SORGHUM OR MAIZE IN WEST AFRICAN POULTRY RATIONS

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INTRODUCTION

Sorghum has frequently substituted for corn in feed rations in other regions of the world including the US depending on relative prices. In West Africa, however, feed and poultry producers rely on maize for the principal cereal in their rations. A common complaint about sorghum is that it has high tannin levels.

Tannins affect nutritional value of grain by binding proteins and therefore making digestion difficult. So tannin levels are especially important in starter rations for chicks. Tannin also impedes digestion for adolescent and adult animals. So prices would need to be lower than for maize to substitute.

Most of the feed mixers and poultry producers believe that tannin is still a limiting factor in substituting sorghum for maize in chicken rations. In contrast most sorghum breeders and food scientists assert that tannin is a historical problem and is no longer important in most traditional cultivars and especially not in new cultivars, which generally have been specifically selected for minimal or zero tannin levels.[1]

This bulletin will first address the tannin issue by reviewing actual and potential sorghum cultivars for tannin levels in four countries, Burkina Faso, Mali, Niger and Senegal. In each country samples of the main sorghum cultivars used by farmers have been collected along with improved varieties soon to be released. These samples were analyzed for tannin content by in country and Texas A&M labs. The results are presented here.

The feed sector is an important secondary market for cereal producers. But for a secondary market to function the prices in the primary market (food for sorghum) must fall. The second section of the paper will discuss how technological change in sorghum production can reduce the per unit cost of sorghum grain and thereby enable lower sorghum prices with farmers still making money.

Even without a tannin problem the feed efficiency of sorghum is lower than that of maize but only slightly so. Therefore, besides the tannin levels, the bulletin will systematically review the relative prices over time and between regions of sorghum and maize to identify when and where there is an economic incentive to substitute sorghum for maize in poultry rations.

When sorghum is too high priced to be used as a feed, it is generally because it is being extensively used in its primary market as a food. Programs to increase productivity and thereby reduce production costs to make sorghum more competitive as a feed, will also make sorghum cheaper as a food. Hence, concern with sorghum secondary market will also have nutritional benefits for people.

The final section will draw some implications and policy recommendations for sorghum grain in both the food and feed markets.

[1] Only 1% of US cultivars contain tannins (LRooney et al.,, 2005)

I. TANNIN ANALYSIS

Sorghum samples were collected in each of the four countries with the collaboration of national agricultural research system breeders. In each country samples include improved and traditional varieties most frequently used by farmers.

For each sample a bleach test was first conducted. The bleach test shows the presence of tannins. For those cultivars with a positive bleach test a Vanillin-HCL test was conducted to quantify tannin content for the sample.[2] Following the tests varieties were classified as tannin-type or not. Tannin content was measured in percent of CE (Catechin Equivalent).

The results indicate that tannins are still present in sorghum in the four countries even though the situation varies widely among them. The next section will review each country results in detail. In all four countries the principal present use of sorghum is for human food though in Burkina Faso traditional beer brewed with sorghum is an important use.

a. *Burkina Faso*

In Burkina Faso a total of 28 samples were analyzed both by the food science lab of IRSAT and in Texas A&M. Results of the bleach tests indicate that four samples definitely contain tannin. The results also show an additional 5 characterized as mixed with some kernels having pigmented testas (Table 1). All samples identified in the bleach test were subjected to the more comprehensive level of tannin testing for quantity levels.

Table 1: Bleach test results for sorghum varieties from Burkina Faso

Varieties	**Source**	**Tannin Bleach Texas A&M %**	**Tannin Bleach –IRSAT %**
1. Traditional Varieties			
Local de Loropeni	Poni	No	No
Local de Arbinda*	Soum	mixed	No
Local de Boromo	Bale	No	No
Local de Sebba	Yagha	No	No
Local Rouge Mouhoun	Mouhoun	No	No
Locale de Toussiana	Houet	No	No
Locale du Kenedougou	Kenedougou	No	No
Locale de Pô	Nahouri	**Yes**	**Yes**
Locale de Boulgou	Boaganda	**Yes**	**Yes**
Locale de Sissili	Léo	No	No
Sorgho local Blanc*	Bobo Dioulasso Market	mixed	No
Locale du Comoé	Comoé	No	No
Sokoroni	Houet	**Yes**	**Yes**
Rakis-saaga	Gourcy	No	No

[2] Only the IRSAT food laboratory in Burkina Faso and the INRAN food laboratory in Niger were able to do the Vanillin test. Both Senegal and Mali did not have the chemicals needed for the test and were unable to do the vanillin test in the time frame allowed for this study.

Sorgho local Rouge	Bobo Dioulasso Market	**Yes**	**Yes**
Locale de Boromo	Bale	No	No
Locale du Tuy	Poni	No	No
Mitindade	Houet	No	No
Sindo	Houet	No	No
2. Improved Varieties			
Ouédzouré	INERA	No	No
Gnofing	INERA	No	No
CE 90 X Nagawhite	INERA	No	No
ICSN 1002 X Nagawhite*	INERA	Mixed	mixed
Ouédzouré X 38-3	INERA	mixed	**No**
84 W 966 X Ouédzouré	INERA	No	No
S29*	INERA	mixed	No
SARIASO-07	INERA	No	No
SARIASO-08*	INERA	No	**No**

(*). These samples were characterized as mixed by the Texas A&M lab. Defined as the having kernals in the sample with a pigmeted testa. In taking on farm samples there is always the problem of mixing or blending of several cultivars.

The vanillin HCL test results confirmed the existence of tannin in the suspected samples. However, in some cases the levels are almost insignificant. For example, one cultivar (local de Arbinda) that was suspected from the bleach test has a tannin content level of only 0.03% (Table 2). For commercial purposes, a tannin level of up to 0.4% is not considered a problem (CIRAD, 2004). Using the cut-off point of 0.4% 6 of the 28 samples, tested in this study, have significant levels of tannin. The tannin varieties include four traditional ones and two improved ones. This corresponds to a tannin prevalence level of 21% for the samples from Burkina. The tannin varieties are mainly red sorghums used for local beer.

Table 2: Vanillin test results for sorghum varieties from Burkina Faso

Varieties	**Source**	**Texas Tannin Vanillin % of CE**	**IRSAT Tannin Vanillin % of CE**
1. Traditional Varieties			
Local de Loropeni	Poni	No	No
Local de Arbinda*	Soum	**0.03**	**NT**
Local de Boromo	Bale	No	No
Local de Sebba	Yagha	No	No
Local Rouge Mouhoun	Mouhoun	No	No
Locale de Toussiana	Houet	No	No
Locale du Kenedougou	Kenedougou	No	No
Locale de Pô	Nahouri	**2.67**	**1.40**
Locale de Boulgou	Boaganda	**1.37**	**0.55**
Locale de Sissili	Léo	No	No
Sorgho local Blanc*	Bobo Dioulasso Market	**0.04**	No
Locale du Comoé	Comoé	No	No
Sokoroni	Houet	**0.98**	**0.61**
Rakis-saaga	Gourcy	No	No
Sorgho local Rouge	Bobo Dioulasso Market	**0.96**	**0.40**
Locale de Boromo	Bale	No	No

Locale du Tuy	Poni	No	No
Mitindade	Houet	No	No
Sindo	Houet	No	No
2. Improved Varieties			
Ouédzouré	INERA	No	No
Gnofing	INERA	No	No
CE 90 X Nagawhite	INERA	No	No
ICSN 1002 X Nagawhite*	INERA	**0.63**	**NT**
Ouédzouré X 38-3	INERA	**0.52**	**NT**
84 W 966 X Ouédzouré	INERA	No	No
S29*	INERA	**0.028**	**NT**
SARIASO-07	INERA	No	No
SARIASO-08*	INERA	**0.005**	**NT**

NT = Was not tested.

b. Mali

Sorghum samples were collected from the Bamako area, the Sikasso-Koutiala area, and the Segou area. Bleach tests have indicated only one positive tannin reading by the Texas lab and two positive readings for the LTA/IER lab. Both labs have, however, found six and 13 more mixed cultivars (Table 3).

Table 3: Bleach test results for sorghum varieties from Mali

Varieties	**Source**	**Tannin Bleach Texas A&M %**	**Tannin Bleach – LTA/IER**
1. Traditional Varieties			
Dereni	Koulikoro	mixed	mixed
Malisor	Koulikoro	No	No
Bandoka	Koulikoro	No	No
Bibawili	Koulikoro	mixed	mixed
Jacumbe(CSM63E)	Koulikoro	No	No
Seguetana	Koulikoro	**Yes**	**Yes**
Sotubaka	Sikasso	No	Mixed
Sampli Diema	Sikasso	Mixed	Mixed
Magnozangho	Sikasso	mixed	mixed
Kalagneni	Koutiala	No	**Yes**
Flakeba	Koutiala	mixed	Mixed
Nianiwere-ba	Sikasso	No	mixed
Nougoudjan	Segou	No	No
2. Improved Varieties			
CSM-219	IER	No	Mixed
CSM-417*	IER	mixed	Mixed
98-SB-F2-78	IER	No	Mixed
97-SB-F5DT-154	IER	No	Mixed
97-SB-F5DT-150	IER	No	mixed
00-KO-F5-DT-19	IER	No	No

WASSA	IER	No	No
ZARRA	IER	No	No
KENIKEDJE	IER	No	No
SEGUIFA	IER	No	mixed

(*) mixed sample See the discussion in table 1 table notes.

Using the Vanillin test to quantify tannin levels, none of the Malian varieties has shown any significant level of tannin based on our 0.4% cut-off level (Table 4). The local variety "Seguetana" collected in the Koulikoro region has the highest tannin content for all the varieties from Mali at 0.28%.This was a surprising result given the widespread talk of the tannin problem in the Sahelian countries among feed mixers and intensive poultry producers.

Table 4: Vanillin test results for sorghum varieties from Mali

Varieties	**Source**	**Texas Tannin Vanillin % of CE**
1. Traditional Varieties		
Dereni	Koulikoro	**0.007**
Malisor	Koulikoro	0
Bandoka	Koulikoro	0
Bibawili	Koulikoro	0
Jacumbe(CSM63E)	Koulikoro	0
Seguetana	Koulikoro	**0.280**
Sotubaka	Sikasso	**0.005**
Samplir Diema	Sikasso	**0.12**
Magnozangho	Sikasso	**0.012**
Kalagneni	Koutiala	0
Flakeba	Koutiala	**0.020**
Nianiwere-ba	Sikasso	0
Nougoudjan	Segou	0
2. Improved Varieties		
CSM-219	IER	0
CSM-417*	IER	**0.003**
98-SB-F2-78	IER	0
97-SB-F5DT-154	IER	0
97-SB-F5DT-150	IER	0
00-KO-F5-DT-19	IER	0
WASSA	IER	0
ZARRA	IER	0
KENIKEDJE	IER	0
SEGUIFA	IER	0

In Mali, tannin in sorghum is no longer a problem. None of the 21 varieties tested indicate tannin level of even 0.3 %. This appears to be mainly a result of farmers' efforts to eliminate tannins. For the local varieties, over time farmers have selected for whiter sorghum for their dishes and have eliminated the tannins as a result. The national breeding program has also included tannin elimination as an objective for new sorghum cultivars.

c. Niger

Seven local varieties tested positive for tannin and there was mixed case in the Texas laboratory (Table 5). The INRAN laboratory indicated two tannin and eight mixed cases.

Table 5: Bleach test results for sorghum varieties from Niger

Varieties	**Source**	**Tannin Bleach Texas A&M %**	**Tannin Bleach – LTA/INRAN %**
1. Traditional Varieties			
Fara-Fara	Maradi Market	No	No
El Gandou Ja	Maradi Market	No	No
Mouri	Maradi Market	No	No
Baba dia Fara	FAHL	No	No
Labé-Labé	Tarna	No	No
Fara Dawa	Sarkin Bindingua	No	No
Jadawa	Sarkin Bindingua	No	Mixed
Balbéla	Sarkin Bindingua	**Yes**	mixed
El Bala Kalto	Sarkin Bindingua	No	No
Booza	Kountarou	No	mixed
Ajé Bitchi	Kountarou	No	No
Kierma	Kountarou	No	No
El INRAN	Kountarou	No	No
El Mailafia	Aderawa	No	No
El Bazanga	Aderawa	No	No
Makafo Dawayo	Aderawa	No	No
Kaoura	Aderawa	mixed	**Yes**
El Mori	Aderawa	No	No
El Rourouka	Maraka	No	No
El Illa Yallo	Maraka	No	No
Bourgoundou	Maraka	No	No
El Kimba	Maraka	No	No
El Sebom	Maraka	No	No
Bahou Banza	Maraka	No	No
Matché Da Koumgna	Konni	No	No
El Garewa	Konni Market	No	No
Ta Kambo	Tchierassa Mangou	**Yes**	Mixed
El Rajab	Dagarka	**Yes**	**Yes**
Jan Jaré	Dagarka	**Yes**	mixed
Mallé	Dagarka	No	No
Korbiya	Dagarka (from Nigeria)	**Yes**	Mixed
El Tsedaou blanc/rouge	Dagarka	**Yes**	Mixed
El Zahi	Kakou	**Yes**	mixed

2. Improved Varieties			
F1- 223	INRAN	No	No
90SN-7	INRAN	No	No
Sepon 82	INRAN	No	No
NAD 1	INRAN	No	No
L153-5	INRAN	No	No
IRAT 204	INRAN	No	No
SSD-35	INRAN	No	No
L28	INRAN	No	No

Mixed refers to a combination of cultivars with one or more with pigmented testas. See further discussion in Table notes to Table 1.

The vanillin test for the Niger sorghum varieties indicated that seven sorghum varieties of the 42 samples evaluated have high tannin levels and another was close to the cutoff point of 0.4 (Table 6).

Table 6: Vanillin test results for sorghum varieties from Niger

Varieties	**Source**	**Texas Tannin Vanillin % of CE**
1. Traditional Varieties		
Fara-Fara	Maradi Market	No
El Gandou Ja	Maradi Market	No
Mouri	Maradi Market	No
Baba dia Fara	FAHL	No
Labé-Labé	Tarna	No
Fara Dawa	Sarkin Bindingua	No
Jadawa	Sarkin Bindingua	0.05
Balbéla	Sarkin Bindingua	**1.85**
El Bala Kalto	Sarkin Bindingua	No
Booza	Kountarou	0.26
Ajé Bitchi	Kountarou	No
Kierma	Kountarou	No
El INRAN	Kountarou	No
El Mailafia	Aderawa	No
El Bazanga	Aderawa	No
Makafo Dawayo	Aderawa	No
Kaoura	Aderawa	**1.41**
El Mori	Aderawa	No
El Rourouka	Maraka	No
El Illa Yallo	Maraka	No
Bourgoundou	Maraka	0.01
El Kimba	Maraka	No
El Sebom	Maraka	No
Bahou Banza	Maraka	No
Matché Da Koumgna	Konni	No
El Garewa	Konni Market	No
Ta Kambo	Tchierassa Mangou	**0.92**
El Rajab	Dagarka	**0.98**
Jan Jaré	Dagarka	**1.26**
Mallé	Dagarka	No
Korbiya	Dagarka (from Nigeria)	**1.09**

El Tsedaou blanc/rouge	Dagarka	0.37
El Zahi	Kakou	**0.52**
2. Improved Varieties		
F1- 223	INRAN	No
90SN-7	INRAN	No
Sepon 82	INRAN	No
NAD 1	INRAN	No
L153-5	INRAN	No
IRAT 204	INRAN	No
SSD-35	INRAN	No
L28	INRAN	No

So tannin is still a problem among the cultivars in the field but there are also a wide range of tannin free choices. All the improved sorghum varieties were classified tannin free.

d. Senegal

In Senegal most samples tested positive for tannin content. Only five of the 21 varieties evaluated were classified as non-tannin type by the Texas lab. Two and five were classified as mixed by the Texas and ITA labs respectively.

Table 7: Bleach test results for sorghum varieties from Senegal

Varieties	**Source**	**Tannin Bleach Texas A&M %**	**Tannin Bleach –ITA %**
1. Traditional Varieties			
Bassi	Thiès	**Yes**	**Yes**
Bassi Mbodiene	Thiès	No	No
Tigne	Sebba Market	No	No
Local Tigne	Birkilane Guer	**Yes**	**Yes**
Sorgho (CE 180 – 33)	Ndiobène tallène	**Yes**	**Yes**
Congossane	Kaolack	**Yes**	**Yes**
Bassi	SERAS-SOTIBA Market	**Yes**	**Yes**
Bassi	Tchiaroye Market	**Yes**	Mixed
Fela	Birkelane Korki	**Yes**	Mixed
Tige longue	Diobène tallène	**Yes**	mixed
Local de Birkilane Korki	Birkilane Korki	mixed	No
Dianah Bei	Kolda	**Yes**	mixed
Sorgho CE 14566	Paoskoto Ndemene	**Yes**	**Yes**
Local de Joal	Thiès	**Yes**	mixed
Mbodiène de Joal	Thiès	mixed	No
Local de Birkilane Guer	Birkilane Guer	**Yes**	**Yes**
2. Improved Varieties			
CE 180-33	Kaolack	**Yes**	**Yes**
CE 145-66	Thiès	**Yes**	**Yes**
CE 151-262	ISRA	No	No

CE 196-7-2	ISRA	No	No
F2-20	ISRA	No	No

The vanillin test confirmed the initial finding that most sorghum varieties in Senegal contain tannin. Nine local cultivars had high tannin levels. Another four had levels very close to the cutoff point. Only three local cultivars had negligible or zero tannin levels. Even two of the five improved varieties had high tannin levels.

Table 8: Vanillin test results for sorghum varieties from Senegal

Varieties	**Source**	**Texas Tannin Vanillin % of CE**
1. Traditional Varieties		
Bassi	Thiès	**1.17**
Bassi Mbodiene	Thiès	0
Tigne	Sebba Market	0.08
Local Tigne	Birkilane Guer	**0.73**
Sorgho (CE 180 – 33)	Ndiobène tallène	**0.72**
Congossane	Kaolack	0.34
Bassi	SERAS-SOTIBA Market	**1.35**
Bassi	Tchiaroye Market	**0.46**
Fela	Birkelane Korki	**1.15**
Tige longue	Diobène tallène	0.39
Local de Birkilane Korki	Birkilane Korki	0.35
Dianah Bei	Kolda	**1.22**
Sorgho (CE 14566)	Paoskoto Ndemene	**1.77**
Local de Joal	Thiès	0.40
Mbodiène de Joal	Thiès	0.09
Local de Birkilane Guer	Birkilane Guer	**0.73**
2. Improved Varieties		
CE 180-33	Kaolack	**0.77**
CE 145-66	Thiès	**0.935**
CE 151-262	ISRA	0.025
CE 196-7-2	ISRA	0.005
F2-20	ISRA	0

With 11 out of the 21 samples from Senegal being high tannin varieties, the tannin prevalence in the sample collected in Senegal is 56%. This is the highest of the four countries.

Tannin free and low tannin varieties (Bassi Mbodiene and Modiène de Joal) are found in the Joal area (Thiès region). In this region sorghum is the principal staple for human

consumption.[3] Three improved varieties from ISRA are also tannin free or have marginal tannin levels. This country has the highest potential for sorghum use for poultry feed yet it is in Senegal that the most tannin was found among both the cultivars in the field and the new cultivars being introduced. Given the importance of the poultry industry more effort needs to be put into developing tannin free sorghum cultivars for Senegal. Otherwise feed mixers and poultry producers will increase their reliance on sorghum importation from Mali and international imports of maize.

II. POTENTIAL FOR SORGHUM IN THE FUTURE

a. Technological change and sorghum prices

The principal effect of technological change in sorghum (new cultivars, inorganic fertilizers and water retention techniques) is to decrease per unit production cost. All over the world important technological gains have been made with maize. This has resulted in lower per unit production cost for maize and often cheaper maize compared to sorghum. With a lag behind maize, sorghum productivity has been systematically increased in developed and many developing countries. From the late 50's to the mid 70's sorghum yields were tripled in the US (Miller and Kebede, 1987, p. 7). The social benefits are also higher for a Sahelian country such as Mali from accelerating technological change in sorghum rather than maize as there is a wider effect among low income farmers and a catching up advantage similar to the above experience in the US (Vitale and Sanders, 2005).

In the Sahel sorghum productivity gains have lagged behind those of maize and a catching up phase is now in progress.[4] The gap between farm yields and experiment station yields is presently smaller for maize than for sorghum in Mali (Vitale and Sanders 2005). Most existing sorghum improved varieties when combined with inorganic fertilizer application and good agronomic practices have yields of 2 to 3 metric tons per hectare on the research station. Current farm level yields in the Sahel range from 0.5 to 1.2 tons per ha. Once this yield gap between the research station and farmers' fields is closed, sorghum will have a much lower per unit cost and can sell for less with farmers still making money. Then sorghum will be even more competitive with maize as a feed.

In Niger[5] there are limited maize production areas. Production expansion potentials for Niger is mainly in millet and sorghum. There is also substantial potential for expansion of sorghum in Mali, Senegal and Burkina Faso, both outside and in the cotton-maize zones. With increased productivity sorghum production will be more competitive compared to the imported maize.

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[3] The low levels in the table above generally indicate a mixed sample from the field. See the footnote to Table 1.

[4] Extension efforts geared toward making sure that increasing sorghum productivity is profitable are now underway in three countries of the Sahel in this Marketing –Processing project.

[5] Even in the high rainfall areas of Niger, maize yields are very poor compared to other countries.

b. *Primary and secondary markets*

For agricultural commodities, the primary market is supplied first. In the case of sorghum the primary market is for food. In most of the Sahel millet is preferred over sorghum, when it is available. When there is insufficient millet, people eat sorghum.
The primary market for sorghum grain is food[6] for much of the Sahelian region. The feed market is a secondary market for sorghum grain. Once the farmers have satisfied the food market with sorghum grain, they can sell to poultry feed mixers at a lower price. Feed mixers would prefer contracts but these contracts would be violated by farmers when they can still sell sorghum for food at relatively high prices in the primary market.[7]

Once a primary market is saturated, prices will collapse unless there is a secondary market for the commodity. For example, tomato producers sell to the fresh tomato market first. However, this market is often relatively thin and is quickly saturated. If a tomato processing industry exists in the country, the ketchup or canned tomato factory can buy the tomatoes at a much reduced price once the primary market is saturated. The processing industry then puts a floor price on the tomatoes and this reduces the risk for tomato producers and increases their expected earnings.

Farmers should understand that many feed mixers will be willing to pay prices almost as high as what it will cost them to substitute for maize. For non-tannin sorghum well informed feed mixers should be willing to pay up to 97% of maize price for sorghum grain. For tannin sorghum they can offer up to 87% of maize value. These percentages are the relative feed efficiencies of sorghum with respect to maize for the non-tannin and tannin sorghums (Hancock, 2004)

Feed mixers also will have to recognize that they represent only a secondary market and that farmers will go after the primary market first. In adverse weather years when sorghum has a high price due to low production, farmers will not have enough grain to saturate the primary market and therefore the secondary market will not be supplied with domestic sorghum.[8]. In these years feed mixers will need to import cereals or use local maize.

III. THE CHOICE BETWEEN MAIZE AND SORGHUM

Whenever the relative price of non-tannin sorghum to maize is below this 97%, there is an economic advantage to using non-tannin sorghums and there is no loss in feeding efficiency. When the price is above this ratio, feed mixers and poultry producers would

[6] Beer is also an important product of the red sorghums in Burkina Faso.
[7] There is little tradition of contract law or social pressure to fulfill contracts in the Sahel. This is true for both the farmers and the processors.

[8] Demand for poultry will decline in such years as incomes decline.

prefer maize. Sorghum and maize prices were collected from national market information systems in all four countries.[9] Market retail prices for the capital city in each country were utilized here as the intensive poultry feeding is concentrated in the major urban areas. However, in particular regions the local assembly and transportation costs might shift the relative price ratios to favor sorghum (or maize).

a. Burkina Faso

For the red sorghum in Burkina Faso (most of which has tannin), the primary market is the local beer market. Price data in Burkina Faso distinguish between red and white sorghums.[10] Our analysis is based on white sorghum used here as a proxy for tannin free sorghum.

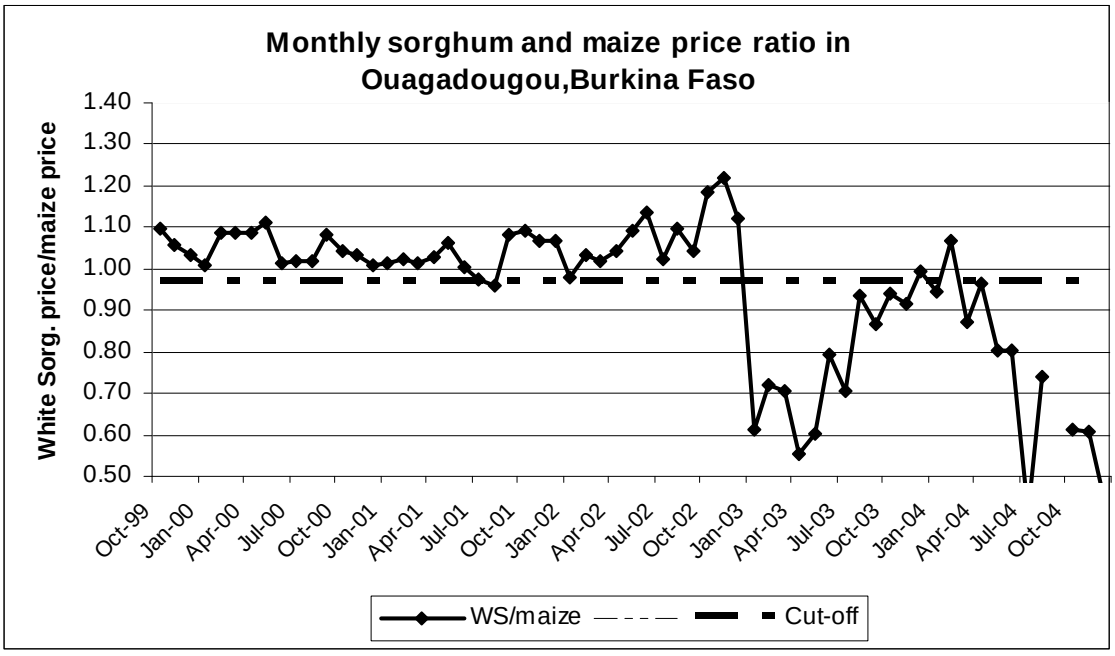

Figure 1: Monthly sorghum and Maize price ratios, Ouagadougou 1999-2004

The Burkina price data show two periods. From October 1999 to September 2002, there was clearly no advantage to using sorghum for poultry feed in Burkina Faso even if it was tannin free[11]. It was more economical to buy maize during that period but only slightly so (Figure 1) hence regional differences in asmbly or transportation costs could have shifted the advantage of maize. Since October 2002, however, sorghum prices have

[9] SIMA in Niger, SIM in Burkina Faso and CSA in Senegal provided price data free of charge. In Mali price data was purchased from CSA.

[10] In Burkina Faso, we use an average price from the three markets in Ouagadougou (Gounghin, Sankaryaré and Paygri). The maize price used is an average of the white and yellow maize in the same Ouagadougou markets. Other countries reported only one sorghum price.

[11] The same analysis holds for red sorghum also.

begun to decline passing below the cut-off line in about January 2003 (Figure 4). Then sorghum would give a big saving substituting for maize as the main cereal component of feed.

In the last two cropping seasons (2002-03 and 2003-04), the data clearly shows that there was an advantage to using sorghum in the poultry rations of Burkina Faso (Figure 1). This is due in part to good sorghum production in Burkina Faso and also to the difficulty of importing maize due to the civil war in Cote d'Ivoire.

b. Mali

In Mali over the five year period , maize was always more profitable than sorghum for the poultry feed mix, as the sorghum maize price ratio is all the time above the cut-off line (Figure 2). However, most of the time from fall of 1999 until fall of 2002 there was essentially no difference in price of the two cereals except for occasional price spikes for sorghum for food use in the hungy season before harvest. So transactions cost differences could easily shift the choice of cereals during this period.

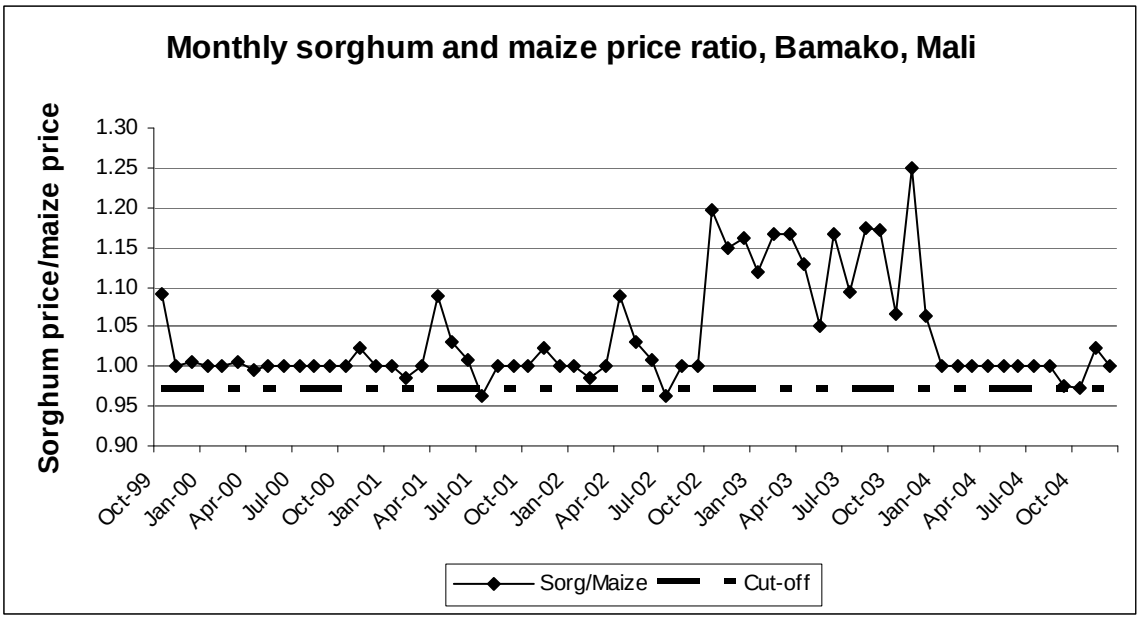

Figure 2: Monthly sorghum and Maize price ratios, Bamako 1999-2004

In the 2003-04 sorghum prices went very high after the bad rainfall in the summer of 2003. So the use of sorghum in the primary market was very important. Of the four countries, Mali is the biggest maize producer and also a neighbor of Guinea and Côte d'Ivoire, which are also among the biggest maize producers in West Africa. Yield gains in sorghum will be necessary to increase its competitiveness here in the face of this competition with imported maize.

c. *Niger*

For Niamey we used the average sorghum and maize prices for the four main cereal retail markets of the City (Petit Marché, Katako, Complexe and Harobanda). Early in 2000 there was an advantage to sorghum but after that the high price ratio apparently reflects the continuing high demand for sorghum in the primary market as a food (Figure 3). Also after 2000 there have been large maize imports into Niger from Benin and Nigeria.

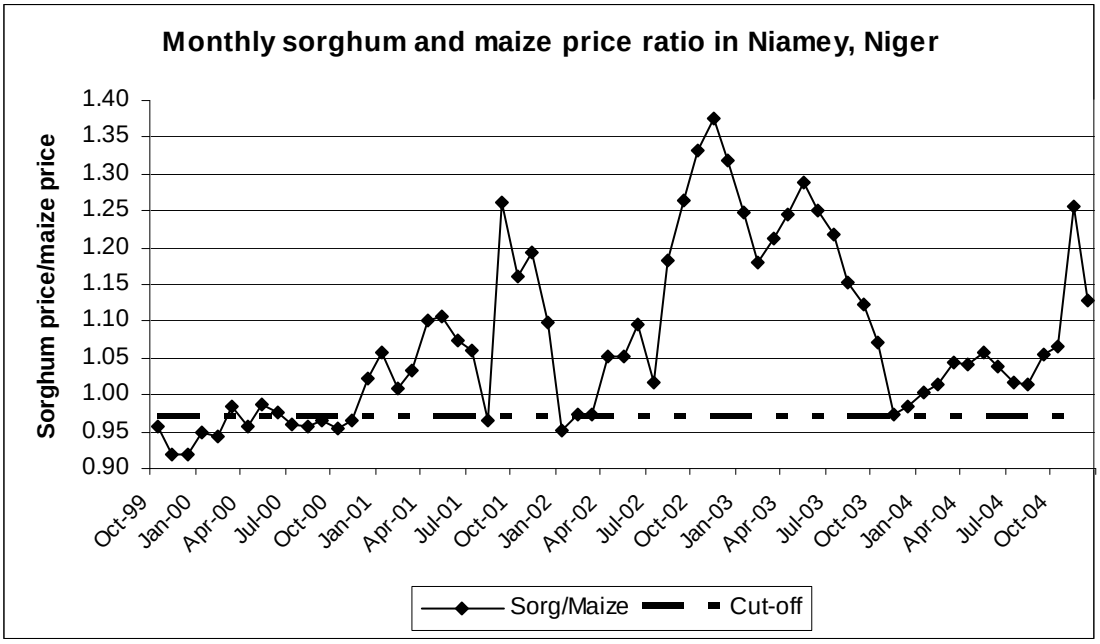

Figure 3: Monthly sorghum and Maize price ratios, Niamey 1999-2004

d. Senegal

The average prices of two markets in Dakar (Tilene and Thiaroye) are used for the analysis of the Senegal price data.

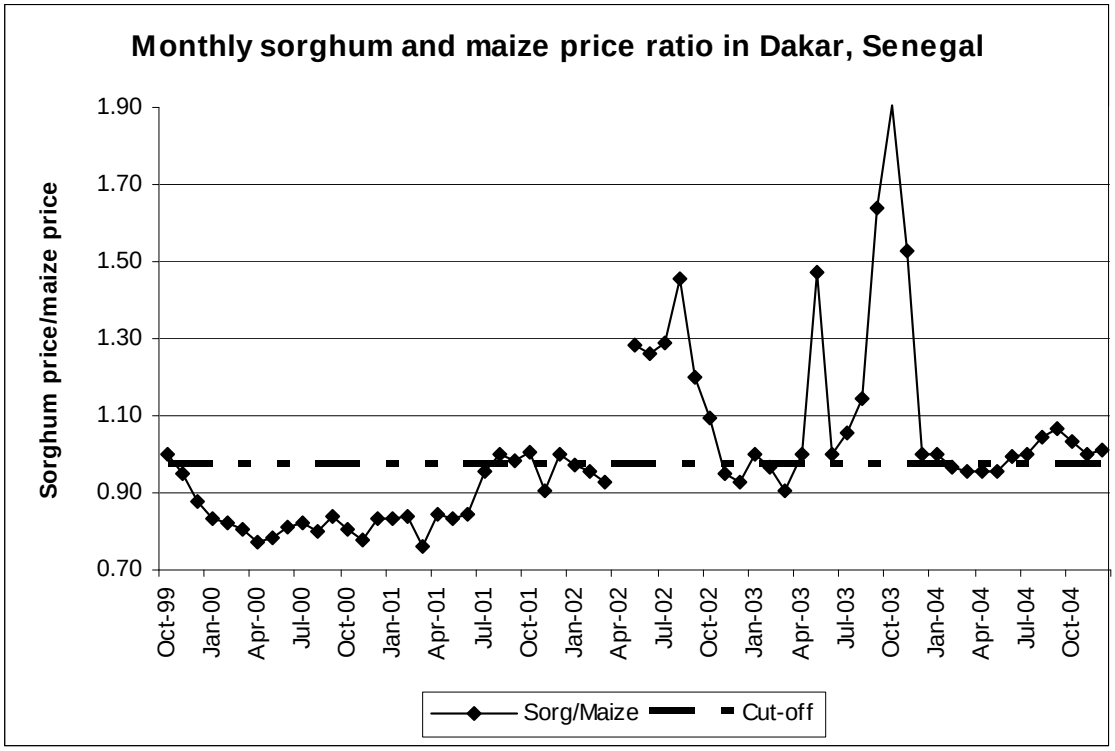

Figure 4: Monthly sorghum-maize price ratios, Dakar 1999-2004

In Senegal, before March 2002, there was a clear advantage for using tannin free[12] sorghum in poultry feed (Figure 4). As in Niger the last few years of poor production conditions have made the use of sorghum for food more important. There was also a government program to increase the production of maize in 2004. The price differences were minimal in 2004 and three of the big feed mixer-intensive poultry producers bought large quantities of sorghum in 2004. l

CONCLUSIONS

We were surprised by the extent of tannin still in the cultivars in the field especially in Burkina Faso and Senegal. In Burkina the beer use is an important explanation. In Senegal the lack of breeding emphasis historically on sorghum appears to be a principal factor and needs to be changed to facilitate the evolution of the poultry industry there. In all the countries zero tannin cultivars can be identified for contracts between farmers' associations and feed mixers and large intensive poultry producers.

Both farmers' associations and sorghum buyers for feed need to keep the distinction between primary and secondary markets clear. When there are shortages of millet/sorghum, there will be high prices for sorghum and little potential to use sorghum as a feed. For rapid introduction of sorghum as a feed technological change is necessary with the consequent falling prices. This technological change process has already occurred with maize. Accelerating the introduction of new sorghum and millet

[12] The figure shows that the prices became low enough to substitute the tannin sorghums for maize.

technologies is one principal focus of the Marketing-Processing project. But in adverse weather years buyers should continue to expect to use domestic maize or import their cereal for feed use as sorghum shifts over into the primary market for food. Gains to sorghum productivity for feed will also have important positive consequences for human nutrition especially in adverse rainfall years.

There have been large scale maize imports into the Sahel from the coastal countries. Due to the higher rainfall with consequent drying and storage problems combined with processors' attempts to buy the cheapest maize, there have been many reports of aflatoxin in this maize. In the next stage of this fieldwork we will be investigating the extent of this aflatoxin problem.

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