot aflatoxin concentration due to the blanching process is defined by Eq. 1 below.

$$R = (B - A) * 100 / B \qquad \text{[Eq. 1]}$$

The value of R was added to the data base for each lot record.

The percentage aflatoxin reduction (R) computed by Eq. 1 probably over estimates blanching efficiency because this study is not a controlled experiment. Only unblanched lots that fail the PAC test are blanched and electronic color sorted. As a result, B values in Eq. 1 are probably higher on the average than would be experienced in a controlled experiment. However, the magnitude of the bias is probably small, especially for the higher unblanched lot concentration. Determination of the magnitude of the bias is beyond the scope of this study.

The PAC indicated that the reject weight (weight of discolored peanuts removed from each lot by the electronic color sorters) is always less than the difference between the recorded blanched and unblanched lot weights. The difference is called by the industry 'disappearance' weight and may be due to losses in moisture and peanut material. The total weight loss by a lot due to the blanching process is a combination of reject and disappearance weight losses. The percentage total, reject, and disappearance weight losses were calculated based upon the initial or unblanched lot weight.

Results and Discussion

The number of lots blanched, the average aflatoxin concentration among all unblanched lots, the average aflatoxin concentration among all lots after the blanching process, and the average percentage reduction in aflatoxin concentration due to the blanching process are shown in Table 1 for each of the 5 crop yr (1990 to 1994).

Table 1. Average aflatoxin concentration in total ng/g for raw shelled peanuts before and after the blanching process and the percentage aflatoxin reduction due to the blanching process for 5 crop yr.[a]

Crop year	Lots blanched	Aflatoxin concentration: Before blanching	Aflatoxin concentration: After blanching	Reduction
		ng/g	ng/g	%
1990	5479	56.3	3.6	90.7
1991	669	36.6	2.5	92.0
1992	311	33.0	2.5	90.4
1993	1861	35.8	3.6	88.0
1994	591	31.0	3.4	86.6
Total	8911	48.1	3.5	89.9

[a]All market types and grades included in average.

For example, in 1990, the average aflatoxin concentration among the 5479 unblanched lots was 56.3 ng/g total aflatoxin. After blanching and electronic color sorting, the average aflatoxin concentration is 3.6 ng/g. Similar large reductions are obtained for each of the 5 crop yr. The large number of lots blanched in 1990 reflects the extreme drought that occurred in the Southeastern United States during that production year.

Table 1 also shows the average percentage aflatoxin reduction due to the blanching process for the 5 crop yr was 89.8% and was greater than 86% for all years. The percentage aflatoxin reduction is used as a measure of the efficiency of the blanching process to reduce the aflatoxin concentration of raw shelled peanut lots. Table 2 shows the average percentage reject weight, disappearance weight, and total weight losses from lots due to the blanching process for each of the 5 crop yr were 9.8, 7.0, and 16.8% of the unblanched lot weight, respectively.

Table 2. Average percentage weight loss due to the blanching process for 5 crop yr. The total weight loss is the sum of reject and disappearance weight losses.[a]

Crop year	Lots blanched	Percentage weight loss		
		Reject	Disappearance	Total
		%		
1990	5479	9.9	6.8	16.8
1991	669	7.6	7.1	14.7
1992	311	7.1	6.8	13.9
1993	1861	11.4	7.5	18.9
1994	591	7.8	6.3	14.1
Total	8911	9.8	7.0	16.8

[a]All market types and grades are included in average.

The five data sets (one for each crop year) were pooled into one large data base containing 8911 records (see Table 1). The lots in the pooled data base were sorted by peanut market type and grade. Table 3 shows that for each market type and grade, the number of lots, the average aflatoxin concentration of unblanched lots, the average aflatoxin concentration of blanched lots, the percentage aflatoxin reduction, and the percentage total weight loss due to the blanching process. Most peanut lots in the pooled PAC data base are collectively US #1 and medium grades (6163 out of 8911) and most lots are runner types (8165 out of 8911). Spanish-With-Split lots had the lowest percentage aflatoxin reduction, 84.8%, and virginia-US # 1 had the highest percentage aflatoxin reduction, 95.3%. However, these two categories accounted for only 65 of the 8911 lots blanched over the 5 crop yr. The pooled average percentage aflatoxin reduction for all 8911 lots was 89.9% (Table 3).

The average aflatoxin reduction associated with blanching virginia, runner, and spanish-type peanuts was 95, 90, and 91%, respectively. The average percentage aflatoxin reduction among lots in each of the seven grade categories varied from about 86 to 95%. Thus, aflatoxin

Table 3. Effect of the blanching process on the removal of aflatoxin from 8911 raw shelled peanut lots of different grades and market types marketed from 1990 to 1994. Each cell (sort category) contains number of lots blanched, average aflatoxin among lots before blanching (ng/g), average aflatoxin among lots after blanching (ng/g), percentage aflatoxin reduction, and percentage total weight loss.

Grade	Market type			Total
	Runner	Spanish	Virginia	
Extra large				
No. lots blanched	-	-	165	165
Afl. before blanch. (ng/g)	-	-	43.8	43.8
Afl. after blanch. (ng/g)	-	-	1.7	1.7
Afl. reduction (%)	-	-	94.6	94.6
Wt. loss from blanch. (%)	-	-	13.5	13.5
Jumbo				
No. lots blanched	623	43	-	666
Afl. before blanch. (ng/g)	40.3	60.9	-	41.6
Afl. after blanch. (ng/g)	2.8	2.5	-	2.8
Afl. reduction (%)	90.7	94.7	-	90.9
Wt. loss from blanch. (%)	10.5	11.9	-	10.6
Medium				
No. lots blanched	3500	-	151	3651
Afl. before blanch. (ng/g)	47.9	-	44.0	47.8
Afl. after blanch. (ng/g)	3.1	-	1.7	3.1
Afl. reduction (%)	91.0	-	94.8	91.1
Wt. loss from blanch. (%)	14.4	-	19.5	14.6
US #1				
No. lots blanched	2318	149	45	2512
Afl. before blanch. (ng/g)	56.7	47.6	47.9	56.0
Afl. after blanch. (ng/g)	4.0	3.1	1.7	3.9
Afl. reduction (%)	89.5	91.3	95.3	89.7
Wt. loss from blanch. (%)	22.2	14.2	24.7	21.8
US split				
No. lots blanched	924	17	41	982
Afl. before blanch. (ng/g)	31.8	27.5	39.3	32.0
Afl. after blanch. (ng/g)	4.1	2.2	1.9	4.0
Afl. reduction (%)	85.0	91.4	93.6	85.5
Wt. loss from blanch. (%)	13.3	12.1	15.2	13.4
Select w/split				
No. lots blanched	243	-	-	243
Afl. before blanch. (ng/g)	59.9	-	-	59.9
Afl. after blanch. (ng/g)	4.9	-	-	4.9
Afl. reduction (%)	8[illegible]5	-	-	88.5
Wt. loss from blanch. (%)	18.5	-	-	18.5
With splits				
No. lots blanched	557	20	115	692
Afl. before blanch. (ng/g)	47.0	37.8	46.9	46.7
Afl. after blanch. (ng/g)	3.9	4.4	2.2	3.6
Afl. reduction (%)	88.2	84.8	94.3	89.2
Wt. loss from blanch. (%)	20.2	12.5	27.4	21.2
Total				
No. lots blanched	8165	229	517	8911
Afl. before blanch. (ng/g)	48.3	47.7	44.5	48.1
Afl. after blanch. (ng/g)	3.6	3.0	1.8	3.5
Afl. reduction (%)	89.6	91.4	94.6	89.9
Wt. loss from blanch. (%)	16.7	13.5	19.5	16.8

was reduced with equal efficiency for all peanut market types and grades by the blanching process.

The 8911 lots from the 5 crop yr were sorted by lot aflatoxin concentration before blanching. All lots with the same unblanched aflatoxin concentration were grouped together into unblanched aflatoxin concentration categories. The lowest aflatoxin concentration category before blanching was 16 ng/g because lots testing 15 ng/g or less were accepted by the PAC sampling plan and were not usually sent to blanching facilities. Among the lots in each unblanched aflatoxin category, the following averages were calculated: (a) aflatoxin concentration after blanching (Fig. 1), (b) percentage aflatoxin reduction due to the blanching process (Fig. 2), (c) percentage reject weight (Fig. 3), (d) percentage disappearance weight (Fig. 3), and (e) the percentage total weight loss (Fig. 3).

The amount of aflatoxin found in lots after the blanching process appears to be related to the aflatoxin concentration in lots before the blanching process (Fig. 1). The higher the aflatoxin concentration in unblanched lots,

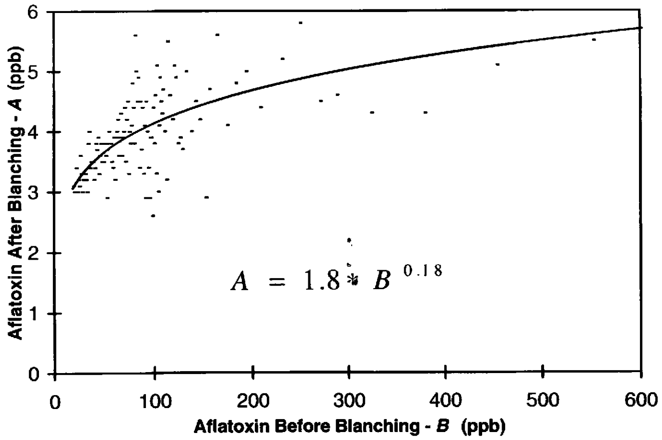

Fig. 1. Lot aflatoxin concentration before and after the blanching process for 8911 lots blanched over 5 crop yr from 1990 to 1994.

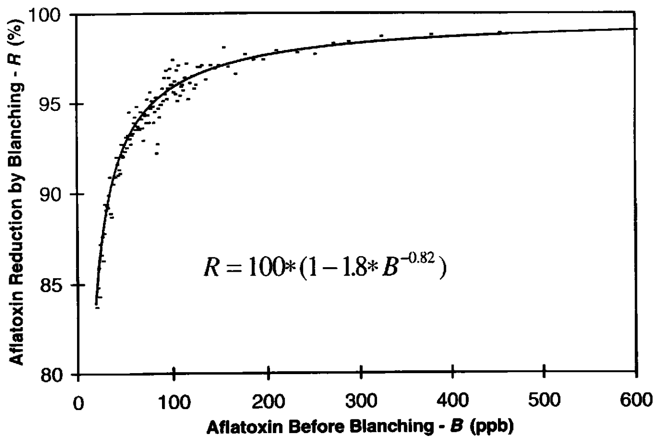

Fig. 2. Percentage aflatoxin reduction due to the blanching process versus aflatoxin in 8911 unblanched lots that were blanched over 5 crop yr from 1990 to 1994.

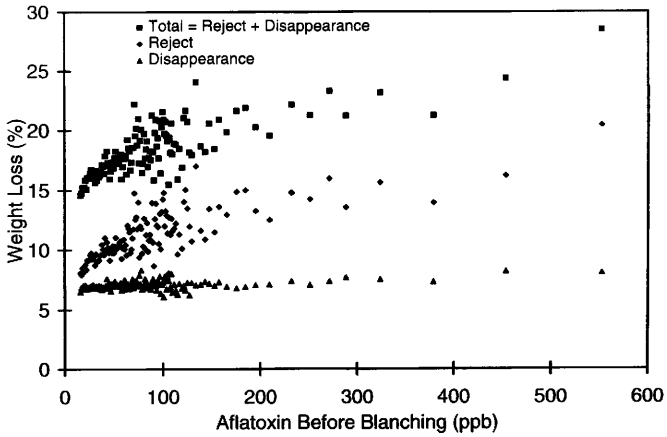

Fig. 3. Percentage reject, disappearance, and total weight loss versus aflatoxin in 8911 unblanched lots that were blanched over 5 crop yr from 1990 to 1994. Total weight loss is equal to the reject weight loss plus disappearance weight loss.

the higher the aflatoxin concentration in lots after the blanching process. The rate of change in lot aflatoxin concentration after the blanching process is very gradual, however, for unblanched lot concentrations above 200 ng/g.

Using regression analyses, a power function

$$A = c1 * B^{c2} \quad \text{[Eq. 2]}$$

was fit to the observations shown in Fig. 1. The coefficients c1 and c2 were determined to be 1.80 and 0.18, respectively. The correlation coefficient is 0.69. The predicted curve is shown also in Fig. 1.

The percentage aflatoxin reduction achieved by the blanching process is also a function of the aflatoxin concentration in unblanched lots (Fig. 2). The lower the aflatoxin concentration in unblanched lots, the lower the percentage aflatoxin reduction achieved by the blanching process. Blanching lots with 16 ng/g of aflatoxin removed about 83.5% of the aflatoxin. However, blanching lots with 200 ng/g of aflatoxin removed about 98% of the aflatoxin. Even though no PAC aflatoxin data exist for unblanched lots below 16 ng/g, one would expect the percentage aflatoxin reduction achieved by the blanching process to continue to decrease toward zero as the aflatoxin concentration of unblanched lots approaches zero.

From Eqs. 1 and 2, an equation that predicts the percentage aflatoxin reduction, R, was determined.

$$R = 100 *(1 - 1.8 * B^{-0.82}) \quad \text{[Eq. 3]}$$

and is shown in Fig. 2 along with the observed values.

The percentage reject, disappearance, and total weight losses are a function of the unblanched lot aflatoxin concentration (Fig. 3). The weight of peanuts rejected by the color sorters (reject weight) increased as the unblanched lot concentration increased. About 8% of the lot was rejected by color sorters for unblanched lots at 16 ng/g aflatoxin. However, about 15% of the lot was rejected by color sorters for unblanched lots above 200 ng/g aflatoxin. The percentage disappearance weight was a constant over a wide range of unblanched lot concentrations and averaged about 7%. Since the percentage total weight loss is the sum of reject and disappearance losses, the percentage total weight loss also increased with the unblanched lot concentration. At 16 ng/g aflatoxin, the total weight loss averaged about 15%. For lot concentrations above 200 ng/g, the total weight loss averaged about 22%.

Because manufacturers receive peanut lots that are accepted by the PAC aflatoxin sampling plan, most (but not all) of these lots have aflatoxin contents below 15 ng/g. Manufacturing processes used to make consumer-ready products often include roasting, blanching, and electronic color sorting which should reduce further the aflatoxin concentration of these lots. However, as Fig. 2 suggests, the percentage aflatoxin reduction achieved by the accumulation of all manufacturing processes probably will be less than 83% because most lots received by the manufacturer are well below 16 ng/g aflatoxin.

Summary and Conclusions

On the average, the combination of blanching and electronic color sorting is a very effective method of reducing the aflatoxin concentration of contaminated lots of raw shelled peanuts. The percentage aflatoxin reduction due to blanching averaged more than 89% for all raw shelled peanut lots blanched over 5 crop years from 1990 to 1994. The percentage aflatoxin reduction achieved by the blanching process did not appear to be related to market type or grade (seed size) of peanuts. However, the percentage aflatoxin reduction and the percentage total weight loss resulting from the blanching process appears to be related to the aflatoxin concentration in unblanched lots. The lower the aflatoxin concentration of unblanched lots, the lower the percentage aflatoxin reduction and smaller the total weight loss that occurs due to the blanching process.

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