ENHANCEMENT OF COFFEE QUALITY THROUGH THE PREVENTION OF MOULD FORMATION

GCP/INT/743/CFC

STORAGE AND DEFECTS

KENYA

STORAGE

A – PROTOCOL

MYCOLOGY OF COFFEE BEAN DEFECTS

1. BACKGROUND

The means of separating certain physical defects of coffee beans are available and widely applied. If evidence of correlation between OTA producer development and these classes were to be established a ready means of eliminating some contamination from production would follow, though this strategy is not prevention.

2. OBJECTIVES

The experiment tests the hypothesis that fungal communities and average levels of OTA contamination are different among some defect classess as compared with sound beans.

3. OVERVIEW OF EXPERIMENT

The procedure compares sound coffee of a batch to its out-sorted defects for wet processed coffee and for mbuni coffee. It will describe the distribution of the fungal community in the overall batch to reveal any preferential occurrence that can be attributed to visible features.

Two batches of wet processed coffee are sampled from each of three selected sources and two batches of mbuni coffee are sampled from each of three sources. One batch from each of the sources is sorted into the main classes. The proportion of each defect is noted and OTA and mould analyses are carried out on samples from each defect class. The beans collected from different sources serve as replicate treatments.

The second batch of coffee from each source is clearly labeled and put into a coffee storage facility for 1 year, after which it is sorted and analysed as for the first batch.

4. METHODS

4.1. Sampling and processing of the samples

Collect 2 batches of 100 kg of green beans produced by wet processing from each of 3 coffee factories: two from the cooperative sector and one from the large estate sector. The coffee must be from the current harvest season and must be properly dried (less than 11% moisture db). Bag and clearly label one batch of coffee from each source and put these into storage. Sort the remaining batches of coffee, by hand, into the main defect classes and sound beans.

Weigh and record the individual weights of each category. Immediately seal them in plastic bags and set aside for equilibration and Aw measurement (on the following morning) as described in section 4.2. After Aw measurement, conduct mycological analysis on subsamples from each of the three replicates of each category of beans according to the procedure outlined in Section 4.3. OTA content of each of the three replicates of the bean categories should be determiined according to the procedure outlined in Section 4.4. Retain residual samples for re-checking if necessary.

The same procedure should be followed for green beans coming from mbuni.

4.2 Measurement of water activity

Immediately after sorting and before mycological analysis, seal about 50g of each of the seven defects from the batch in plastic bags. Allow the samples to equilibrate overnight. In the morning, introduce the Aw probe into each bag with as little disruption to the air in the bag as possible. Note the Aw after 10min and check at about 12 and 15min and so on to assess whether equilibrium has been reached and the reading is steady. Record the temperature at which the measurement was taken. The beans used in this analysis can be returned to the experimental unit. This may be useful in cases where a small amount of a particular defect has been found.

4.3 Mycological analysis

Randomly select somewhat more than 100 beans from each of the bean categories**.** Commit them to *i analysis* as described in the mycological handbook setting up 14 plates of seven beans per plate or 98 beans. From the defect class “broken beans” select the larger broken beans for this purpose.

4.4. OTA analysis

Remove two 500g samples from each of the categories of beans coming from each of the three farms (if this amount of coffee is not available for any category of defect, divide what is available into 2 samples). These samples should be clearly labelled and packed in plastic bags to be sent to CIRAD for analysis. Ensure that the moisture content of the beans is less than 11% db.

B – MAIN CONCLUSIONS

1. STORAGE

1.1. Coffee from Estate sector (Azania estate)

1.1.1. Parchment P3

- No significant differences have been shown between samples before and after 1 year storage.
- Dominant taxa observed on beans is composed of *Penicillium, Fusarium*, yellow and black *Aspergillii* before storage whereas only black *Aspergillii* have been observed after one year of storage.

1.1.2. Mbuni

- No significant differences have been shown between samples before and after 1 year storage for weight of defects, total infection rates and OTA
- Increase of infection by ochre group and decrease of Aw during storage.
- Dominant taxa observed on beans is composed of *Penicillium, Fusarium*, yellow and black *Aspergillii* before storage whereas only black *Aspergillii* have been observed after one year of storage

1.2. Coffee from Cooperative sector

1.2.1. Parchment P3 (Kirura FCS and Gathiruini FCS)

a) Kirura

- No significant differences shown before and after storage for weight of defects, total infection rates and OTA contamination
- Increase of Aw and infection by ochre group during storage
- Total infection: black *Aspergillus* group predominant before storage is replaced by yellow and green *Aspergillus* after storage for the observed sample.

b) Gathiruini

- No significant differences shown before and after storage
- Total infection: *Fusarium* have been replaced by black *Aspergillus* after storage

1.2.2. Mbuni (Kiambu FCS and Barikongo FCS)

a) Barikongo

- No significant differences shown before and after storage for weight of defects, total infection rates, infection by ochre group and OTA contamination
- Increase of water activity after storage
- Dominant taxa are similar before and after storage

b) Kiambu

- No significant differences shown before and after storage for weight of defects, total infection rates, infection by ochre group and OTA contamination
- Increase of water activity after storage
- Dominant taxa are similar before and after storage

2. DEFECTS AND OTA CONTAMINATION

2.1. P3

- Diseased beans contribute for more 70% of the total OTA contamination in coffee from Farmers Cooperative Societies whereas the impact of diseased beans is negligible with estate sector

2.2. Mbuni

- Diseased beans and foxy beans contribute for more 70% of the total OTA contamination in coffee from Farmers Cooperative Societies whereas the impact of the same defects is negligible with estate sector.

C - DATA

1. ESTATE

1.1. P3 / Lights

Source: **Azania (**Thika) Date of collection: 14 April 2004 .
Region of origin: UM3 Date of milling: 20 april 2004
Date of sorting before storage: may 2004 - Storage of beans after milling
Date of sorting/analysis after storage: 14/19 April 2005

Before storage										
Classification	Weight (kg)	% of total	% of beans	AW	oC	% infection	Dominant taxa	%Ochre infection	Ref/Lab (CIRAD)	OTA µg/kg
Black beans	0,9	0,9	1,0	0,565	23,8	27	Penicillium	4	2697/04	**3,16**
Diseased beans	6,8	6,8	7,4	0,562	23,7	30	Fusarium	6	2696/04	**0,50**
Foxy beans	0			-	-	-	-	-		
Hulled ears	5,8	5,8	6,3	0,559	23,5	32	Penicillium	5		
Insect damaged beans	1,0	1	1,1	0,564	23,7	22	Yellow asp	8	2695/04	**0,02**
Stinkers	0			-	-	-	-	-		
Sound beans	77,2	77,2	84,2	0,537	24,5	14	Black Asp	7		
Sub-total	91,7	91,7	**100,0**							
Husks										
Pods and dust	8,3	8,3								
Sweepings										
Total	**100,0**									
After storage										
Classification	Weight (kg)	% of total	% of beans	Aw	°C	% Infection	Dominant taxa	% Ochre infection	Ref/Lab (CIRAD)	OTA µg/kg
Black beans	0,76	0,8	0,89	0,555	22,7	86	Black Asp	27	1265/05	**traces**
Diseased beans	9,7	10,0	11,32	0,555	22,2	52	Black Asp	10	1263/05	**traces**
Foxy beans	0,3	0,3	0,35	0,543	23,1	68	Black Asp	6	1266/05	**traces**
Hulled ears	6,6	6,8	7,70	0,538	22,6	7	Green Asp	1	1267/05	**traces**
Insect damaged beans	1,5	1,5	1,75	0,558	22,3	79	Black Asp	34	1264/05	**traces**
Stinkers	0,06	0,1	0,07	0,553	23,7	51	Black Asp	4		
Sound beans	66,8	68,9	77,93	0,541	22,4	22	Black Asp +Fusarium	2	1262/05	**traces**
Sub-total	85,72	88,4	100,00							
Husks	0,26	0,26		0,54	24,6					
Pods	10,9	11,24		0,548	23,3					
Sweepings	0,12	0,12		0,581	24,1					
Total	97,000									

Statistical analysis

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	95,238	95,238	0,095
Residual	10	10021,030	1002,103	
Total	11	10116,268		

Before = After

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,0002058	0,00021	2,210
Residual	10	0,0009312	0,00009	
total	11	0,001137		

Before = After

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	2148,810	2148,810	4,074
Residual	10	5274,857	527,486	
Total	11	7423,667		

Before = After

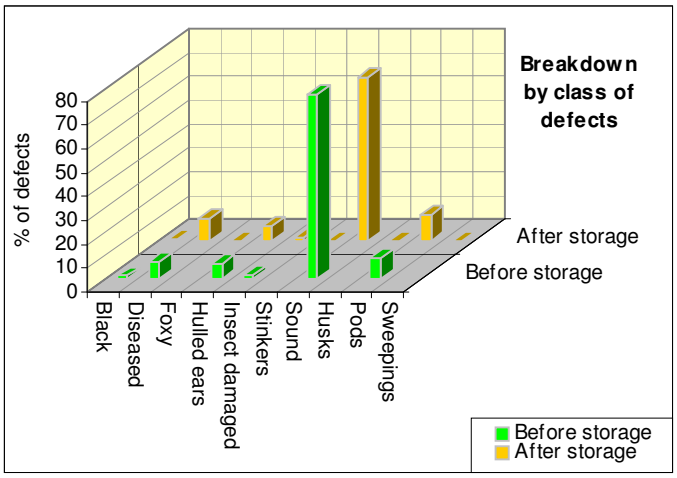
Infection by ochre group

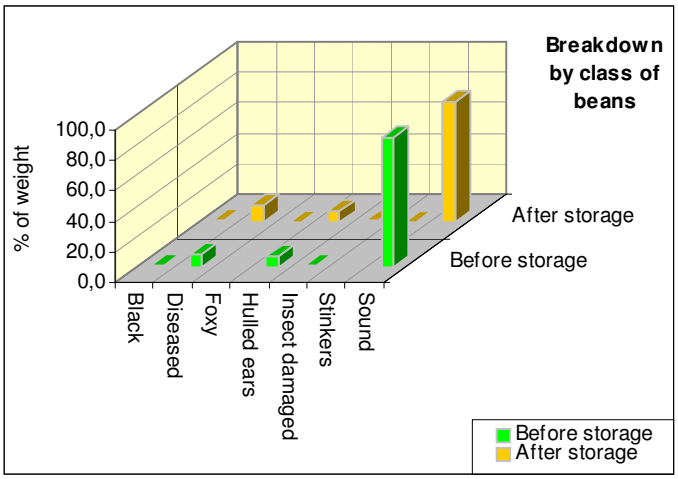
Variation	df	Sum Squares	Mean Squares	F
Storage	1	105,000	105,000	1,006
Residual	10	1044,000	104,400	
total	11	1149,000		

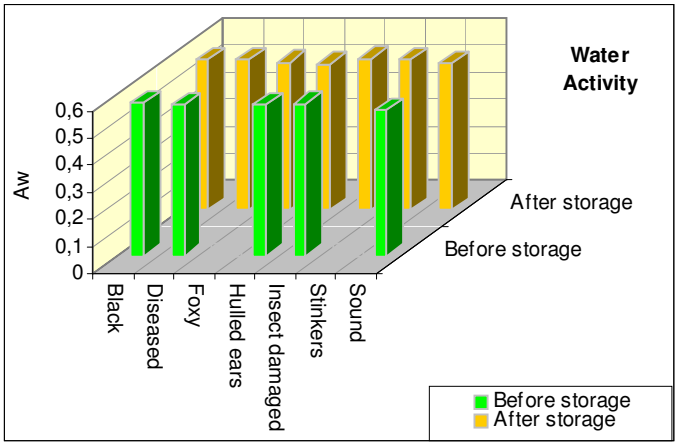
Before = After

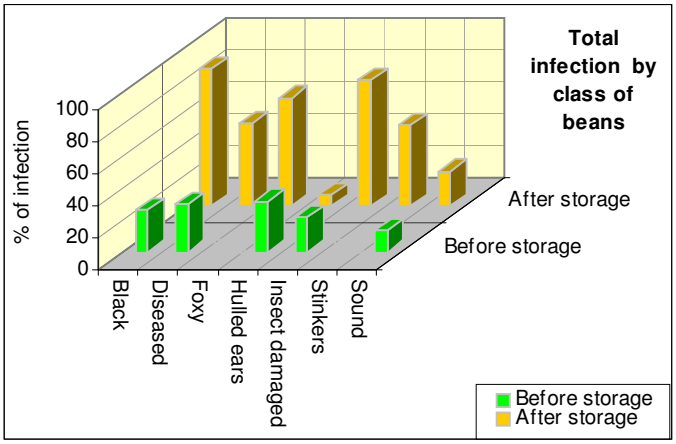
Statistical analysis regarding OTA contents is not possible

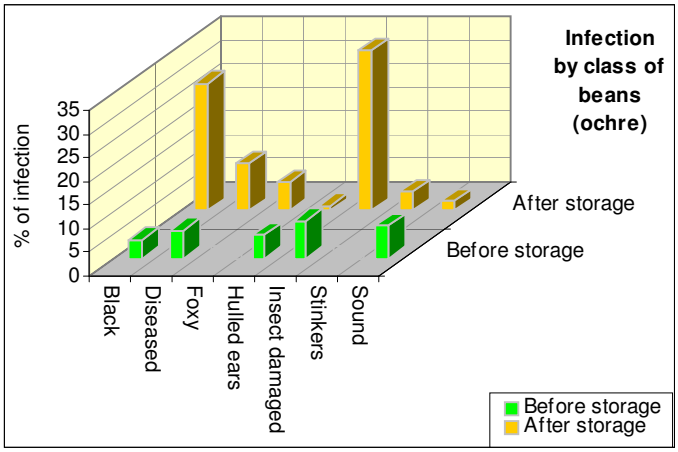
- **No significant differences shown before and after storage.**
- **Total infection: though there is not significant differences regarding infection rates, dominant taxa has shift to black *Aspergillus* group during storage.**

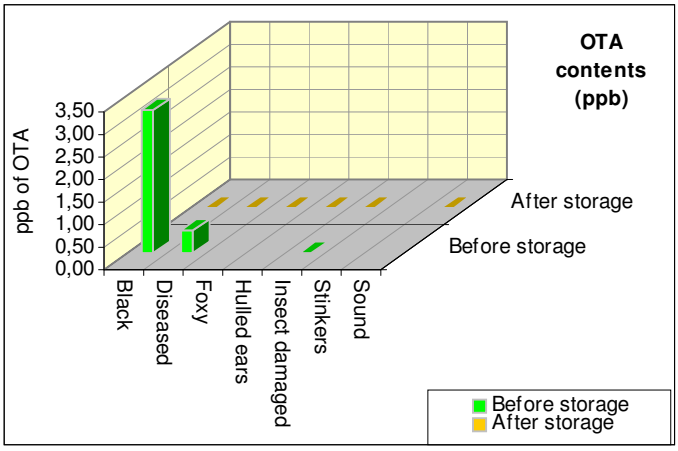












1.2. Mbuni

Source: **Azania Estate (**Thika) Date of collection: 6 April 2004
Region of origin: Um3 Date of milling: 7 april 2004 - Storage in beans after milling
Date of sorting before storage: may 2004
Date of sorting/analysis after storage: 4/13 April 2005.

Before storage										
Classification	**Weight kg**	**%of total**	**% of beans**	**AW**	**°C**	**% infection**	**Dominant taxa**	**%Ochre infection**	**Ref/Lab**	**OTA µg/kg**
Black beans	2,7	2,7	3,0	0,622	21,2	92	Fusarium	2	2700/04	**0,20**
Diseased beans	20,7	20,7	23,1	0,610	21,3	78	Fusarium	0	2699/04	**<0,02**
Foxy beans	1,55	1,55	1,7	0,627	21,3	97	Cy	2	2702/04	**0,23**
Hulled ears	2,1	2,1	2,3	0,624	21,2	37	Black Asp	5	-	**NA**
Insect damage	0,88	8,8	1,0	0,639	21,2	94	Black Asp	8	2698/04	**0,02**
Stinkers	1,1	1,1	1,2	0,643	21,7	87	Cy	2	2701/04	**0,10**
sound beans	60,7	60,7	67,6	0,594	22,2	78	Black Asp	0	2703/04	**traces**
Sub total	**89,728**	**89,7**	**100,0**							
Husk										
Pods and dust	10,27	10,3		N/A	N/A					
Sweeepings										
Total	100		200,0							
After storage										
Bean Classification	**Weight kg**	**% of total**	**% of beans**	**Aw**	**°C**	**% Infect.**	**Dominant taxa**	**% Ochre infection**	**Ref/Lab**	**OTA µg/kg**
Black	6,490	6,7	7,4	0,558	24	40	Black Asp	9	1259/05	**0,1**
Diseased	28,700	29,8	32,8	0,533	23,3	80	Black Asp	5	1256/05	**traces**
Foxy	0,690	0,7	0,8	0,556	23,5	76	Black Asp	9	1260/05	**traces**
Hulled ears	2,920	3,0	3,3	0,559	23,6	56	Penicillium	3	1261/05	**0,1**
Insect damage	1,000	1,0	1,1	0,565	23,4	95	Black Asp	23	1257/05	**0,1**
Stinker	1,000	1,0	1,1	0,569	23,4	66	Black Asp	12	1258/05	**4,4**
Sound	46,600	48,3	53,3	0,542	23,7	52	Black Asp	3	1255/05	**traces**
Sub total	**87,4**	**90,6**	**100,0**							
Husks	0,690	0,7		0,574	23,7					
Pods	7,850	8,1		0,569	23,3					
Sweepings	0,510	0,5		0,586	24					
Total	96,450	100,0	100,0							

Statistical analysis

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,481	0,481	0,001
Residual	10	6130,857	510,905	
total	11	6131,338		

Before = After

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,016	0,016	**73,396**
Residual	12	0,003	0,000	
total	13	0,019		

Before > After

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	686,000	686,000	1,774
Residual	12	4641,429	386,786	
total	13	5327,429		

Before = After

Infection by ochre group

Variation	df	Sum Squares	Mean Squares	F
Storage	1	144,643	144,643	**5,071**
Residual	12	342,286	28,524	
total	13	486,929		

Before > After

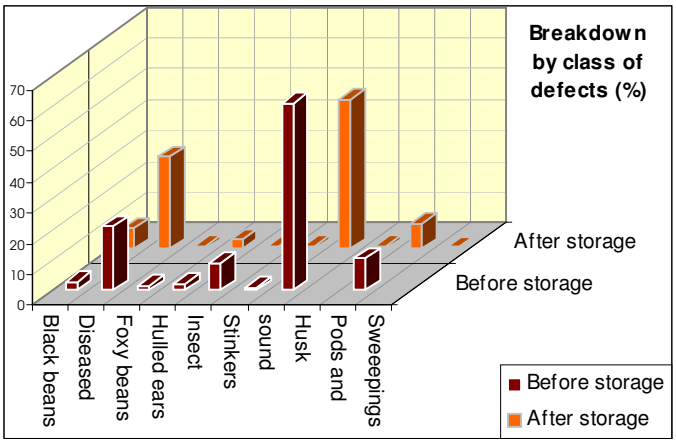
OTA

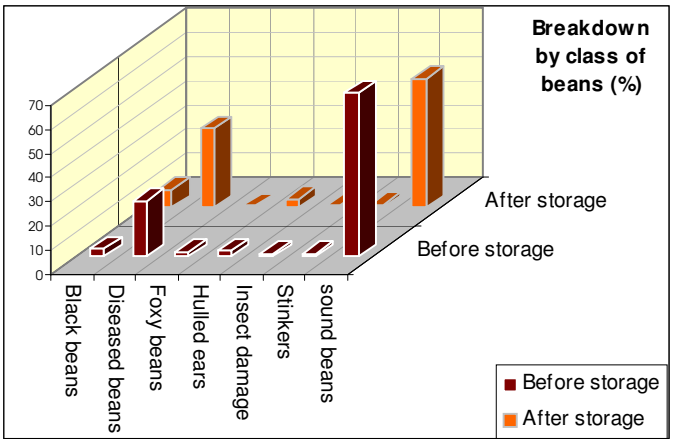
Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,0614	0,0614	0,083
Residual	10	7,3663	0,7366	
total	11	7,4277		

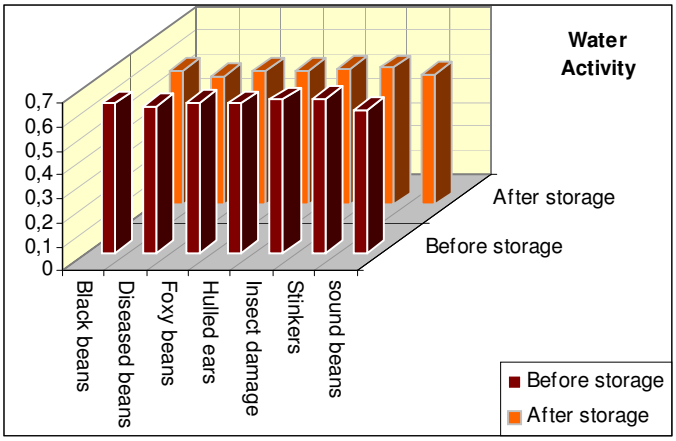
Before = After

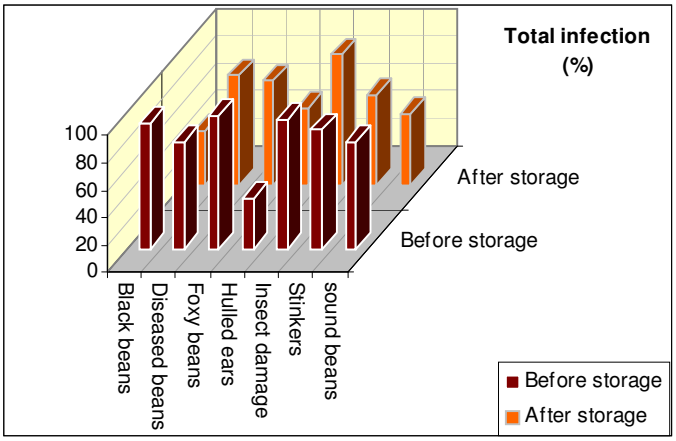
note
Transformation for OTA data:
X →log(X), traces → log(0,01), <0,02 → log(0,015)

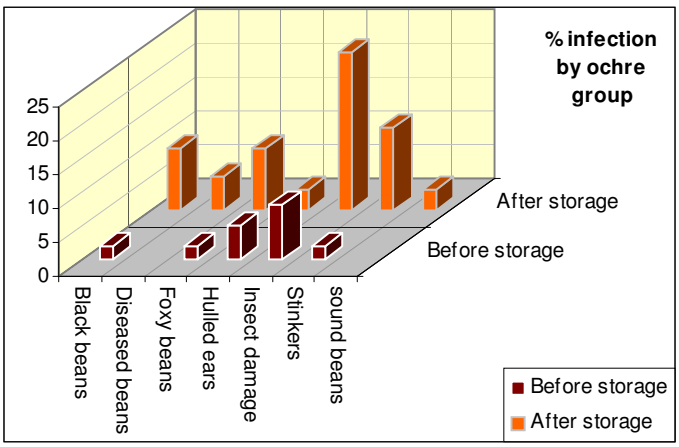
- **No significant differences shown before and after storage for weight of defects, total infection rates and OTAcontamination**
- **Decrease of Aw during storage**
- **Increase of infection by ochre group during storage**
- **Total infection: though there is not significant differences regarding infection rates, dominant taxa has shift to black *Aspergillus* group during storage.**

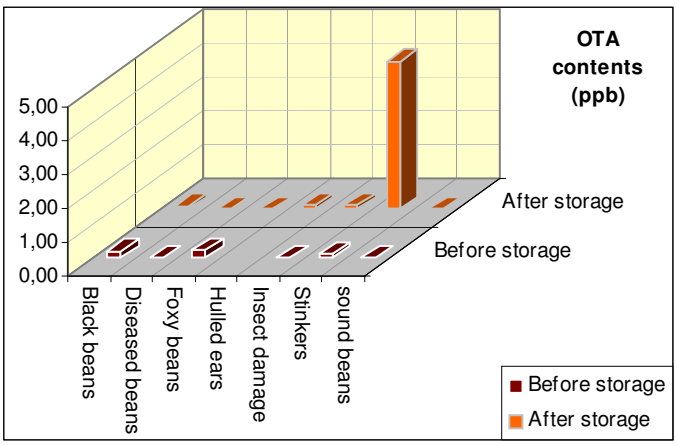












2. FARMERS COOPERATIVE SOCIETIES

2.1. P3 / Lights

Source: **Kirura** Date of collection: 14 May 04 Date of sorting/analysis: 10/22 May 2005
Region of origin: UM1 Date of milling: 20 may 2004
Date of sorting before storage: may 2004

Before storage											
Classification	**Weight kg**	**% of total**	**% of beans**	**AW**	**°C**	**% infection**	**Dominant taxa**	**%Ochre infection**	**Ref/Lab**	**OTA µg/kg**	
Black beans	2,3	2,3	2,4	0,53	23,0	91	Black Asp	5	2729/04 -2963/04	**0,2**	**0,9**
Diseased beans	15,4	15,4	15,9	0,55	23,0	69	Black Asp	7	2728/04-2962/04	**152,6**	**0,3**
Faded beans									NA		
Foxy beans	1,0	1,0	1,1	0,54	23,1	69	Black Asp	11	2731/04-2965/04	**0,3**	**3,1**
Green W D			0,0						NA		
Hulled ears	9,0	9,0	9,3	0,55	22,9	42	Black Asp	8	3044/04-3045/04	**0,2**	**0,3**
Insect damage	0,5	0,5	0,6	0,53	22,8	85	Black Asp	17	2727/04-2961/04	**10,0**	**0,5**
Moulded beans			0,0						NA		
Stinkers	0,2	0,2	0,2	0,53	23,2	73	Black Asp	8	2730/04-2964/04	**5,1**	**2,5**
Sound beans	68,0	68,0	70,5	0,57	23,2	63	Black Asp	4	3020/04-3021/04	**0,1**	**0,2**
Sub total	**96,5**	**96,5**	**100,0**								
Pods and dust	3,5	3,5									
Husks/stones											
Sweepings											
Total	100,0	100,0									

After storage											
Classification	**Weight kg**	**% of total**	**% of beans**	**AW**	**OC**	**% infection**	**Dominant taxa**	**%Ochre infection**	**Ref/Lab**	**OTA µg/kg**	
Black beans	0,8	1,2	1,2	0,556	25,5	84	Yellow Asp	39	1606/05	**77,8**	
Diseased beans	10,8	15,8	15,9	0,551	23,5	90	Yellow Asp	37	1603/05	**9,3**	
Faded beans	3,2	4,7	4,7	0,583	25,4	99	Other Asp	30	1601/05	**1,2**	
Foxy beans	0,8	1,2	1,2	0,558	24,6	82	Yellow Asp	34	1605/05	**5,6**	
Green W D	0,2	0,3	0,3	0,571	24	99	Green Asp	16			
Hulled ears	4	5,8	5,9	0,565	23,5	53	Green Asp	20	1602/05	**0,0**	
Insect damaged	0,4	0,6	0,6	0,554	23,6	70	Green Asp	16	1604/05	**3,4**	
Moulded beans	0,1	0,1	0,1	0,605	25,2						
Stinkers											
Sound beans	47,8	69,8	70,2	0,581	24,7	66	Green Asp	15	1600/05	**0,2**	
Sub total	**68,1**	**99,4**	**100,0**								
Pods and dust		0,0									
Husks/stones	0,2	0,3		0,572	25,6						
Sweepings	0,2	0,3		0,567	25,7						
Total	68,5	100,0									

STATISTICAL ANALYSIS

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	39,683	39,683	0,069
Residual	14	8016,109	572,579	
total	15	8055,792		

Before = After

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,003	0,003	**10,852**
Residual	14	0,004	0,000	
total	15	0,007		

Before < After

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	380,030	380,030	1,464
Residual	13	3375,304	259,639	
total	14	3755,333		

Before = After

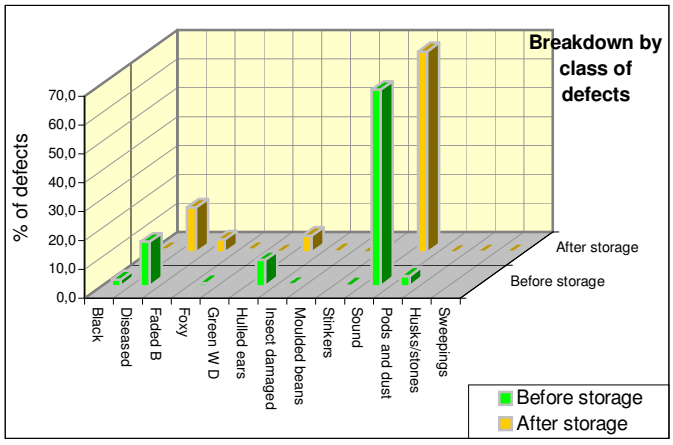
Infection by ochre group

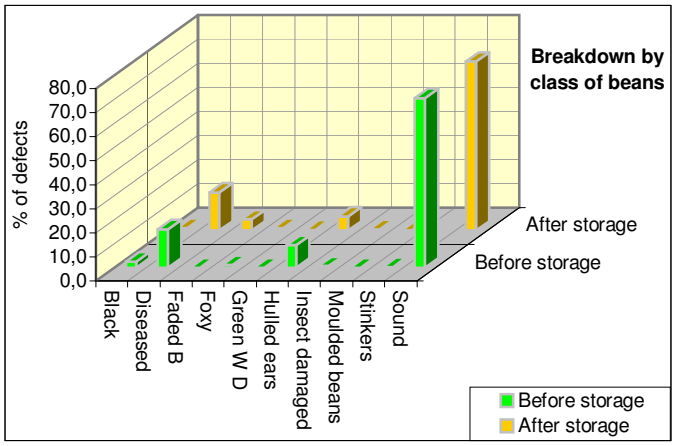
Variation	df	Sum Squares	Mean Squares	F
Storage	1	1117,811	1117,811	**17,287**
Residual	13	840,589	64,661	
total	14	1958,400		

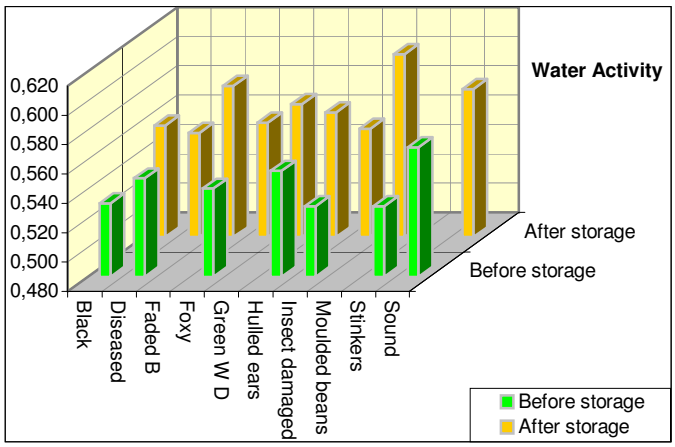
Before < After

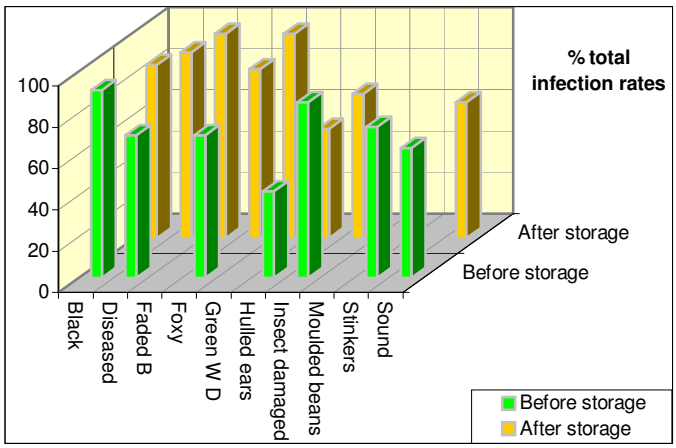
OTA				
Variations	df	Sum Squares	Mean Squares	F
stockage	1	0,206	0,206	0,092
residuelle	13	29,120	2,240	
total	14	29,326		
Before = After				

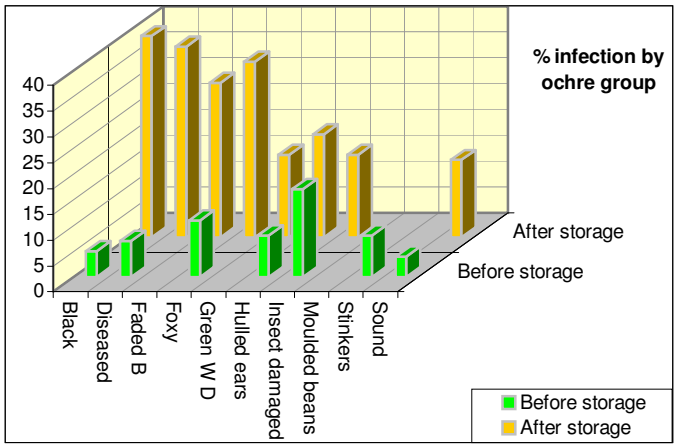
- **No significant differences shown before and after storage for weight of defects, total infection rates and OTA contamination**
- **Increase of Aw and infection by ochre group during storage**
- **Total infection: black *Aspergillus* group predominant before storage is replaced by yellow and green *Aspergillus* after storage for the observed sample.**

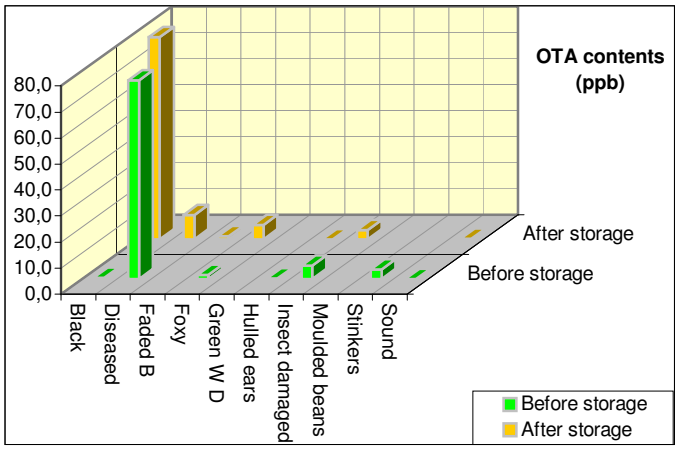












Source: **Gathiruini** Date of collection: 14 May 04 Date of sorting/analysis: 10/22 May 2005
Region of origin: UM1 Date of milling: 20 may 2004
Date of sorting before storage: may 2004

Before storage

Classification	Weight kg	% of total	% of beans	AW	oC	% infection	Dominant taxa	%Ochre infection	Ref/Lab	OTA µg/kg	
Black beans	1,26	1,3	1,3	0,51	22,5	85	Yellow Asp	29	2734/04-2968/04	3,9	4,5
Diseased beans	6,76	6,8	6,8	0,52	22,3	93	Black Asp	23	2733/04-2967/04	2,3	130,0
Foxy beans	0,20	0,2	0,2	0,51	22,7	81	Black Asp	16	2736/04-2970/04	5,0	11,6
Green W D B											
Hulled ears	11,04	11,0	11,2	0,52	22,3	40	Unknown	7	3046/04-3047/04	0,5	0,5
Insect damage	0,46	0,5	0,5	0,51	22,3	92	Fusarium	23	2732/04-2966/04	499,3	75,1
Stinkers	0,01	0,0	0,0		N/A				2735/04-2969/04	1,5	3,5
Sound beans	79,00	79,0	80,0	0,53	22,7	66	Fusarium	17	3022/04-3023/04	0,2	0,1
Sub total	**98,7**	**98,7**	**100,0**								
Pods and dust	1,27	1,3		N/A	N/A						
Husks/stones											
Sweepings											
Total	100,0	100,0									

After storage

Classification	Weight kg	% of total	% of beans	AW	oC	% infection	Dominant taxa	%Ochre infection	Ref/Lab	OTA µg/kg	
Black B	0,6	0,7	0,7	0,556	23,2	99	Yellow Asp	30	1608/05	131,5	
Diseased	6,5	7,7	7,8	0,52	22,5	49	Black Asp	3	1609/05	40,2	
Foxy b	0,3	0,4	0,4	0,544	23,5	67	Black Asp	7	1613/05	49,4	
Green W D B	0,2	0,2	0,2	0,539	23,4	65	Yellow Asp	16	1610/05	5,1	
Hulled ears	6,11	7,2	7,3	0,515	22,4	22	Green Asp	3	1607/05	1,7	
Insect	0,2	0,2	0,2	0,536	22,8	72	Black Asp	11	1611/05	2,4	
Stinkers											
Sound	69,89	82,4	83,4	0,493	23,7	35	Black Asp	2	1612/05	0,7	
Sub total	**83,8**	**98,8**	**100,0**								
Pods and dust											
Husks/stones	0,8	0,9		0,533	24,2						
Sweepings	0,2	0,2		0,561	23,6						
Total	84,8	100									

STATISTICAL ANALYSIS

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	254,815	254,815	3,127
Residual	11	896,262	81,478	
total	12	1151,077		

before = after

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,001	0,001	2,327
Residual	11	0,003	0,000	
total	12	0,004		

before = after

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	1016,529	1016,529	1,877
Residual	11	5958,548	541,686	
total	12	6975,077		

before = after

Infection by ochre group

Variation	df	Sum Squares	Mean Squares	F
Storage	1	254,815	254,815	3,127
Residual	11	896,262	81,478	
total	12	1151,077		

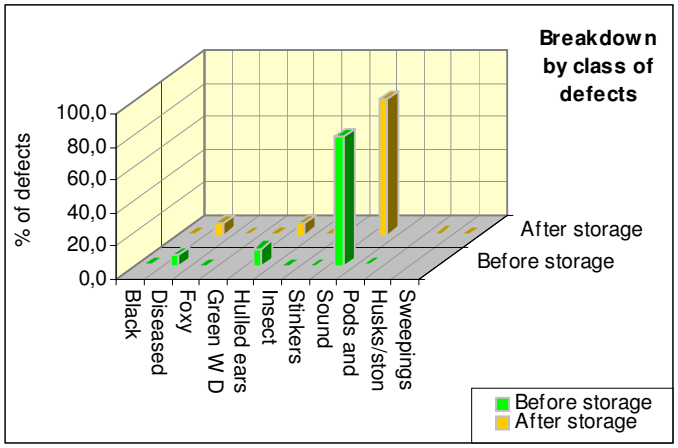
before = after

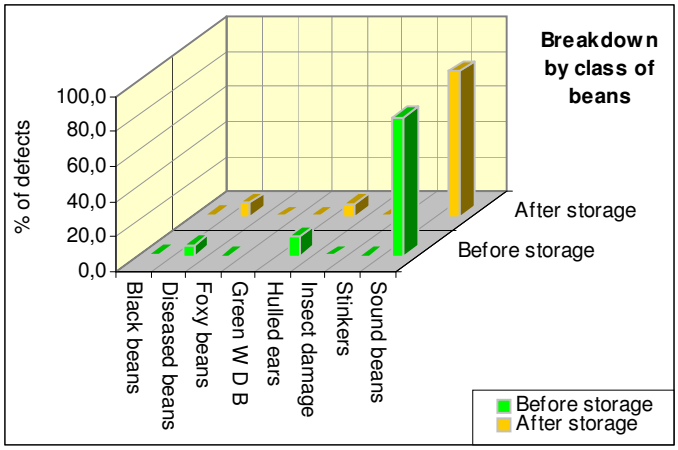
OTA

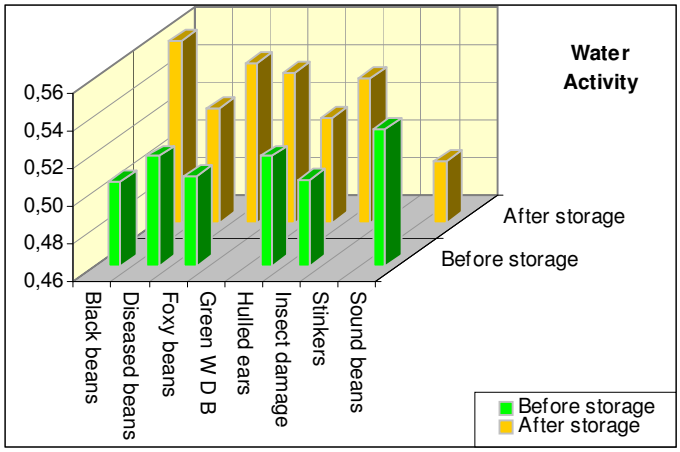
Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,181	0,181	0,173
Residual	12	12,574	1,048	
total	13	12,755		

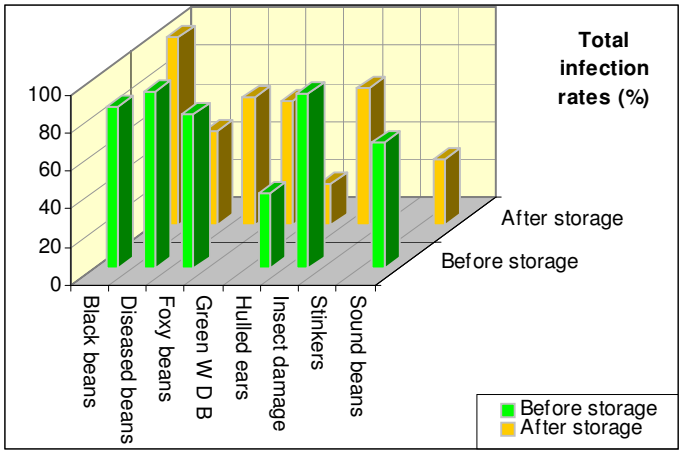
Before = After

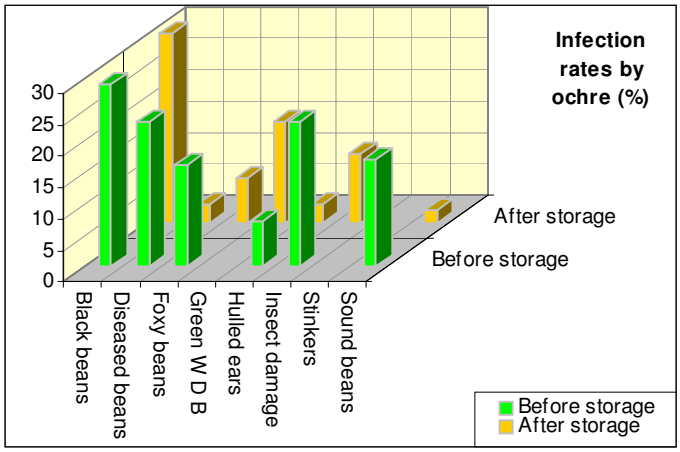
- **No significant differences shown before and after storage**
- **Total infection: *Fusarium* have been replaced by Black *Aspergillus* after storage**

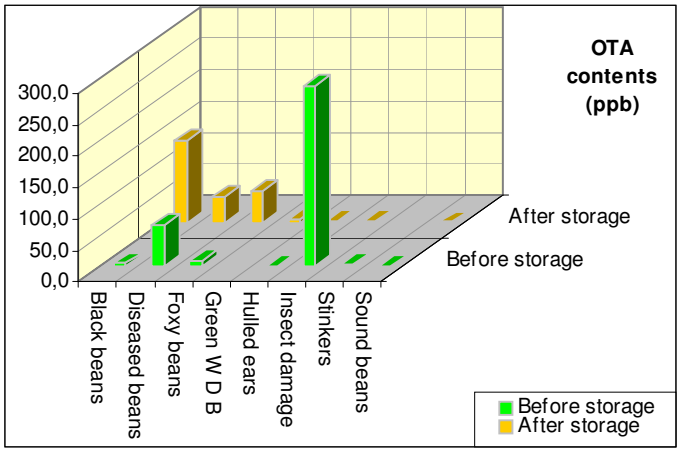












2.2. Mbuni

Source: Barikongo/FCS Date of collection: 19 May 04
Region of origin: UM2 Date of sorting/analysis: 20 may 2004
Storage in beans for 1 year
Date of sorting/analysis: 23 May – 1 June 05

Before storage											
Classification	**Weight kg**	**% of total**	**% of beans**	**AW**	**oC**	**% infection**	**Dominant taxa**	**% Ochre infection**	**Ref/Lab**	**OTA µg/kg**	**OTA µg/kg**
Black beans	7,54	7,5	8,0	0,528	22,8	88	Yellow Asp	43	2739/04-2973/04	**2,2**	**0,3**
Diseased beans	21,90	21,9	23,3	0,536	22,6	92	Black Asp	21	2738/04-2972/04	**2,3**	**0,4**
Faded beans											
Foxy beans	1,22	1,2	1,3	0,542	23,1	88	Black Asp	18	2741/04-2975/04	**28,1**	**169,5**
Green W D B											
Hulled ears	0,40	0,4	0,4	0,550	22,6	81	Black Asp	14	3048/04-3049/04	**1,7**	**0,6**
Insect damage	1,02	1,0	1,1	0,533	22,4	92	Black Asp	35	2737/04-2971/04	**2,7**	**10,9**
Stinkers	0,34	0,3	0,4	0,555	23,0	89	Black Asp	20	2740/04-2974/04	**3,7**	**1,3**
Sound beans	61,60	61,6	65,5	0,525	23,4	91	Black Asp	10	3024/04-3025/04	**0,2**	**0,4**
Sub total	**94,0**	**94,0**	**100,0**								
Pods and dust	5,98	6,0									
Sweepings											
Total	**100,00**	**100,00**									

After storage											
Classification	**Weight kg**	**% of total**	**% of beans**	**AW**	**°C**	**% infection**	**Dominant taxa**	**% Ochre infection**	**Ref/Lab**	**OTA µg/kg**	
Black B	4,40	4,5	4,5	0,575	22,5	86	Green Asp	6	2149/05	**1,6**	
Diseased	14,10	14,5	14,6	0,582	22,3	77	Black Asp	63	2146/05	**82,0**	
Faded beans	0,10	0,1	0,1	0,59	23,0						
Foxy b	2,16	2,2	2,2	0,59	22,5	87	Black Asp	5	2148/05	**7,4**	
Green W D B	1,90	2,0	2,0	0,587	22,7	93	Black Asp	12	2150/05	**1,0**	
Hulled ears	3,00	3,1	3,1	0,573	22	97	Black Asp	2	2145/05	**29,6**	
Insect	0,53	0,5	0,5	0,585	22,2	100	Black Asp	11	2147/05	**0,4**	
Stinkers	0,13	0,1	0,1	0,587	22,3	94	Black Asp	4	2144/05	**32,1**	
Sound	70,50	72,7	72,8	0,573	22,8	90	Black Asp	64	2143/05	**1,5**	
Sub total	**96,82**	**99,8**	**100,0**								
Pods	0,08	0,1		0,579	23,1						
Sweepings	0,10	0,1		0,587	23,5						
Total	**97,00**	**100,00**									

STATISTICAL ANALYSIS

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	39,683	39,683	0,070
Residual	13	7916,565	565,469	
total	14	7956,247		

Before = After

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,008	0,008	**93,524**
Residual	14	0,001	0,000	
total	15	0,009		

Before < After

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	11,905	11,905	0,341
Residual	13	453,429	34,879	
total	14	465,333		

Before = After

Infection by ochre group

Variation	df	Sum Squares	Mean Squares	F
Storage	1	16,858	16,858	0,038
Residual	13	5756,875	442,837	
total	14	5773,733		

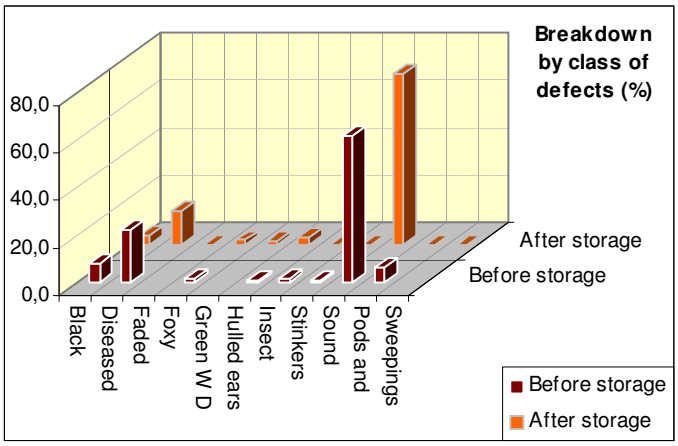
Before = After

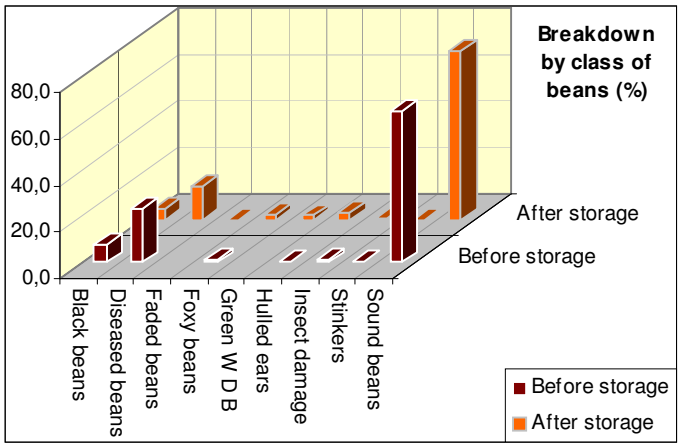
OTA

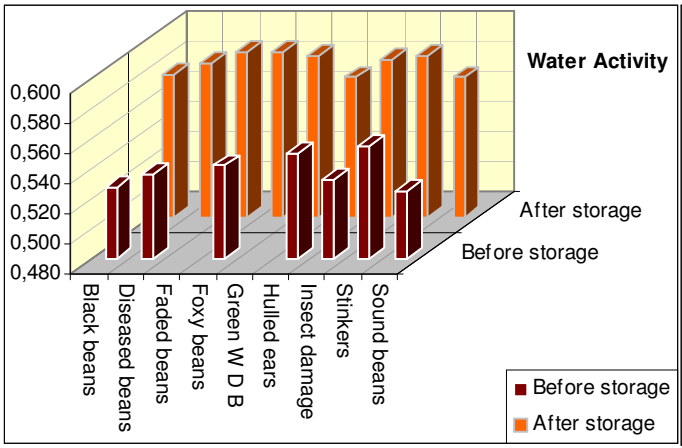
Variation	df	Sum Squares	Mean Squares	F
Storage	5	0,299	0,060	0,054
Residual	8	8,861	1,108	
total	13	9,160		

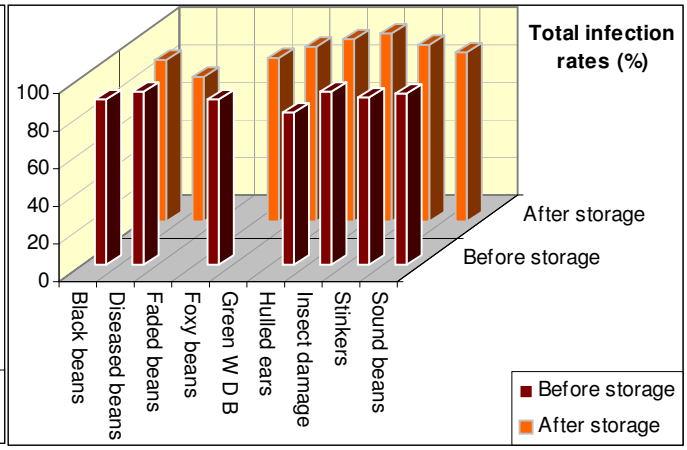
Before = After

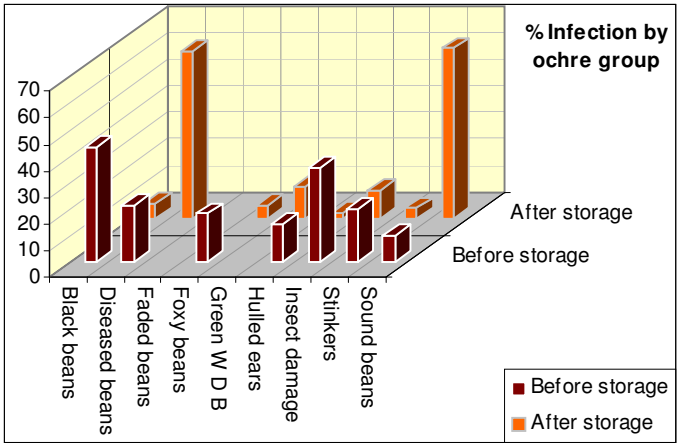
- **No significant differences shown before and after storage for weight of defects, total infection rates, infection by ochre group and OTA contamination**
- **Increase of water activity after storage**
- **Dominant taxa are similar before and after storage**

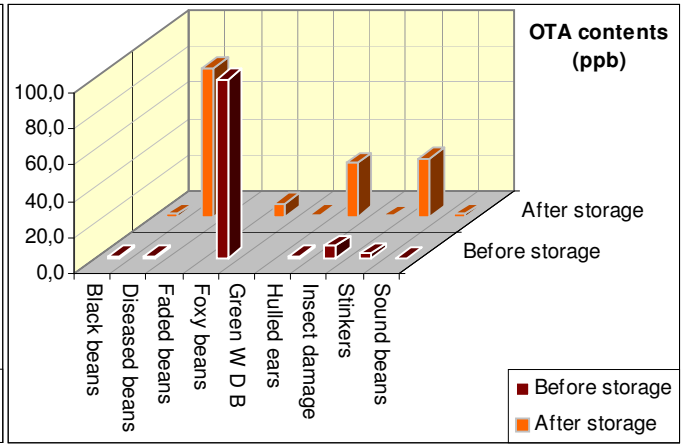












Source: Kaimbu
Region of origin: UM2

Date of collection: 28 May 04
Date of sorting before storage: june 2004
Date of milling: june 2004
Date of sorting/analysis: 24 May – 27 June 05

Before storage

Classification	Weight kg	% of total	% of beans	AW	oC	% infection	Dominant taxa	%Ochre infection	Ref/Lab	OTA µg/kg	OTA µg/kg
Black beans	7,16	7,2	7,3	0,54	21,1	100	Yellow Asp	57	2744/04-2978/04	0,6	3,5
Diseased beans	17,72	17,7	18,0	0,54	21,4	98	Black Asp	24	2743/04-2977/04	1,2	146,0
Faded beans											
Foxy beans	1,56	1,6	1,6	0,56	22,4	100	Black Asp	6	2745/04-2979/04	727,0	241,9
Green W D B											
Hulled ears	7,14	7,1	7,3	0,56	21,1	85	Black Asp	12	3050/04-3051/04	0,5	0,6
Insect damage	1,22	1,2	1,2	0,55	20,5	97	Black Asp	22	2742/04-2976/04	21,4	0,9
Stinkers	0,26	0,3	0,3	0,54	21,1	100	Black Asp	29			
Sound beans	63,30	63,3	64,4	0,55	22,4	100	Black Asp	27	3026/04-3027/04	0,9	0,2
Sub total	**98,36**	**98,4**	**100,0**								
Pods and dust	1,64	1,6		N/A	N/A						
Sweepings											
Total	**100,00**	**100,00**									

After storage

Classification	Weight kg	% of total	% of beans	AW	oC	% infection	Dominant taxa	%Ochre infection	Ref/Lab	OTA µg/kg	
Black Beans	6,03	6,2	6,2	0,603	21,2	90,0	Black Asp	14,0	2157/05	0,9	
Diseased beans	15,44	15,8	15,9	0,608	20	93,0	Black Asp	4,0	2154/05	11,5	
Faded	0,2	0,2	0,2				Black Asp	5,0			
Foxy beans	2,04	2,1	2,1	0,624	20,4	83,0	Black Asp	4,0	2156/05	420,8	
Green W D B	1,75	1,8	1,8	0,617	20,3	87,0	Black Asp	8,0	2158/05	46,9	
Hulled ears	6,89	7,0	7,1	0,616	20,3	74,0	Black Asp	5,0	2153/05	0,7	
Insect	1,2	1,2	1,2	0,62	20	100,0	Black Asp	1,0	2155/05	6,1	
Stinkers	0,31	0,3	0,3	0,63	20,7	98,0	Black Asp	0,0	2152/05	2,5	
Sound beans	63,4	64,8	65,2	0,6	20,7	92,0	Black Asp	4,0	2151/05	1,3	
Sub total	**97,3**	**99,4**	**100,0**								
Pods	0,19	0,2		0,632	21,3		Black Asp				
Sweepings	0,37	0,4		0,644	20,7						
Total	97,82	100,0									

STATISTICAL ANALYSIS

Weight of defects

Variation	df	Sum Squares	Mean Squares	F
Storage	1	39,683	39,683	0,084
Residual	14	6635,471	473,962	
total	15	6675,153097		

Before = After

Aw

Variation	df	Sum Squares	Mean Squares	F
Storage	1	0,0162	0,0162	**180,980**
Residual	13	0,0012	0,000090	
total	14	0,017374		

Before < After

Total infection

Variation	df	Sum Squares	Mean Squares	F
Storage	1	211,001	211,001	4,090
Residual	13	670,732	51,595	
total	14	881,7333333		

Before = After

Infection by ochre group

Variation	df	Sum Squares	Mean Squares	F
Storage	1	1620,321	1620,321	**13,208**
Residual	14	1717,429	122,673	
total	15	3337,750		

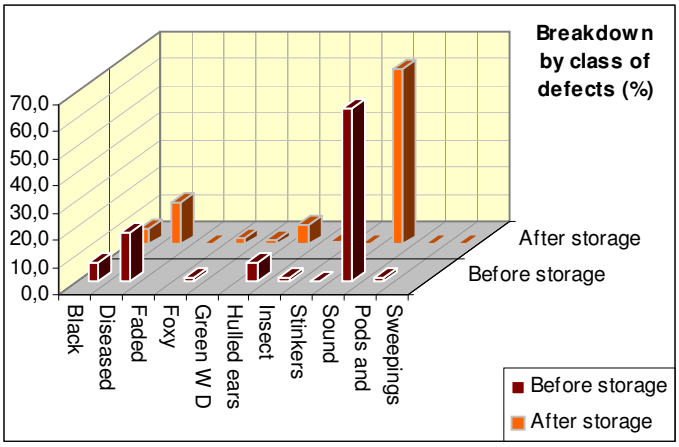
Before ≠ After

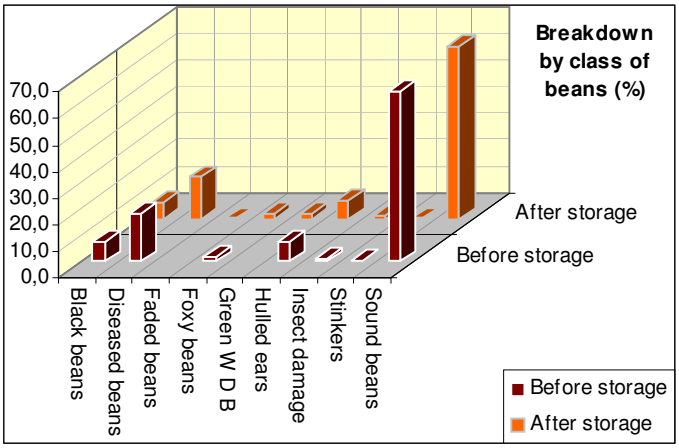
OTA

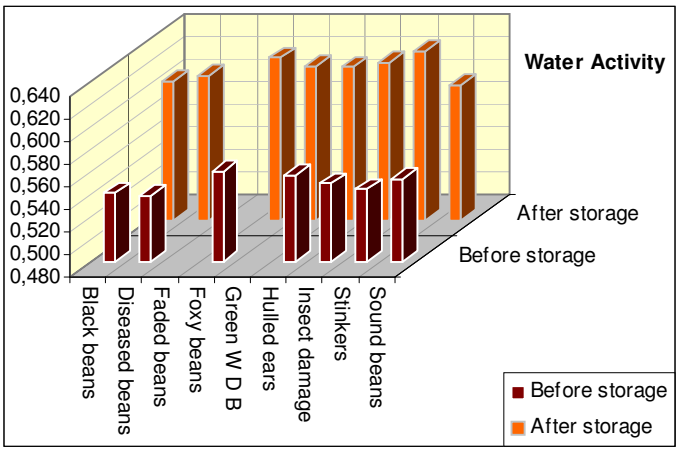
Variation	df	Sum Squares	Mean Squares	F
Storage	5	0,021	0,004	0,002
Residual	6	13,704	2,284	
total	11	13,725		

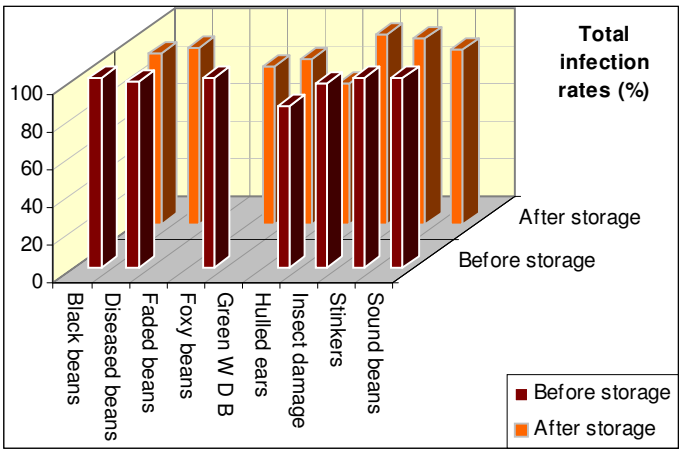
Before = After

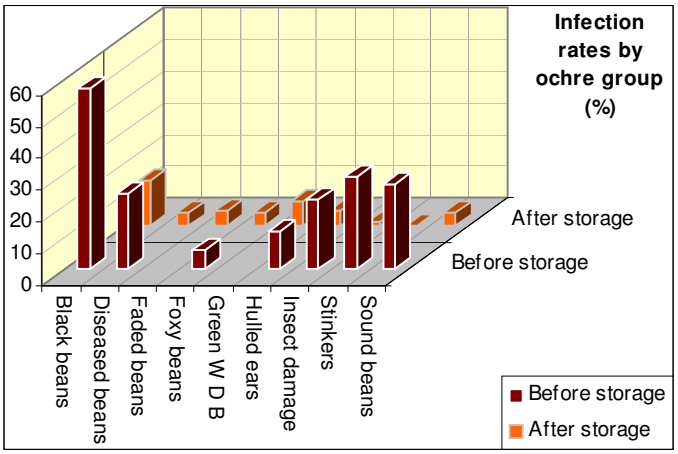
- **No significant differences shown before and after storage for weight of defects, total infection rates, infection by ochre group and OTA contamination**
- **Increase of water activity after storage**
- **Dominant taxa are similar before and after storage**

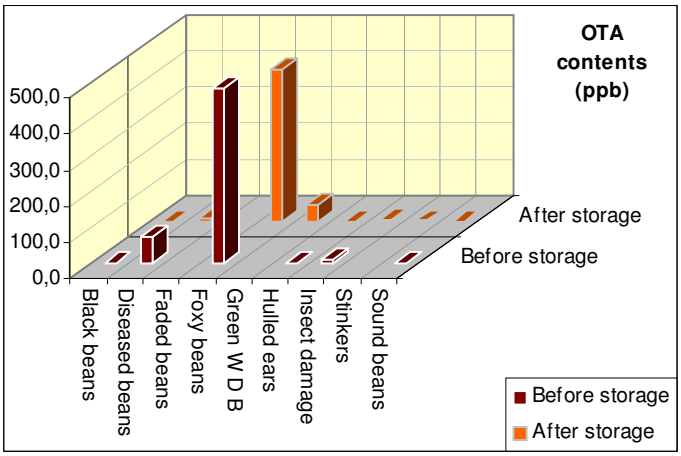












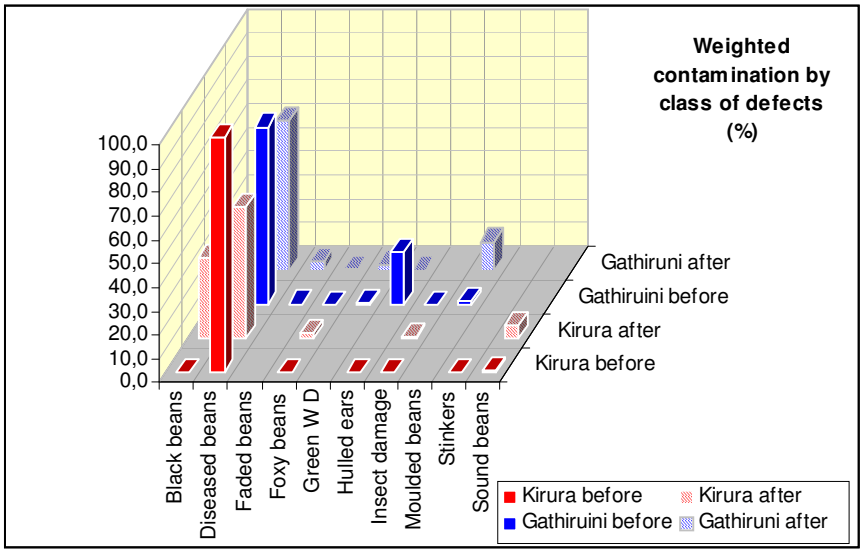
D – OTA CONTAMINATION AND DEFECTS

1. P3

Before storage							After storage				
Azania P3	kg	OTA (ppb)	OTA	% OTA			Azania P3	kg	OTA (ppb)	OTA	% OTA
Black	1,0	**3,16**	3,10	45,3			Black	0,89	**traces**	0,00	0,9
Diseased	7,4	**0,50**	3,73	54,5			Diseased	11,32	**traces**	0,01	11,3
Foxy			0,00				Foxy	0,35	**traces**	0,00	0,4
Hulled ears	6,3		0,00				Hulled ears	7,70	**traces**	0,01	7,7
Insect damaged	1,1	**<0,02**	0,02	0,2			Insect damaged	1,75	**traces**	0,00	1,8
Stinkers							Stinkers	0,07		0,00	0,0
Sound	84,2						Sound	77,93	**traces**	0,08	78,0
Total	100,0		6,85	0,1			Total	100,0		0,10	0,0

Before storage							After storage				
Kirura P3		OTA (ppb)		mean	OTA	% OTA	Kirura P3	kg	OTA (ppb)	OTA	% OTA
Black beans	2,4	0,2	0,9	**0,6**	1,31	0,1	Black	1,2	**77,8**	91,42	34,0
Diseased beans	**15,9**	**152,6**	**0,3**	**76,5**	**1218,95**	**98,4**	**Diseased beans**	**15,9**	**9,3**	**148,04**	**55,1**
Faded beans	0,0						Faded B	4,7	**1,2**	5,42	
Foxy beans	1,1	0,3	3,1	**1,7**	1,83	0,1	Foxy	1,2	**5,6**	6,54	2,4
Green W D	0,0						Green W D	0,3			
Hulled ears	9,3	0,2	0,3	**0,3**	2,33	0,2	Hulled ears	5,9	**0,0**		
Insect damage	0,6	10,0	0,5	**5,3**	2,94	0,2	Insect damaged	0,6	**3,4**	2,00	0,7
Moulded beans	0,0						Moulded beans	0,1			
Stinkers	0,2	5,1	2,5	**3,8**	0,87	0,1	Stinkers				
Sound beans	70,5	0,1	0,2	**0,2**	10,57	0,9	Sound	70,2	**0,2**	15,08	5,62
Total	100,0				1238,80	12,4	Total	100,0		268,50	2,7

Before storage							After storage				
Gathiruini P3		OTA (ppb)		mean	OTA	% OTA	Gathiruini P3	kg	OTA (ppb)	OTA	% OTA
Black beans	1,3	**3,9**	**4,5**	4,2	5,33	0,9	Black beans	0,7	**131,5**	94,12	18,9
Diseased beans	**6,8**	**2,3**	**130,0**	**66,1**	**452,79**	**74,4**	**Diseased beans**	**7,8**	**40,2**	**311,88**	**62,7**
Foxy beans	0,2	**5,0**	**11,6**	8,3	1,68	0,3	Foxy beans	0,4	**49,4**	17,68	3,6
Green W D B						0,0	Green W D B	0,2	**5,1**	1,21	0,2
Hulled ears	11,2	**0,5**	**0,5**	0,5	5,55	0,9	Hulled ears	7,3	**1,7**	12,37	2,5
Insect damage	**0,5**	**499,3**	**75,1**	**287,2**	**133,79**	**22,0**	Insect damage	0,2	**2,4**	0,57	0,1
Stinkers	0,0	**1,5**	**3,5**	2,5	0,03	0,0	Stinkers				
Sound beans	80,0	**0,2**	**0,1**	0,1	9,64	1,6	Sound beans	83,4	**0,7**	59,47	12,0
Total	100,0				608,80	6,1	Total	100,0		497,30	5,0



2. Mbuni

Before storage							After storage				
Azania Mbuni	kg	OTA (ppb)	OTA	% OTA			**Azania Mbuni**	kg	OTA (ppb)	OTA	% OTA
Black beans	3,0	**0,20**	0,59	38,2			Black beans	7,4	**0,1**	0,56	9,2
Diseased beans	23,1	**<0,02**	0,35	22,5			Diseased beans	32,8	**traces**	0,03	0,5
Foxy beans	1,7	**0,23**	0,39	25,7			Foxy beans	0,8	**traces**	0,00	0,0
Hulled ears	2,3						Hulled ears	3,3	**0,1**	0,37	6,0
Insect damage	1,0	**<0,02**	0,01	1,0			Insect damage	1,1	**0,1**	0,14	2,3
Stinkers	1,2	**0,10**	0,13	8,3			Stinkers	1,1	**4,4**	4,98	81,1
sound beans	67,6	**traces**	0,07	4,4			sound beans	53,3	**traces**	0,05	0,9
Total	100,0		1,54	**0,0**			Total	100,0		6,14	**0,1**
Before storage							**After storage**				
Kiambu Mbuni		OTA (ppb)		mean	OTA	% OTA	**Kiambu Mbuni**	kg	OTA (ppb)	OTA	% OTA
Black beans	7,3	0,6	3,5	**2,0**	14,62	0,7	Black B	6,2	**0,9**	5,49	0,4
Diseased beans	**18,0**	**1,2**	**146,0**	**73,6**	**1326,30**	**61,4**	Diseased	15,9	**11,5**	182,32	14,6
Faded beans							Faded	0,2			
Foxy beans	**1,6**	**727,0**	**241,9**	**484,4**	**768,32**	**35,6**	**Foxy beans**	**2,1**	**420,8**	**882,70**	**70,5**
Green W D B							Green W D B	1,8	**46,9**	84,35	6,7
Hulled ears	7,3	0,5	0,6	**0,5**	3,80	0,2	Hulled ears	7,1	**0,7**	5,27	0,4
Insect damage	1,2	21,4	0,9	**11,2**	13,85	0,6	Insect	1,2	**6,1**	7,47	0,6
Stinkers	0,3						Stinkers	0,3	**2,5**	0,80	0,1
Sound beans	64,4	0,9	0,2	**0,5**	32,46	1,5	Sound	65,2	**1,3**	84,43	6,7
Total	100,0				2159,35	**21,6**	Total	100,0		1252,83	**12,5**
Before storage							**After storage**				
Barikongo Mbuni		OTA (ppb)		mean	OTA	% OTA	**Barikongo Mbuni**	kg	OTA (ppb)	OTA	% OTA
Black beans	8,0	**2,2**	**0,3**	1,3	10,16	5,1	Black B	4,5	**1,6**	7,14	0,5
Diseased beans	**23,3**	**2,3**	**0,4**	**1,3**	**30,50**	**15,4**	**Diseased**	**14,6**	**82,0**	**1193,70**	**83,9**
Faded beans							Faded beans	0,1			
Foxy beans	**1,3**	**28,1**	**169,5**	**98,8**	**128,17**	**64,7**	Foxy b	2,2	**7,4**	16,49	1,2
Green W D B							Green W D B	2,0	**1,0**	2,02	0,1
Hulled ears	0,4	**1,7**	**0,6**	1,2	0,49	0,2	Hulled ears	3,1	**29,6**	91,81	6,5
Insect damage	1,1	**2,7**	**10,9**	6,8	7,37	3,7	Insect	0,5	**0,4**	0,20	0,0
Stinkers	0,4	**3,7**	**1,3**	2,5	0,92	0,5	Stinkers	0,1	**32,1**	4,31	0,3
Sound beans	65,5	**0,2**	**0,4**	0,3	20,53	10,4	Sound	72,8	**1,5**	106,60	7,5
Total	100,0				198,14	**2,0**	Total	100,0		1422,27	**14,2**