Benin Groundnut Producers' Perceptions, Awareness and Action about Aflatoxin

By C.M. Jolly, S. Vodouhe, B. Bayard, P.E. Jolly, J.T. Williams[1]*

ABSTRACT

Aflatoxin (AF) contamination of groundnut poses a serious health and economic threat to Benin market participants. However, most farmers are unaware of the problem. A study of 182 farmers was conducted in 2002 using a Health Belief Model (HBM) to examine Benin farmers' health beliefs, perception constructs of awareness, susceptibility, seriousness of the problem, barriers, and benefits derived from reducing AF levels. Exploratory Factor Analysis was employed to evaluate the HBM model constructs. The average age of farmers was 40.4 years with a Standard Deviation (SD) of 10.8, and farmers had an average of 18.32 years of farming experience. Approximately 93% of farmers stated that sorting of groundnuts was important or very important, while 77% thought that they were sure or definitely sure of the negative effects of AF on human health. The exploratory factor analysis revealed that two factors embodied the susceptibility, barrier and benefit constructs. The study results indicated that the reduction of AF in groundnuts was multidimensional and required policy intervention to increase awareness of the health risks, and to manipulate the factors that influenced the constructs at the farm and policy level.

Key Words: Producer, groundnut, aflatoxin, health belief model.

Groundnut (peanut, *Arachis Hypogea, L.*) is considered a secondary agricultural crop but an important food nutrient source for Benin consumers. It covers 5% of caloric intake, 8.5% of protein, and 20.5% of lipid needs and plays a vital role in animal feed (Adomou, 1999). Unfortunately, research has revealed that the presence of *Aspergilus flavus*, a fungus that produces aflatoxin (AF) in groundnut and corn, is a common contaminant (Adomou, 1999), and can cause serious harm to human and animal health. About 125 people died from aflatoxicosis (poisoning that results from ingestion of AF-contaminated feed) by consuming AF-contaminated corn in eastern and central provinces of Kenya in 2004 (CDC, 2004). AF contamination of grains inflicts annual losses of more than $750 million in Africa, and is a major economic and health problem for Benin (Cardwell, *et al.*, 2001).

Numerous studies have linked aflatoxins to various diseases, such as cancer of liver and hepatitis B and C (Peers *et al.* 1987). The risk of ingestion of AF contaminated food products is serious in Benin where aflatoxin-albumin adducts were detected in 99% of 479 children (Gong *et al.* 2004). It is stated that AF is related to immune suppression, and the immune modulating transcription effects of aflatoxin may occur quite early in HIV infection Jolly *et al.* (2013). These authors further stated that chronic exposure of HIV positive patients to aflatoxin may lead to higher levels of virus replication. Aflatoxin is ubiquitous but studies have linked aflatoxin production in foods to environmental conditions, poor processing of grains and lack of proper storage facilities in developing countries (Farombi, 2006).

Post-harvest handling techniques have been used to reduce the level of AF. (Aoaka-Attah *et al.*, 2007). Traditional attempts to suppress the harmful effects of AF include the consumption of fruits rich in chlorophyll, green tea and kaolinite clays (Farombi, 2006). The seed of the 'Bitter Kola' (from the family of Guttiferae) native to Nigeria and Ghana, high in biflavonoids, has been known to reduce hepathotoxicity. Regulation is the most widely used method to reduce AF contamination in foods. The Food and Drug Administration (FDA) has regulated the levels of AF in human foods to not more than 20 parts per billion (ppb). The maximum limit imposed by the Food and Agricultural Organization (FAO) of the United Nations in 1995 was 30 ppb. The European countries have recently imposed a 4 ppb on peanuts and 2 ppb for maize (N'Dede *et al.* 2012).

Awareness and knowledge of AF problems may help prevent its spread and reduce the associated health risks. In this paper, we use a Health Belief Model (HBM) to examine farmers' awareness and perceptions of AF contamination of groundnuts in Benin Rosenstock *et al.* 1988. The study assumes that farmers' awareness of the problem is an

[1]First author, Auburn University, Second author, University of the Republic of Benin, Third author, CEO, Agroconsult Consultancy, Haiti, S.A., Fourth author, University of Alabama, Birmingham, Fifth author, University of Georgia.

*Corresponding author's Email: cjolly@auburn.edu.

important step toward decision making to reduce its effects.

Dimensions of the Health Belief Model

Based on the concept that food health risks are multidimensional (Dosman *et al.*, 2001), we use a health belief model (HBM) as a theoretical framework to evaluate Benin farmers' awareness and the perception of the health effects of groundnut AF contamination and ingestion. The HBM consists of the following dimensions: *perceived susceptibility*—feelings of personal vulnerability that includes one's perception of the risk of contracting the disease; *perceived severity or seriousness*--the perceived seriousness of contracting the disease and the consequences of being physically or socially affected by the disease that provides the motivation to change behavior; *perceived benefits*—the financial, economic and health benefits, and the perceived beliefs that actions taken to reduce the disease may be feasible and efficacious; *perceived barriers*—the potential negative aspects of particular health behaviors that may act as impediments to adopting recommended behavioral changes. The combined levels of susceptibility and severity provided the energy or force to act, and perception of benefits (less barriers) provided by a preferred action (Mikhail and Petro-Nustas, 2001).

The HBM model was extended to include a section on self-efficacy (Neuwark-Sztainer and Story, 1996). The self-efficacy relates to one's perceived ability to modify a specific behavior a notion that was developed from social cognitive theory (Martinez *et al.*, 2004). The HBM was chosen as the basis of the theoretical framework for this study because of its proven ability to successfully predict the adoption of health behaviors (Hanson and Benedict, 2002) and its tacit inclusion of economic and financial motivations of reducing a problem.

The HBM is appropriate since the levels of AF in a large number of individuals may not cause observable problems. Increased levels of problem awareness will stimulate the individual to develop an enabling attitude that will empower him/her to seek knowledge to develop appropriate attitude to motivate behavioral change.

Materials and Method

Research Area

A face to face survey of 182 farmers in three agro-ecological zones in Benin (Figure1) was conducted in in 2002. Benin is a West African country situated between Nigeria on the east, Togo on the west and Burkina Faso and Niger on the north, with the Atlantic Ocean on the south. We carried out the survey in three zones representative of groundnut producing areas in Benin. The southern area, (villages around Savalou,) is considered the Southern Guinea Savanna, the central region, (Djougou,) represents the Northern-Guinea Savanna and Kandi represents the Sudan Savanna. These zones experience varied climatic conditions which influence the growth of fungi.

Data Collection and Analysis

A convenience sample of individuals producing groundnut was chosen. We visited the villages and met with the chief and producers. After we explained to the villagers the purpose and the nature of the research we asked for volunteers to participate in the study. The survey included questions about farmers' demographic characteristics, awareness and knowledge of AF problems, susceptibility, severity, benefits, and barriers. Responses to questions were recorded on a 5-point-Likert scale in terms of how sure the respondent was about the statements. Higher values indicate greater agreement with the statements.

Previous studies appearing in the literature provided a guide for data collection (Wdowik *et al.*, 2001). Questions were designed so that each element (choice response) represents an answer a respondent might give if asked the question (Krummel *et al.*, 2002). This was done to minimize respondent bias. Before commencement of the survey, the instrument was pre-tested and subjected to an assessment of internal consistency, reliability and construct validity.

Upon completion of the data collection, descriptive statistics were used to examine the distribution of the responses to the questions. Following the descriptive analysis, an exploratory factor analysis of the items defining farmers' awareness and perceptions was conducted using SAS. Factor analysis focuses on the patterns of correlation between variables and identifies commonality among them. Selection of factors was based on Varimax rotation. Items, with factor correlations greater than 0.40, were retained.

Results and Discussion

Socio-demographic Profile of Respondents. Approximately 71% of the 181 respondents were males and 29% females (Table 1). Respondents' ages varied between 20 to 70 years with an average of 40.5 years. The majority of the farmers (69%) had no formal

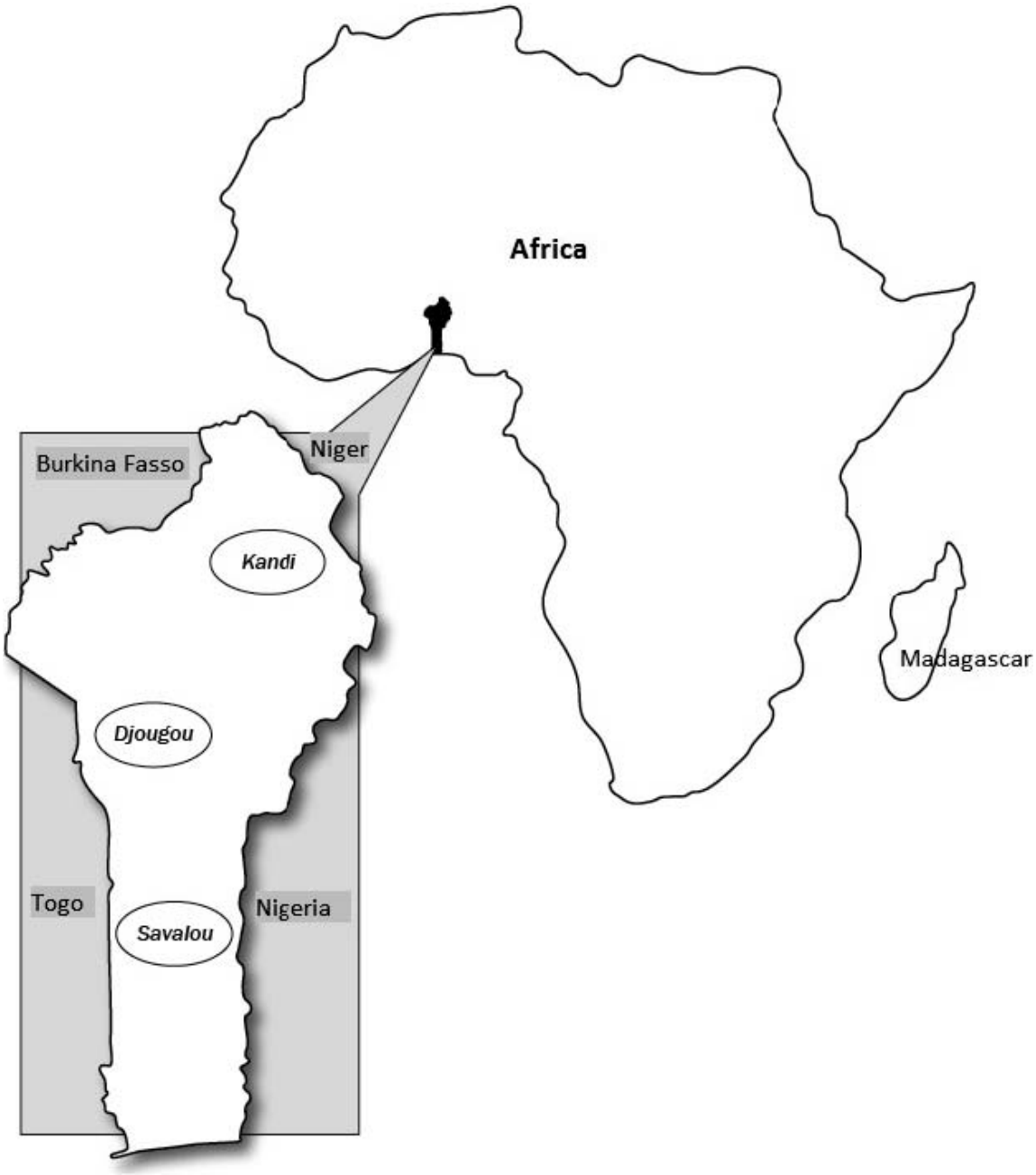

Fig. 1. Map of Benin Showing Research Sites.

schooling. The respondents had on average 18.32 years of farming experience, ranging from less than one to 53 years. Most farmers (71%) had more than 10 years of farming experience. The average size farm was about 5.76ha with 1.35ha in groundnut production in association with other crops, and with an average of 1.10 ha in pure groundnut stand. Household farm revenue was fairly evenly distributed.

Awareness of AF in Groundnuts. Factor analysis showed that seven questions (variables) assessed farmers' awareness of AF problems in crops and its health effects (Table 2). Items with the highest correlations included the consciousness of the socio-economic impacts of AF (0.908), the awareness of the AF contamination of groundnuts (0.879) and crops (0.848), and the harmful effects of AF on humans.

Farmers stated that they were somewhat sure, sure or definitely sure (referred to as 'certain') and not sure and may be sure, (referred to as 'uncertain'), that they were aware of the dangers of AF. About 62% of the farmers were somewhat sure, sure, or definitely sure that they were aware of AF contamination in crops while 75% declared that they were aware of AF in groundnuts (Table 2). A substantial number of respondents recognized

Table 1. Socio-demographic profile of farmers in Benin.

	Number of farmers	Percentage
Sex		
Female	53	29.3
Male	128	70.7
Age (years)		
Less than 35	56	30.9
35 to 50	91	50.3
over 50	34	18.8
Education		
No formal education	122	69.3
Primary school	46	26.1
Other	8	4.6
Agricultural revenue/year		
Less than 275000 FCFA	64	35.6
275,000 to 575,000 FCFA	56	31.1
over 575,000 FCFA	60	33.3
Years in farming		
Up to 10 years	53	29.3
11 to 20 years	67	37.0
more than 20 years	61	33.7

the harmful effects of AF on animals (56.9%), on human health (80%), and the negative economic consequences (71.6%).

Male farmers revealed greater degree of certainty on average (89.85 %) than female farmers (56.6 %) (Table3). There was no difference in the levels of assurance of awareness of the dangers of AF among the three age groups, those less than 35 years old (89.85 % or 10.7 % selected not sure or may be), those between 35 years and 50 years (78.02 %) and those older than 50 years old (70.59 %) selected sure or definitely sure. Farmers with lower levels of agricultural revenue were most certain (92.18 %) compared to middle revenue earners (76.78 %) and high agricultural revenue earners (70.0 %) that they were aware of the dangers of AF in groundnuts. There were also differences in awareness among farmers with varying years of farming experience. Farmers with less than 10 years of farming experience showed less uncertainty (11.32 %) of awareness than those with between 11 and 20 years (11.95 %), and those with more than 20 years of farming experience (36.07 %) (Table 3).

Farmers' Perceptions of AF Problems. Farmers' perceptions of AF contamination were examined by asking questions that elicited their susceptibility to and the seriousness of the problem, the barriers to reduce its incidence, and the benefits of reducing its effects.

Susceptibility. Exploratory factor analyses reveal two sub-constructs "Health Belief" and "Self-Confidence" (Table 4). The first sub-construct termed "Health Belief" was composed of five items with correlations greater than 0.40. Two items dealt with farmers' beliefs that they were genetically well-built so their body could fight any disease (0.745), and the belief that they took traditional medicine to fight poison so they would never be sick (0.703). The three other items stressed farmers' belief that the benefits of eating groundnuts were greater than any associated health problems (0.669), that they roasted their nuts before they ate them, so that they would not be sick (0.664), and that groundnuts were good for a healthy body (0.409). The other sub-construct related to farmers "Self-Confidence" in the behavioral actions taken to prevent disease from AF ingestion and was defined by four items. The contents of items with the highest correlations concerned the belief that farmers ate all kinds of nuts, but they were always healthy (0.804), that they sorted the nuts they ate so they would never be sick (0.715) that they took local medicine and could never be sick (0.663), and that eating a few discolored groundnuts would not sicken them (0.566).

A majority of farmers (87.8 %) recognized that eating few discolored groundnuts could not sicken them. Ninety-three percent of the respon-

Table 2. Farmers' awareness of aflatoxin problems (frequency distribution) and correlations.

	Not Sure	Maybe	Somewhat sure	Sure	Definitely sure	Factor
			%			
1.Are you aware of aflatoxin contamination in crops	28.7	9.4	8.8	37.0	16.0	0.848
2.Are you aware of aflatoxin contamination in groundnuts	18.2	7.2	9.9	29.3	35.4	0.879
3.Are you aware of effects of aflatoxins on animals	30.9	12.2	3.9	28.7	24.3	0.600
4.Are you aware of the harmful effects of aflatoxins on humans	16.6	3.9	2.2	39.8	37.6	0.818
5.Discolored nuts are not harmful when eaten	33.7	5.5	7.7	19.9	33.1	0.718
6.Damaged and broken nuts do not spoil the others in storage	02.2	6.1	10.5	47.0	34.3	0.666
7.Are you aware of the socio-economic impacts of aflatoxin	19.4	8.9	4.4	18.3	48.9	0.908

Table 3. Perceived awareness of groundnut aflatoxin contamination by categories of Benin farmers (values in percentage).

Perceptions	Categories	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	$\chi^2(p)$
				Gender			
				%			
	Female	32.08	11.32	20.75	33.96	1.89	
	Male	3.91	6.25	15.63	50.78	23.44	38.76 (0.0001)
				Age Groups			
				%			
	< 35 years old	5.36	5.36	23.21	44.64	21.43	
	35 to 50 years old	12.09	9.89	13.19	50.55	14.29	
	> 50 years old	23.53	5.88	17.65	35.29	17.65	11.218 (0.189)
				Agricultural revenue			
				%			
Awareness	Income less than 275000 FCFA[a]	3.13	4.69	14.06	62.50	15.63	
	275000 to 575000 FCFA	17.86	5.36	17.86	44.64	14.29	
	> 575000 FCFA	16.67	13.33	18.33	30	21.67	18.94 (.015)
				Years in farming			
				%			
	<=10 years in farming	3.77	7.55	22.64	43.40	22.64	
	11 to 20 years in farming	2.99	8.96	17.91	53.73	16.42	
	> 20 years in farming	29.51	6.56	11.48	39.34	13.11	28.22 (0.0004)

[a]The FCFA in French is the name of two currencies used in Africa which are guaranteed by the French treasury. The two CFA franc currencies are the West African CFA franc and the Central African CFA franc. Although theoretically separate, the two CFA franc currencies are effectively interchangeable. The exchange rate is equivalent to 500 FCFA to one U.S. dollar (500FCFA=US $1.00).

dents were unsure if eating varied qualities of groundnuts would sicken them. On the other hand, approximately 90% of farmers were sure that groundnuts were good for a healthy body. More than 75% of respondents were not sure that taking local medicine could prevent them from sickness due to the ingestion of AF-contaminated groundnuts. A large majority of respondents (92%) were uncertain of whether that they would get sick if they sorted the groundnuts that they ate. About (84%) were uncertain that their genetically strong body could ward of any disease resulting from aflatoxin contamination, and 81.6% were uncertain that traditional medicine could prevent sickness from ingestion of aflatoxin contaminated groundnuts. About 37% of respondents thought that the benefits from eating groundnuts were greater than any associated health risks.

In terms of the degree of susceptibility, subconstruct "Health Belief", there was a marked difference between males (68.78%) and females (52.83%) in certainty of their susceptibility of the ill-effects of AF(Table 5). Farmers between the ages of 35 and 50 years old revealed less certainty about their confidence to ward off the harmful effects of AF than older or younger farmers (70.58 %). Farmers with low levels of revenue were more certain (81.25 %) about their susceptibility to the harmful effects of AF than the farmers with higher levels of revenue. Female farmers were also more confident (24.53% uncertain) about their ability to withstand the effects of AF than male farmers (12.50%). However, there was no difference among the various income groups in their confidence to withstand the likely injurious effects of AF. There was also no difference in age in terms of farmers' self-confidence in being able to withstand the threats of AF in groundnuts.

Seriousness. The seriousness construct was divided into two sub-constructs "Self-belief" and "Cynicism" and are seen in table 6. The self-belief sub-construct included the belief that farmers had been eating groundnuts for years, but never got sick (0.918), that their animals had never been sick from eating contaminated nuts (0.902), and that sickness from discolored nuts was short lived (0.897). The last item of this factor concerns the belief that eating few discolored groundnuts may make them sick, but could not kill them (0.790). The second seriousness factor termed "cynicism", which indicated disbelief that there were negative effects of AF-contaminated groundnuts, is comprised of two

Table 4. Respondents' susceptibility and seriousness regarding aflatoxin problems (%) and correlations.

	Not Sure	Maybe	Somewhat sure	Sure	Definitely sure	Factors health belief	Factors self-confident
	Susceptibility						
	%						
1.Eating a few discolored groundnuts will not sicken me	70.7	8.8	8.3	8.3	3.9	-0.053	0.566
2.I eat all kinds of nuts, but I am always healthy	72.4	16.6	4.4	6.1	0.6	0.075	0.804
3.Groundnuts are good for a healthy body	1.7	6.6	1.7	23.2	66.9	0.409	-0.231
4.I take local medication, so I am always healthy	64.6	6.1	4.4	17.1	7.7	-0.232	0.663
5.I sort the nuts I eat, so I will never be sick	70.2	12.7	9.9	6.6	0.6	0.099	0.715
6.I roast my nuts before I eat them, so I won't be sick	24.9	8.3	2.8	35.9	28.2	0.664	-0.230
7.The benefits from eating groundnuts are greater than any associated health problems	35.9	14.9	11.6	25.4	12.2	0.669	-0.041
8.I am genetically well built so my body can fight any disease	65.2	12.2	6.6	3.3	12.7	0.745	0.153
9.I take traditional medicine to fight poison so I will never be sick	67.8	5.6	8.3	17.8	0.6	0.703	0.173
	Seriousness						
	%						
1.My animals have never been sick from eating contaminated nuts	48.6	8.8	8.8	18.8	14.9	0.902	0.079
2.We have been eating groundnuts for years but we have never gotten sick.	48.1	14.9	6.1	16.6	14.4	0.918	0.115
3.Sickness from discolored nuts is for a short time	50.8	16.0	2.2	18.8	12.2	0.897	0.027
4.There are no diseases related to eating of nuts	90.6	5.0	1.7	2.2	0.6	-0.017	0.839
5.Eating discolored groundnuts may make me sick, but they cannot kill me.	42.5	14.4	11.0	28.7	3.3	0.790	0.188
6.There are numerous cases of liver, kidney, or cancer diseases these past years in the village.	7.2	17.7	7.2	44.8	23.2		
7.Aflatoxin contaminated nuts germinate as well as other nuts	89.5	8.8	1.7	0.0	0.0	0.1880	

items, namely individuals' beliefs that there are no diseases related to eating of nuts (0.839) and that AF-contaminated nuts germinate as well as uncontaminated nuts (0.670) (Table 6).

A significant number of farmers believed that: their animals had never been sick from eating contaminated nuts (66%); they had been eating groundnuts for years, but they had never gotten sick (69%); sickness from discolored nuts is short lived (69%); there were no diseases related to eating nuts (97%); and AF contaminated nuts germinated as well as uncontaminated nuts (100%). Approximately 32% of respondents felt that eating discolored groundnuts may have made them sick, but could kill them. Sixty-eight percent of respondents were sure or definitely sure that there were numerous cases of liver and kidney diseases, or cancer in their village during the past years.

Female farmers were less certain (23.64 %) about the seriousness of the dangers of AF than male farmers (Table 6). In terms of the sub-construct 'Self-Belief' there was no difference among age groups; similar results were obtained for 'Cynicism'. There was a significant difference among income groups for the seriousness sub-construct 'Self-belief, but there was no difference for the 'Cynicism' sub-construct. Female and male farmers expressed similar degrees of assurance about the cynicism of AF effects on their well-being. There were also no

Table 5. Susceptibility to AF contamination by categories of Benin farmers.

Perceptions	Categories	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	χ^2 (p)
				Gender			
				%			
Susceptibility (health belief)	female	0	47.17	45.28	7.55	0	
	male	3.13	28.13	49.22	7.81	11.72	12.02 (0.017)
				Age groups			
				%			
	< 35 years old	5.36	42.86	39.29	5.36	7.14	
	35 to 50 years old	1.10	29.67	51.65	9.89	7.69	8.8263 (0.3572)
	> 50 years old	0	29.41	52.94	5.88	11.76	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	1.56	17.19	57.81	10.94	12.50	18.09 (0.020)
	275000 to 575000 FCFA	3.57	37.5	44.64	3.57	10.71	
	> 575000 FCFA	1.67	46.67	41.67	8.33	1.67	
				Years in farming			
				%			
	<=10 years in farming	5.66	37.74	37.74	9.43	9.43	9.783 (0.280)
	11 to 20 years in farming	1.49	37.31	50.75	4.48	5.97	
	> 20 years in farming	0.00	26.23	54.10	9.84	9.84	
				Gender			
				%			
Susceptibility (Self-confidence)	female	20.75	54.72	16.98	7.55	---	28.31 (0.0001)
	male	64.06	23.44	8.59	3.91	---	
				Age groups			
				%			
	< 35 years old	53.57	39.29	7.14	0.00	----	
	35 to 50 years old	47.25	27.47	15.38	9.89	----	14.34 (0.026)
	> 50 years old	58.82	35.29	5.88	0.00	----	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	57.81	23.44	14.06	4.69	----	6.22 (0.398)
	275000 to 575000 FCFA	46.43	42.86	7.14	3.57	----	
	> 575000 FCFA	48.33	33.33	11.67	6.67	----	
				Years in farming			
				%			
	<=10 years in farming	66.04	28.30	5.66	0.00	----	11.58 (0.0710)
	11 to 20 years in farming	47.76	32.84	10.45	8.96	----	
	> 20 years in farming	42.62	36.07	16.39	4.92	----	

differences for income groups and the years of experience in farming.

Barriers. Perception of barriers referred to social, financial, and economic barriers to control AF levels in groundnuts (Table 7). The results indicated two separate sub-constructs, namely "Costs" which comprised the financial expenditures for the actions to minimize the effects of AF contamination, and "Lack of Control", which is the inability to influence market or environmental forces. With high correlations on indicators such as sorting groundnut kernels was too costly (0.811), sorting groundnuts kernels was time consuming (0.800), proper storage required too much space (0.716), harvest during the first rainy season was impossible (0.661), and irrigation was not possible in the zone (0.625), the first factor seems to deal mainly with cost issues. The second seriousness construct had two indicators including the belief that all quality nuts fetched the same market price (0.843) and that timely harvesting of groundnuts was impossible (0.807).

Frequency distributions of response scores are presented in table 8. An overwhelming number of farmers assumed that sorting groundnut kernels was too costly (89%), that sorting groundnuts kernels was time consuming (66%), that seed treatment was too costly (69%), that irrigation

Table 6. Perceived seriousness of AF contamination by categories of Benin farmers.

Perceptions	Categories	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	χ^2 (p)
				Gender			
				%			
Seriousness (self-belief)	female	39.62	37.74	16.98	5.66	0.00	24.79 (0.0001)
	male	29.69	28.13	3.91	25.78	12.50	
	total						
				Age Groups			
				%			
	< 35 years old	33.93	37.50	5.36	16.07	7.14	5.2913 (0.726)
	35 to 50 years old	34.07	28.57	9.89	18.68	8.79	
	> 50 years old	26.47	26.47	5.88	29.41	11.76	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	23.44	21.88	4.69	35.94	14.06	29.85 (0.0002)
	275000 to 575000 FCFA	41.07	33.93	3.57	10.71	10.71	
	> 575000 FCFA	35.00	36.67	15.00	11.67	1.67	
				Years in farming			
				%			
	<=10 years in farming	24.53	39.62	1.89	24.53	9.43	19.96 (0.010)
	11 to 20 years in farming	47.76	28.36	7.46	10.45	5.97	
	> 20 years in farming	22.95	26.23	13.11	26.23	11.40	
				Gender			
				%			
Seriousness (cynicism)	female	5.66	20.75	71.70	1.69	----	1.13 (0.769)
	male	7.03	22.66	65.63	4.69	----	
				Age groups			
				%			
	< 35 years old	8.93	33.93	53.57	3.57	----	11.15 (0.083)
	35 to 50 years old	6.59	17.58	70.33	5.49	----	
	> 50 years old	2.94	14.71	82.35	0.00	----	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	3.13	17.19	78.13	1.56	----	8.06 (0.233)
	275000 to 575000 FCFA	5.36	26.79	62.50	5.36	----	
	> 575000 FCFA	11.67	23.33	60.00	5.00	----	
				Years in farming			
				%			
	<=10 years in farming	7.55	30.19	58.49	3.77	----	10.01 (0.123)
	11 to 20 years in farming	8.96	23.88	61.19	5.97	----	
	> 20 years in farming	3.28	13.11	81.97	1.64	----	

was not possible in their region (67%), that proper storage required too much space (74%), and that harvest during the first rainy season was possible only during the humid period (70%). Roughly 70% of respondents did agree that timely harvest of groundnuts was possible, and about 80% were uncertain that all quality nuts were sold for the same price on the market.

There were significant differences by gender in the "Cost' sub-construct (Table 8). There were also age differences in certainty of meeting the cost of reducing the incidence of AF, with younger farmers showing the most uncertainty (Table 9). There were no differences among income groups about the certainty of handling the costs of reducing the incidence of AF contamination of groundnuts. For the 'Lack of Control' sub-construct, there were no significant differences in age, income, and years of experience in farming. However, there was a significant gender difference for this construct.

Benefits. The factor structure for the perceived benefits of AF reduction is presented in table 7. The benefit construct comprised of two sub-constructs that can be termed "Hygienic Benefit" and "Health Improvement". The first factor consisted of three items with high correlations that included the beliefs that clean nuts attracted a better

Table 7. Respondents' perceived barriers and benefits to reduce aflatoxin contamination and correlations.

	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	Factors cost	Factors lack of control
				Barriers			
				%			
1.Sorting groundnut kernels is too costly	8.3	1.1	1.1	28.2	61.3	0.811	-0.341
2.Sorting groundnuts kernels is time consuming	3.9	4.4	25.4	24.3	42.3	0.800	-0.088
3.Seed treatment is too costly	12.7	8.8	8.8	45.3	24.3	0.625	-0.173
4.Irrigation is not possible here	25.4	5.0	2.8	31.5	35.4		
5.Proper storage requires too much space	6.1	14.9	5.0	39.2	34.8	0.716	0.097
6.Harvest during the first rainy season is possible only during the humid period	10.5	10.5	8.3	43.6	27.1	0.661	0.189
7.Timely harvesting of groundnut is impossible	53.0	7.7	8.8	23.8	6.6	-0.156	0.807
8.All quality nuts have the same price	80.1	0.6	0.0	8.3	11.0	0.079	0.843
				Benefits			
				%			
1.Sorting of nuts is hygienic	0.6	7.2	5.5	40.3	46.4	0.655	0.148
2.Roasting of nuts destroys diseases	47.0	6.1	27.6	17.7	1.7	0.017	0.849
3.Proper drying and storage of nuts reduce disease organisms	58.0	3.3	9.4	21.5	7.7	0.066	0.831
4.Clean nuts give a better product price	2.2	0.0	83.0	46.4	43.1	0.827	0.072
5.Clean nuts always sell faster	1.7	0.6	1.7	36.5	59.7	0.794	0.0600
6.Clients are indifferent to groundnuts	87.3	2.8	0.0	2.8	7.2	0.245	-0.043

product price (0.827), that clean nuts always sold faster than others (0.794), and that sorting of nuts was hygienic (0.655). The second benefit construct dealt with two indicators stressing the beliefs that roasting of nuts destroyed diseases (0.849) and that proper drying and storage of nuts reduced diseases (0.831).

The correlations on the "Pest Control" sub-construct varied from 0.614 to 0.53, while that of the "Storage Control" ranged from 0.828 for sorting of seeds before planting to 0.478 for sorting of groundnuts. The cultural practices ranged from 0.525 for the use of spray to 0.692 for windrowing. The correlations for the consumption sub-constructs were relatively high and varied from 0.633 to 0.831 (Table 10).

An important number of respondents declared that sorting was hygienic (86%) that clean nuts were sold for a higher price (89%), and that clean nuts always sold faster (96%). A substantial number of farmers did not believe that roasting of nuts destroyed diseases (80%), or that proper drying and storage of nuts reduced disease organisms (70%) (Table 7).

The 'Hygiene' sub-construct connoted the benefit derived from the cleaning of the groundnut, and the 'Health Improvement' emanating from consuming a cleaner product (Table 9). A higher percent of females (94.34%) than males (88.28%) expressed certainty about the hygienic benefits of having a cleaner product (table 9). Farmers younger than 35 and those >50 years were more assertive of the hygienic benefits of a cleaner product. Surprisingly, farmers in the lower income group indicated that they were more certain about the hygienic benefits of AF reduced groundnuts. A slightly higher percent of farmers with between 11 and 20 years of farming were more certain of the hygienic benefits of a cleaner groundnut.

Male farmers were less certain than females of the health improvement benefits of cleaner groundnuts. There was no significant difference among age groups about the health improvement benefits of cleaner groundnuts. However, the various income groups differed in their opinion about the benefits of cleaner groundnuts. The highest income group was less certain about the health improvement effects of an AF reduced groundnut. Farmers with less than 10 years of experience were also less certain of the health improvement benefits of cleaner groundnuts.

Planned Action. Farmers planned actions were divided into two parts, production and consumption (Table 10). The planned action involved statements indicating whether farmers had ever performed certain actions, whether they planned to do them, whether they performed the actions last season or whether they did them all the time. Under the production actions we discovered three

Table 8. Perceived barriers to groundnut AF control by categories of Benin farmers (values in %).

Perceptions	Categories	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	χ^2 (p)
				Gender			
				%			
Barrier (cost)	female	0.0	9.43	50.94	32.08	7.55	
	male	3.13	5.47	12.5	39.84	39.06	38.94 (0.0001)
				Age groups			
				%			
	< 35 years old	3.57	14.29	10.71	46.43	25.0	21.73 (0.0054)
	35 to 50 years old	0.00	3.3	29.67	37.36	29.67	
	> 50 years old	5.88	2.94	29.41	23.53	38.24	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	3.13	1.56	14.06	45.31	35.94	12.691 (0.122)
	275000 to 575000 FCFA	1.79	8.93	26.79	39.29	23.21	
	> 575000 FCFA	1.67	10.00	31.67	28.33	28.33	
				Years in farming			
				%			
	<=10 years in farming	3.77	13.21	13.21	37.74	32.08	12.60 (0.126)
	11 to 20 years in farming	0.00	1.49	29.85	37.31	31.34	
	> 20 years in farming	3.28	6.56	26.23	37.70	26.23	
				Gender			
				%			
Barrier (lack of control)	female	45.28	13.21	37.74	3.77	0.0	21.20 (0.0003)
	male	51.56	15.63	11.72	10.16	10.94	
				Age groups			
				%			
	< 35 years old	41.07	17.86	17.86	16.07	7.14	11.80 (0.160)
	35 to 50 years old	54.95	16.48	18.68	3.30	6.59	
	> 50 years old	50.0	5.88	23.53	8.82	11.26	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	57.81	15.63	15.63	4.69	6.25	5.6568 (0.6856)
	275000 to 575000 FCFA	39.29	17.86	23.21	10.71	8.93	
	> 575000 FCFA	50.0	11.67	20.0	10.0	8.33	
				Years in farming			
				%			
	<=10 years in farming	49.06	13.21	16.98	15.09	5.66	12.986 (0.1155)
	11 to 20 years in farming	50.75	17.91	14.93	2.99	13.43	
	> 20 years in farming	49.18	13.11	26.23	8.20	3.28	

sub-constructs "Pest Control", "Storage Control", and "Cultural Practices." About 90.8% of farmers stated that they did not plan to treat their seeds before planting, while 52.3% sated that they did not plan to treat for termites. Most farmers (73.4%) said that they dried their seeds all the time before planting. Approximately 89.9% indicated that they sorted their seeds all the time before storage and planting, 42.2% said that they heaped the groundnut vine after harvest, and 32.1% said they placed their groundnut in a storage room. The farmers were negative about the use of proper storage practices. About 93.6% affirmed that they did not use fertilizer; 92.7% did not spray to control pests; 99.1% did not use irrigation, and 38.9 % did not windrow.

The consumption part also had three sub-constructs: "Utilization", "Preparation", and "Selection". Farmers' responses varied for the consumption sub-constructs (Table 10). About 66.6% said they did use dried stored groundnuts, 58.0% stated that they used discolored groundnuts all the time, and 86.2% revealed that they did not plan to use clean seeds. For preparation before use farmers were much more positive. The responses varied from 54.1% who indicated that they sorted before use to 84.4% who avowed that they cleaned their utensils before preparation of groundnuts. The

Table 9. Perceived benefits of groundnut AF control by categories of Benin farmers.

Perceptions	Categories	Not sure	Maybe	Somewhat sure	Sure	Definitely sure	χ^2 (p)
				Gender			
				%			
Benefit (hygiene)	female	---	0.00	5.66	69.81	24.53	47.5115 (0.0001)
	male	---	0.78	10.94	17.19	71.09	
				Age groups			
				%			
	< 35 years old	---	1.79	17.86	19.64	60.71	14.925 (0.0208)
	35 to 50 years old	----	0.00	3.3	3.46	58.24	
	> 50 years old	---	0.00	11.76	38.24	50.0	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	---	1.56	9.38	17.19	71.88	13.236 (0.039)
	275000 to 575000 FCFA	---	0.00	10.71	39.29	50.0	
	> 575000 FCFA	---	0.00	8.33	43.33	48.33	
				Years in farming			
				%			
	<=10 years in farming	---	1.89	16.98	20.75	60.38	13.989 (0.0298)
	11 to 20 years in farming	---	0.00	4.48	31.34	64.18	
	> 20 years in farming	---	0.00	8.20	44.26	47.54	
				Gender			
				%			
Benefit (health improvement)	female	20.75	7.55	37.74	30.19	3.77	28.38 (0.0001)
	male	44.53	26.56	16.41	10.94	1.56	
				Age groups			
				%			
	< 35 years old	50.0	12.5	25.0	10.71	1.79	12.85 (0.117)
	35 to 50 years old	32.97	20.88	24.18	18.68	3.30	
	> 50 years old	29.41	35.29	14.71	20.59	0.00	
				Agricultural revenue			
				%			
	Income less than 275000 FCFA	20.31	35.94	18.75	23.44	1.56	28.558 (0.0004)
	275000 to 575000 FCFA	39.29	19.64	28.57	12.5	0.00	
	> 575000 FCFA	55.0	6.67	21.67	13.33	3.33	
				Years in farming			
				%			
	<=10 years in farming	49.06	22.64	18.87	5.66	3.77	23.50 (0.0028)
	11 to 20 years in farming	46.27	11.94	17.91	23.39	1.49	
	> 20 years in farming	18.03	29.51	31.15	19.67	1.64	

sub-constructs for selection showed that 77.1% examined the nuts carefully all the time before use, while 60.6% inspected the products, and 46.8% selected the source before purchase.

Summary and Conclusion

Farmers were generally aware of the AF problem; however, being aware does not translate into action towards solution. Altekruse *et al.*, (1995), and Daniels *et al.*, (2001) suggested that this awareness of a particular hygienic practice does not lead to adequate implementation of the practice. The rankings of the variables hinted that the majority of farmers (more than 60%) were aware of AF contamination in crops and of the health and economic effects of AF. The readiness to take action to reduce the effects was based on the perceived benefits and barriers, either external or internal, put in place to impede AF reduction, and the utility derived from its reduction (Jolly *et al.* 2009).

Previous studies have shown that gender role in food preparation influences food safety risk perception (Siegrist *et al.*, 2002; Schaefer *et al.* 1993). In Benin, agricultural production is mainly dominated by men who are the prime target of any program in agriculture. The study showed that men were more likely to be aware of AF contamination in groundnuts. These results imply that special attention

Table 10. Farmers planned action to reduce aflatoxin in groundnut production and consumption.

Factors	No, I do not plan	No, I plan the future	No, I plan next season	Yes, I did	Yes, all the time	Factor loadings
	Production					
	%					
Production Action						
Pest Control						
Treat seeds	90.8	3.7	2.8	0.9	0.9	.614
Treat termites	52.3	11.9	6.4	13.8	11.0	.687
Drying	0.0	11.9	0.9	13.8	73.4	.530
Storage Control						
Sorting seeds/before	0.0	1.0	0.0	9.2	89.9	.828
Heaping vine during drying	43.1	0.9	2.8	9.2	42.2	.571
Sorting pods/before	20.2	6.0	1.0	11.9	61.5	.792
Room cleaning/before	0.0	52.3	0.9	13.8	32.1	.478
Cultural Practices						
Fertilizer	93.6	1.8	0.0	0.9	2.8	.616
Spray	92.7	3.7	0.0	1.8	0.0	.610
Irrigation	99.1	0.9	0.0	0.0	0.0	.525
Window	38.5	0.9	1.8	11.9	27.5	.692
	Consumption					
	%					
Consumption Action						
Utilization						
Dry store	15.6	2.8	13.8	66.1	1.8	.676
Discolored	25.7	1.8	1.8	11.0	58.0	.831
Seeds	86.2	0.9	0.9	0.0	9.2	.768
Preparation						
Sort	18.3	9.2	6.4	11.9	54.1	.654
Wash	28.4	1.8	2.8	7.3	58.7	.705
Clean/utensils	6.4	0.0	0.0	7.3	84.4	.633
Discard bad nuts	25.7	1.8	1.8	11.0	58.7	.744
Selection						
Examine	2.8	0.0	0.9	17.4	77.1	.750
Inspect	12.8	4.6	2.8	14.7	60.6	.828
Source of groundnuts	28.4	5.5	3.7	12.8	46.8	.749

should be given to women who are primarily involved in preparation of food and of groundnuts for planting.

A large number of farmers felt that discolored nuts were not harmful when eaten and that damaged and broken nuts did not spoil the others in storage. While most farmers (more than 80%) found that groundnuts were good for a healthy body, a majority (more than 70%) did not feel that consumption of AF-contaminated groundnuts was risk free. In fact, Jolly *et al*., (2006) stated that a large number of Ghanaian farmers used the spoiled nuts for processing into human or animal feed. The results indicated that farmers were concerned about the effects of ingestion of contaminated groundnut on their health, and their physical capacity to resist contaminated groundnut consumption. Palis *et al*., (2006) also noted a dichotomy in the belief of pesticide handlers in the Philippines who believed pesticide to be both a poison and a medicine.

The susceptibility factor was divided into two sub-constructs "health belief" and "self-confidence". The farmers believed that there was a health risk associated with the ingestion of AF contaminated groundnuts and they alleged that their actions or behavior change may reduce this risk of AF health effects. However, farmers were not willing to accept the cost of reducing AF levels unless they felt personally threatened by the consumption of AF contaminated nuts and preferred to shift the responsibilities to the other market participants along the marketing chain (N'dede *et al*. 2012). The only differences in susceptibility are in income groups and gender. In terms of health belief, men felt they were more susceptible to consuming the AF contaminated groundnut but they were also less confident that they had the ability to ward off

the harmful effects of AF contaminated groundnut. Older individuals were more certain of their susceptibility of being harmed by AF contamination than younger ones. However, growth in net household income increased the uncertainty of perception susceptibility.

Age was positively related to the seriousness, benefits and barriers. A study by Krewski *et al* (1994) reported that respondents in the higher age categories (55 and older) were more likely to rate risks than those younger than 30 years old. In this study, the older farmers were more likely to take the dangers of AF seriously. Males were also more likely to consider the certainty of the dangers than females. Farmers' ratings on the seriousness constructs showed that they perceived the dangers of eating poor quality nuts. In spite of many farmers' concerns about ingestion of AF-contaminated groundnuts, there were few who were skeptical of the health risks associated with AF contamination. A number of farmers believed that they were strong enough to resist the harmful effects of AF.

In terms of barriers to control AF problems, the analyses revealed that the costs associated with sorting, harvesting, and storage of groundnuts were important, and there was an indication of a sense of a lack of control of the market and environmental forces that weakened farmers' willingness to take action to reduce the associated risks. Farmers' scores on these concerns suggested that these factors represented crucial issues to them.

The planned action constructs showed that production and consumption could be each divided into three sub-constructs. Farmers' responses varied more for the production sub-constructs than for consumption. Farmers' production actions related more towards what they thought would be feasible and according to their present practices and not to the future. High net income household also increased the level of uncertainty of taking action to reduce the level of AF contamination. Nesbitt *et al*. (2009) also found that income increases food safety risks.

This investigation produced useful information on the pattern of farmers' awareness and perceptions of AF problems in Benin. Though the study was conducted in one country in West Africa the results on individuals' perception towards food safety risks are rather universal. The results also suggested important issues that should be considered in order to develop policies aimed at raising greater awareness of AF problems among the farming population in Benin.

Acknowledgements

The study was funded by the Peanut Collaborative Research Program, USAID Grant no. LAG-G-00-96-90013-00, and supported by Auburn University and f the University of the Republic of Benin. The authors would like to thank the Ministry of Agriculture, Breeding and Fisheries of Benin for its support.

Literature Cited

Adomou, M. 1999. Valuation des systèmes de production, de multiplication, et de distribution de semences améliorées d'arachide en Afrique de l'Ouest et en Afrique Centrale. Project TCP/RAF/7823.

Altekruse, S.F., D.A. Street, S.B. Fein, A.S. Levy. 1995. Consumer knowledge of foodborne microbial hazards and food-handling practices. J. Food Prot. 59(3):287-294.

Amoako-Attah, R.T. Awuah, K.A. Kpodo, S.C. Fialor, C.M. Jolly. 2007. Cost effectiveness of selected post harvest pod handling techniques against damage, moldiness and aflatoxin contamination of shelled groundnut in Ghana. J. Sci Tech. 27(1):1-17.

Cardwell, K.F., Desjardins A, Henry SH, Munkvold G, Robens J (2001). Mycotoxins: The Cost of Achieving Food Security and Food Quality. Website: www.apsnet.org/online/feature/mycotoxin/top.html. [Accessed 12/6/02].

Center for Disease Control and Prevention (CDC). Outbreak of Aflatoxin Poisoning – Eastern and Central Provinces, Kenya, January-June 2004. MMWR. 53(34):790-793.

Daniels, R., B. Daniels, P. Gilmet, D. Noonan. 2001. Audits International 2000 home food safety study report. www.audits.com/HFSS.html

Dosman, D.M., W.L. Adamowicz, S.E. Hrudey. 2001. Socioeconomic determinants of health-and food safety-related risk perceptions. Risk Anal. 21(2):307-314.

Farombi, E.O. 2006. Aflatoxin contamination of foods in developing countries: Implications for hepatocellu; ar carcinoma and chemoprevemntive strategies. Afr J. Biotech. 5(1):1-14.

Gong, Y., A. Hounsa, P.C. Turner, A.J. Hall, K.F. Cardwell, C.P. Wild. 2004. Post weaning exposure to aflatoxin results in impaired child growth: a longitudinal study in Benin, West Africa. Environ Health Persp. 112:1334-1338.

Hanson, J.A., J.A. Benedict. 2002. Use of Health Belief Model to examine older adult's food-handling behaviors. J. Nutr Educ Behav. 34:S25-S30.

Jolly, C.M., B. Bayard, S. Vodouhe. 2009. Risks of ingestion of aflatoxin-contaminated groundnuts in Benin: Scale measurements, beliefs, and socio-economic factors. Risk Anal. 29(10): 1395-1409.

Jolly, P.E., S. Inusah, W.O. Ellis, A. Nyarko, T.D. Phillips, J.H. Williams. 2013. Association between high aflatoxin B1 levels and high viral load in HIV-positive people. World Mycotox J. 6(3):255-261.

Jolly, P.E., Y. Jiang, W. Ellis, R. Awuah, O. Nnedu, T. Phillips, J.S. Wang, E. Afiyie- Gyawu, L. Tang, S. Pearson, P. Williams, and C.M. Jolly. 2006. Determinants of aflatoxin levels in Ghanaians: Sociodemographic factors, knowledge of aflatoxin and food handling and consumption practices. Intl. J. Hyg Environ Health. 209(4):345-358.

Krewski, D., P. Slovic, S. Bartlett, J. Flynn, C. Mertz. 1994. Health Risk Perceptions in Canada (ERC 94-3). Environmental Risk Management Working paper.

Krummel, D.A., D. Humphries, I. Tessaro. 2002. Focus Groups on Cardiovascular Health in Rural Women: Implications for Practice. J. Nutr Educ Behav. 34(1):38-46.

Lynne, D.G., L.R. Rola. 1988. Improving attitude-behavior prediction models with economic variables: Farmer actions toward soil conservation. J. Soc Psych. 128(1):19-28.

Martinez, B., T.B. Gratton, C. Coggin, A. Rene, W. Walker. 2004. A study of pesticide safety and health perceptions among pesticide

applicators in Tarrant County, Texas. J. Environ Health. 66(4):1-9.
Mikhail, B.I., W.I. Petro-Nustas. 2001. Transcultural adaptation of champion's Health Belief model scales. J. Nur Schol. 33(2):1-13.
N'dede, C.B., C.M. Jolly, S.D. Vodouhe, P.E. Jolly. 2012. Economic risks of aflatoxin contamination in marketing of peanut in Benin. Econ. Research Intl. Article ID 230638, 12 pages dol:10.1155/2012/230638.
Nesbitt, A., S. Majowicz, R. Finley, B. Marshall, F. Pollar, J. Sargeant, C. Ribble, J. Wilson, N. Sittler. 2009. High-risk food consumption and food safety practices in a Canadian community. J. Food Prot 72(12):2575-2586.
Neumark-Sztainer, D., Story, M. 1996. The use of health behavior theory in nutrition counseling. Top in Clinical Nutr. 11(2):60-73.
Palis, F.G., R.J. Flor, J.H. Aarburton, M. Hossain. 2006. Our farmers at risk: behavior and belief system in pesticide safety. J. PubHealth. 28(1):43-48.
Peers, F., X. Bosch, J. Kaldor, A. Linsell, M. Pluijmen. 1987. Aflatoxin exposure, hepatitis B virus infection and liver cancer in Swaziland. Int J Cancer 39:545-553.
Rosenstock, I.M., V.J. Strecher, M.H. Becker. 1988. Social learning theory and the health belief model. Health Educ Q. 15:175-183.
Schafer, R.B., E. Schafer, G.L. Bultena, E.O. Holberg. 1993. Food safety: An application of Health Belief Model. J. Nutr Educ. 25:17-24.
Siegrist, M., G. Cvetkovich, H. Gutscher. 2002. Risk preference predictions and gender stereotypes. OrganizBeh Hum Dec. 87:91-102.
Wdowik, M.J., P.A. Kendall, M.A. Harris, G. Auld. 2001. Expanded health belief model predicts diabetes self-management in college students. J. Nutr Educ. 33:17-33.