AFRICAN GRAIN TRADE SUMMIT

RESILIENT GRAIN MARKETS: UNLOCKING AFRICA'S FOOD SECURITY POTENTIAL

2ND-4TH, OCTOBER 2025 | ZANZIBAR, TANZANIA

Main Session 3

Grain quality and food safety.

Harmonizing standards and combating aflatoxins for competitive trade

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African Regional Standards Organization (ARSO)

Session Sponsors: IITA Transforming African Agriculture | iGRAIN®

Grain Quality and Food Safety - Harmonizing Standards and Combating Aflatoxins for Competitive Trade

Resilient Grain Markets: Unlocking Africa's Food Security Potential

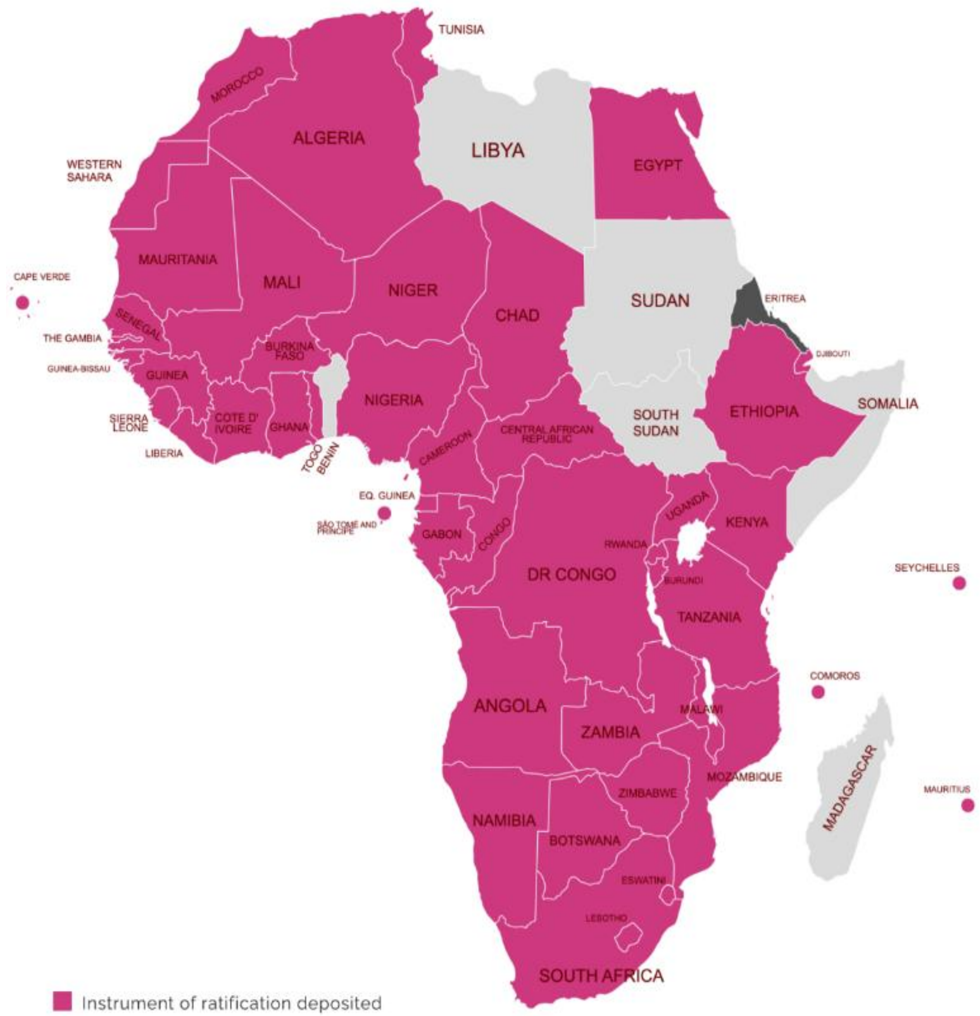
11th African Grain Trade Summit 2025

Zanzibar, Tanzania

2nd – 4th October, 2025

Reuben Gisore, Technical Director, ARSO

AfCFTA Agreement:



Instrument of ratification deposited
AfCFTA Agreement signed
AfCFTA Agreement not signed

Last updated: August 2024

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AfCFTA
54 Countries signed and
48 Ratification

Listed by date on which the AfCFTA instrument of ratification was deposited with the AUC Chairperson

Ghana	10-05-2018
Kenya	10-05-2018
Rwanda	26-05-2018
Niger	19-06-2018
Chad	02-07-2018
Eswatini	02-07-2018
Guinea	16-10-2018
Côte d'Ivoire	23-11-2018
Mali	01-02-2019
Namibia	01-02-2019
Uganda	09-02-2019
South Africa	10-02-2019
Congo, Rep.	10-02-2019
Djibouti	11-02-2019
Mauritania	11-02-2019
Senegal	02-04-2019
Togo	02-04-2019
Egypt	08-04-2019
Ethiopia	10-04-2019
Gambia	16-04-2019
Sahrawi Arab Democratic Rep.	30-04-2019
Sierra Leone	30-04-2019
Zimbabwe	24-05-2019
Burkina Faso	29-05-2019
São Tomé & Príncipe	27-06-2019
Equatorial Guinea	02-07-2019
Gabon	07-07-2019
Mauritius	07-10-2019
Central African Rep.	22-09-2020
Angola	04-11-2020
Lesotho	27-11-2020
Tunisia	27-11-2020
Cameroon	01-12-2020
Nigeria	05-12-2020
Malawi	15-01-2021
Zambia	05-02-2021
Algeria	23-06-2021
Burundi	26-08-2021
Seychelles	15-09.-2021
Tanzania	17-01-2022
Cape Verde	05-02-2022
Democratic Rep. of the Congo	23-02-2022
Morocco	20-04-2022
Guinea-Bissau	27-09-2022
Botswana	19-02-2023
Comoros	19-02-2023
Mozambique	05-07-2023
Liberia	31-07-2024

ARSO

44 Member States
11 Non-Member States
1 Observer Member

About ARSO

The African Organization for Standardization (ARSO) was established in 1977 by UNECA and OAU with the mandate to:

a. harmonize national and/or sub-regional standards as African Standards and issue necessary recommendations to member bodies for this purpose;

b. **promote and coordinate standardisation and conformity assessment practices in Africa;**

c. **operate a regional certification marking scheme with a view to certifying the quality of and promoting African products;**

d. encourage and facilitate the development by AU Member States of technical regulations to be based on African harmonised standards and/or international standards;

e. promote and facilitate exchange of experts, information and co-operation in training of personnel in standardisation activities;

f. create appropriate bodies in addition to the organs of the organization for the purposes of fulfilling its objectives.

Harmonization of Standards: Sectors

1) THC 01, *Basic and general standards*
2) THC 02, *Agriculture and food products*
3) THC 03, *Building and civil engineering*
4) THC 04, *Mechanical engineering and metallurgy*
5) THC 05, *Chemistry and chemical engineering*
6) THC 06, *Electrotechnology*
7) THC 07, *Leather and textile products*
8) THC 08, *Transport and communications*
9) THC 09, *Environmental management*
10) THC 10, *Energy and natural resources*
11) THC 11, *Management and quality*
12) THC 12, *Services*
13) THC 13, *Traditional and complimentary medicine*
14) THC 14, *Healthcare technology*
15) THC 15, *Household goods and services*
16) ARSO Conformity assessment committee
17) ARSO Consumer committee

100 Technical Bodies

(1) 92 Technical Committees (TCs)

(2) 5 Project Committees (PCs)

(3) 2 Specialized Working Groups (SWGs)

(4) 1 ARSO/AFSEC Joint Technical Committee 01, *Renewable energy*

- 291 Harmonized Standards approved in June 2025 (including revisions)
- Over 1500 active standards work items under consideration
- Plans to accelerate harmonization to cover 4,500 standards in next 5 years

Harmonization of Standards: Numbers

Technical Harmonization Sector	No. of standards published	Products (Goods)	Services	Tests, analysis, sampling	Codes, glossaries, units
THS 01, Basic and General Standards	145	65	5	28	47
THS 02, Agriculture and Food Products	629	318	60	137	124
ARSO/TC 12, *Cereals, pulses and derived pdts*	69	36	4	14	15
THS 03, Building and Civil Engineering	294	88	6	174	26
THS 04, Mechanical Engineering and Metallurgy	109	68	0	35	6
THS 05, Chemistry and Chemical Engineering	107	39	0	52	16
THS 06, Electrotechnology	60	30	0	7	23
THS 07, Leather and Textile Products	260	124	9	97	30
THS 08, Transport and Communications	161	106	23	20	12
THS 09, Environmental Management	59	31	2	7	19
THS 10, Energy and Natural Resources	0	0	0	0	0
THS 11, Quality Management	6	0	0	0	6
THS 12, Services	112	1	87	0	24
THS 13, Traditional and Complementary Medicine	20	14	0	1	5[2]
THS 14, Healthcare Technology	393	178	27	85	111
THS 15, Household Goods and Services	0	0	0	0	0
Conformity Assessment Committee	68	0	0	0	68
Consumer Committee	16	0	0	0	16
Specialized Working Groups	1	0	1	0	0
Total	2440	1062	220	643	528

AfCFTA tariff lines: 5129: Goods and services responding to tariff lines: 1,282
Percentage number of standards responding to tariff lines: 25%

Accelerating Harmonisation of Standards

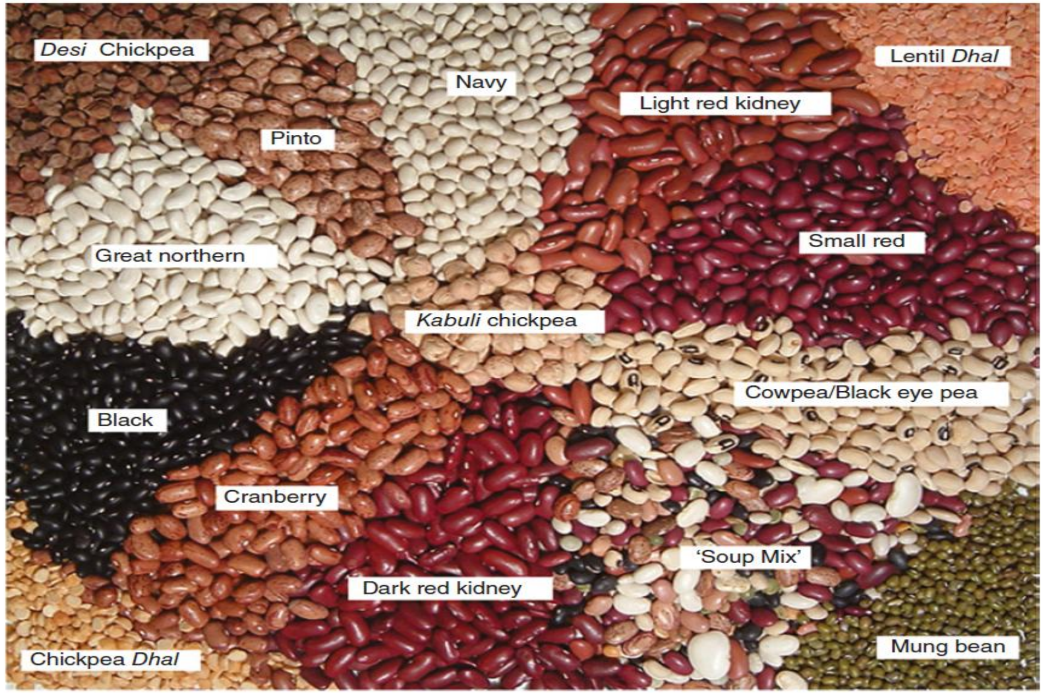
Project stage	Associated document	Timeframe (indigenous/REC) Max	Timeframe IS	Timeframe (Emergencies)
0: Preliminary stage	Preliminary Work Item (PWI)	Not applicable	Not applicable	Not applicable
1: Proposal stage	New Work Item Proposal (NWIP)	3 to 5 months (3 months for circulation and balloting and 2 months to review ballot results and approval by SMC)	1 Months	21 days
2: Preparatory stage	Working Draft (WD)	2 months	0	0
3: Committee stage	Committee Draft (CD)	6 months	0	15 days
4: Enquiry stage	Draft African Standard (DARS)	4 months (2 months' for public review) (2 months to resolve comments)	2 Months	30 days
5: Ballot stage	Final Draft African Standards (FDARS)	1 month	1	6 days
6: Approval stage	African Standards (ARS)	3 months	3 months	15 days
7: Publication stage	African Standards (ARS)	Immediately upon approval	Immediately upon approval	Immediately upon approval
Maximum duration		21 months	7 months	3 months

* 1 Month means 30 days

Global Production				Production in Africa		
Crop	Tonnes	%		Crop	Tonnes	%
Maize (Corn)	1,225,000,000	43.0		Maize (Corn)	94,000,000	43.0
Wheat	808,441,600	28.0		Rice (paddy)	41,000,000	19.0
Rice	756,000,000	26.0		Sorghum	28,000,000	13.0
Barley	157,000,000	5.5		Wheat	73,000,000	11.0
Sorghum	60,000,000	2.0		Millet	20,000,000	9
Oats	28,000,000	1.0				
Millet	28,000,000	1.0				
Rye	14,000,000	0.5				
Triticale	10,000,000	0.4				
Quinoa	4,000,000	0.1				
Buckwheat	2,235,193					
Fonio	587,270					

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: **Strategic Significance**

- Cereals, grains, beans and pulses were categorized as Strategic Food Commodities by the AU Abuja Food Security Summit of December 2006.
- Member Sates were urged to ratify and implement harmonized standards and grades including sanitary and phytosanitary standards within and across RECs.
- ARSO Constituted **ARSO/TC 12, *Cereals, pulses and derived products*** as a dedicated technical committee to harmonize standards for the direct farm produce, good agricultural practices, methods of test and sampling, storage and warehouse facilities, derived products
- Grading was incorporated in product standards



Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: What Do Standards Specify?

- ARS 461:2022, *Maize grains (corn) — Specification*
- **Scope:** This African Standard specifies the requirements and methods of sampling and test for maize grains (corn) of varieties grown from common maize *grains, Zea mays indentata* L., and/or *Zea mays indurata* L., or their hybrids intended for human consumption.

S/N	Characteristics	Limits			Method of test
		Grade 1	Grade 2	Grade 3	
(1)	Foreign matter, % m/m	0.5	1.0	1.5	ISO 605
(2)	Inorganic matter, % m/m	0.25	0.5	0.75	
(3)	Broken kernels, % m/m	2.0	4.0	6.0	
(4)	Pest damaged grains, % m/m	1.0	3.0	5.0	
(5)	Rotten & diseased grains, % m/m	2.0	4.0	5.0	
(6)	Discoloured grains, % m/m	0.5	1.0	1.5	
(7)	Moisture, % m/m	13.5	13.5	13.5	ISO 711/712
(8)	Immature/shrivelled grains, % m/m	1.0	2.0	3.0	ISO 605
(9)	Filth, % m/m	0.1	0	0.1	
(10)	Total Aflatoxins, ppb, max	10			ISO 16050
(11)	Aflatoxin B_1, ppb, max	5			
(12)	Fumonisin, ppm, max	2			AOAC Official Method 2001.04
(13)	Total [a] defectives grains, % m/m	4.0	7.0	8.5	ISO 605

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: What Do Standards Specify?: Contaminants

Table 2 — Metal contaminants

S/N	Parameter	Limit (ppm max)	Test method
(1)	Arsenic (As)	0.1	ISO 27085
(2)	Mercury (Hg)	0.1	ISO 6637
(3)	Lead (Pb)	1.0	ISO 6633 (AAS)
(4)	Cadmium (Cd)	0.1	ISO 6561-1 or 6561-2

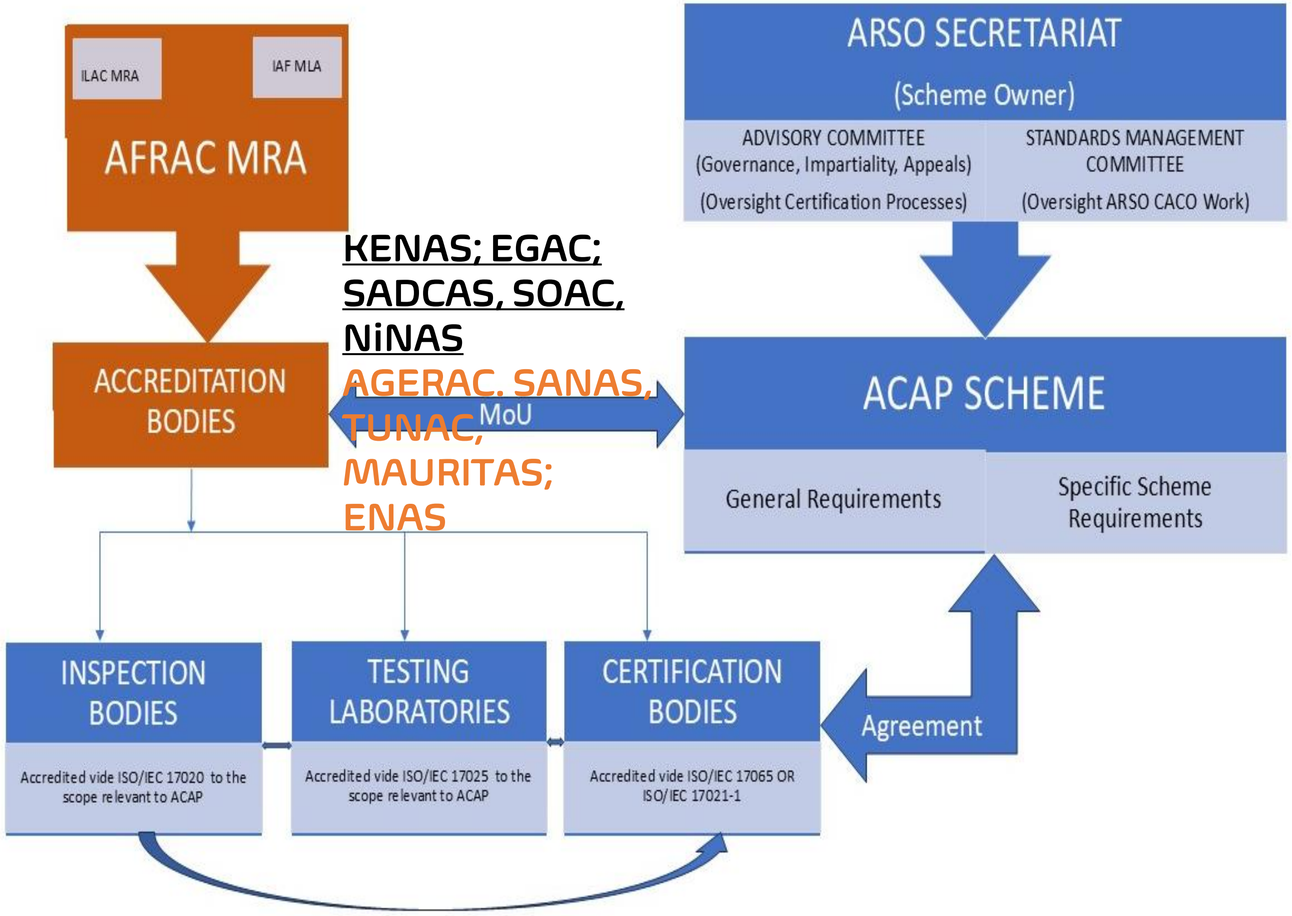
5.2 Pesticide residues

Maize grains shall comply with those maximum pesticide residue limits established by the Codex Alimentarius Commission for this commodity.

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: What Do Standards Specify?: Hygiene

Table 3 — Microbiological limits

S/n	Type of micro-organism	Limits	Test method
(1)	Yeasts and moulds, max. per g	10^5	ISO 21527-2
(2)	S. *aureus* cfu/ g max	10^3	ISO 6888
(3)	*E. coli*, per g	Absent	ISO 7251
(4)	Salmonella, per 25 g	Absent	ISO 6579



Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: What Do Standards Specify?: Marking / Labelling

8.1 In addition to the requirements in ARS 56, each package shall be legibly and indelibly marked with the following:

i) product name as “White Maize Grains, Yellow Maize Grains, Red Maize Grains or Mixed Maize Grains”;
ii) grade;
iii) name, address and physical location of the producer/ packer/importer;
iv) lot/batch/code number;
v) net weight, in kg;
vi) the declaration “Food for Human Consumption’’
vii) storage instruction as “Store in a cool dry place away from any contaminants’’;
viii) crop year;
ix) packing date;
x) instructions on disposal of used package;
xi) country of origin;
xii) a declaration on whether the maize was genetically modified where applicable.

8.2 Labelling of non-retail containers

Information for non-retail containers shall either be given on the container or in accompanying documents, except that the name of the product, lot identification and the name and address of the manufacturer or packer shall appear on the container. However, lot identification and the name and address of the manufacturer or packer may be replaced by an identification mark, provided that such a mark is clearly identifiable with the accompanying documents.

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: The Standards

(1) ARS 457:2024, *Barley grains — Specification*
(2) ARS 461:2022, *Maize grains (corn) — Specification*
(3) ARS 462:2022, *Sorghum grains — Specification*
(4) ARS 463:2022, *Pearl millet grains - Specification*
(5) ARS 464:2022, *Milled rice — Specification*
(6) ARS 465:2023, *Wheat — Specification*
(7) ARS 466:2022, *Milled maize products — Specification*
(8) ARS 468:2023 *Sorghum flour – Specification*
(9) ARS 469:2023 *Millet flour — Specification*
(10) ARS 470:2024, *Wheat flour — Specification*
(11) ARS 858:2022, *Rough (paddy) rice — Specification*
(12) ARS 857:2023, *Finger millet grains — Specification*
(13) ARS 859:2023, *Brown rice — Specification*
(14) ARS 864:2023, *Dry beans — Specification*
(15) ARS 865:2024, *Dry green grams — Specification*
(16) ARS 866:2024, *Dry chickpeas — Specification*

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: The Standards

(1) ARS 867:2023, *Dry cowpeas — Specification*

(2) ARS 868:2023, *Dry pigeon peas — Specification*

(3) ARS 869:2023, *Dry whole peas — Specification*

(4) ARS 870:2023, *Lentils — Specification*

(5) ARS 871:2023, *Dry split peas — Specification*

(6) ARS 872:2024, *Dry soybeans — Specification*

(7) ARS 873:2024, *Dry faba beans — Specification*

(8) ARS 874:2024, *Dry lima beans — Specification*

(9) ARS 935:2024, *Edible full fat soybean flour — Specification*

(10) ARS 939:2024 *Feed maize — Specification*

(11) ARS 1098:2024, *Agricultural structures — Warehouses for the storage of bagged cereals and pulses*

(12) ARS 1099:2024, *Good warehousing practice for bagged cereals and pulses*

(13) ARS 1101:2018(E), *Production and handling of maize (corn) grains — Good agricultural practices*

(14) ARS 1102:2018(E), *Production and handling of rice — Good agricultural practices*

(15) ARS 1348:2024, *Amaranth flour — Specification*

(16) ARS 1349:2024, *Amaranth grains — Specification*

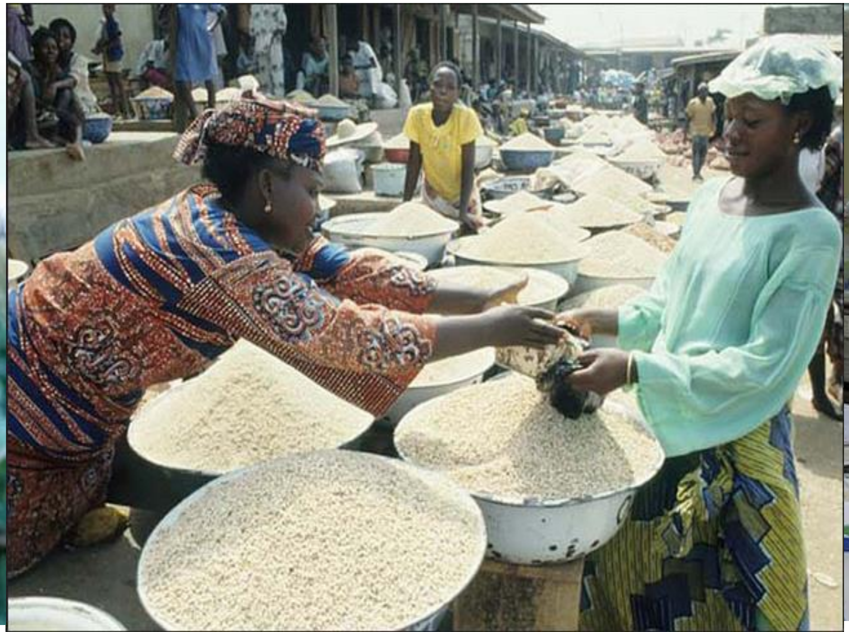
Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: The Standards

1. ARS 1350:2024, *Teff flour — Specification*
2. ARS 1351:2024, *Teff Grain — Specification*
3. ARS 1755:2024, *Breakfast cereals — Specification*
4. ARS 1756:2024, *Fonio grain — Specification*
5. ARS 1757:2024, *Fonio flour — Specification*
6. ISO 6322-1:1996(E), *Storage of cereals and pulses — Part 1: General recommendations for the keeping of cereals*
7. ISO 6322-2:2000(E), *Storage of cereals and pulses — Part 2: Practical recommendations*
8. ISO 6322-3:1989(E), *Storage of cereals and pulses — Part 3: Control of attack by pests*
9. ARS GAPM 19:2018(E), *Good agricultural practices outreach information for African standards on barley*
10. ARS GAPM 20:2018(E), *Good agricultural practices outreach information for African standards on wheat*
11. ARS GAPM 21:2018(E), *Good agriculture practices outreach information for African standards on maize and maize products*
12. ARS GAPM 22:2018(E), *Good agriculture practices outreach information for African standards on rice and rice products*
13. ARS GAPM 23:2018(E), *Good agriculture practices outreach information for African standards on millets and sorghum products*
14. ARS GAPM 24:2018(E), *Good agriculture practices outreach information for African standards on beans and pulses*
15. ARS CTM 1101:2018(E), *Good agricultural practices for maize*
16. ARS CTM 1102:2018(E), *Good agricultural practices for rice*

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: Combating Aflatoxins and Other Mycotoxins



Contamination of grains and other dry agricultural products by moulds may occur in the field, at harvest, and/or during transportation and storage.

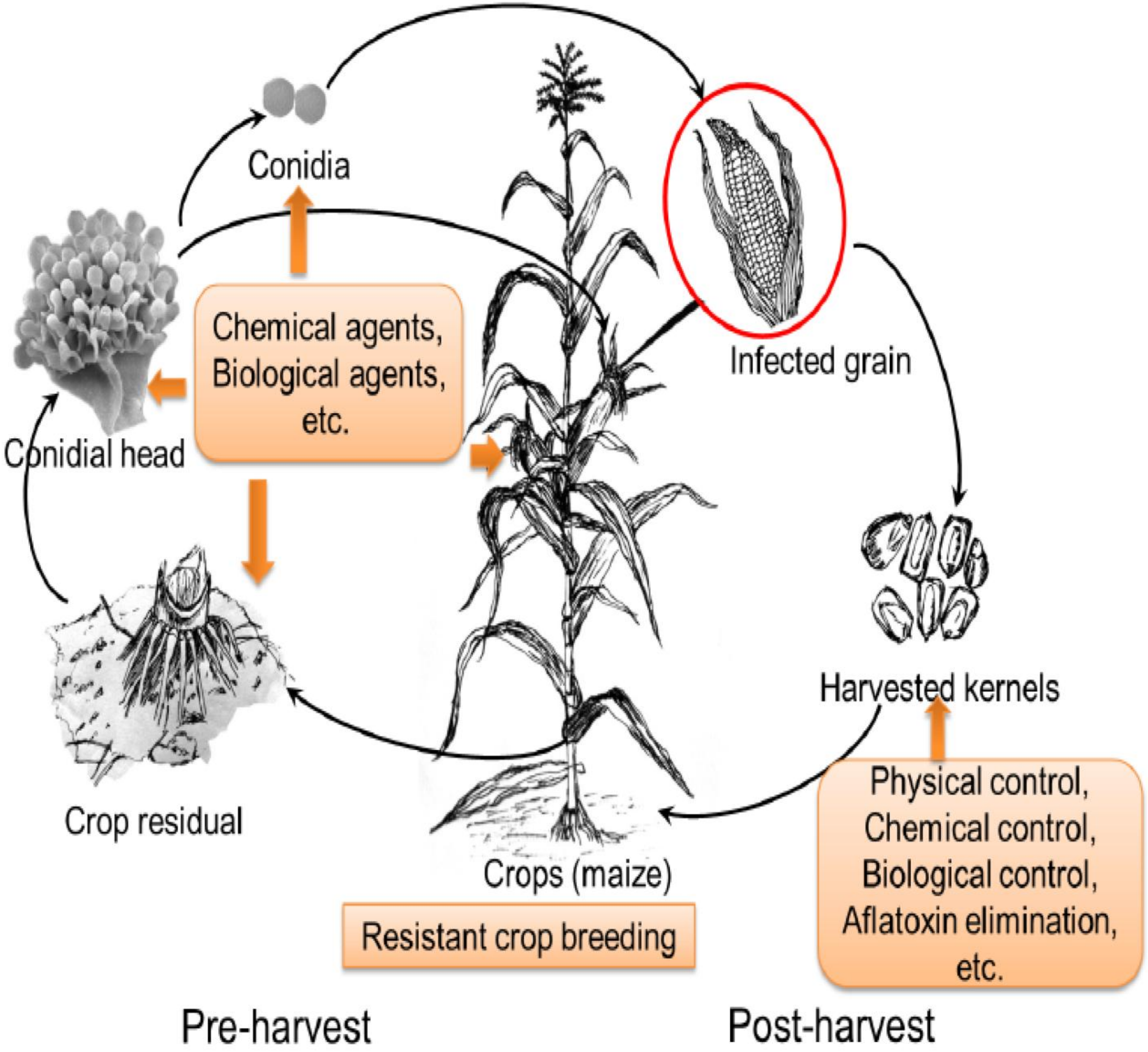

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: Combating Aflatoxins and Other Mycotoxins: Limits for Common Products

Product	Total aflatoxins (µg/kg)	Aflatoxin B1(µg/kg)	Fumonisins mg/kg)
ARS 457:2024, Barley grains	10	5	2
ARS 461:2022, Maize grains (corn)	10	5	2
ARS 462:2022, Sorghum grains	10	5	2
ARS 463:2022, Pearl millet grains	10	5	2
ARS 464:2022, Milled rice	10	5	2
ARS 465:2023, Wheat	10	5	2
ARS 466:2022, Milled maize products	10	5	2
ARS 468:2023 Sorghum flour	10	5	2
ARS 469:2023 Millet flour	10	5	2
ARS 470:2024, Wheat flour	10	5	2
ARS 858:2022, Rough (paddy) rice	10	5	2
ARS 857:2023, Finger millet grains	10	5	2
ARS 859:2023, Brown rice	10	5	2
ARS 864:2023, Dry beans	10	5	2
ARS 865:2024, Dry green grams	10	5	2
ARS 866:2024, Dry chickpeas	10	5	2
ARS 867:2023, Dry cowpeas	10	5	2
ARS 868:2023, Dry pigeon peas	10	5	2
ARS 869:2023, Dry whole peas	10	5	2
ARS 870:2023, Lentils	10	5	2

Standards Landscape for Cereals, Grains, Pulses and Derived Products in Africa: Combating Aflatoxins and Other Mycotoxins: Limits for Common Products

Product	Total aflatoxins (µg/kg)	Aflatoxin B1(µg/kg)	Fumonisins mg/kg)
ARS 871:2023, Dry split peas	10	5	2
ARS 872:2024, Dry soybeans	10	5	2
ARS 873:2024, Dry faba beans	10	5	2
ARS 874:2024, Dry lima beans	10	5	
ARS 935:2024, Edible full fat soybean flour	10	5	2
ARS 939:2024 Feed maize	20	10	2
ARS 1348:2024, Amaranth flour	10	5	2
ARS 1349:2024, Amaranth grains	10	5	2
ARS 1350:2024, Teff flour	10	5	2
ARS 1351:2024, Teff Grain	10	5	2
ARS 1755:2024, Breakfast cereals	10	5	2
ARS 1756:2024, Fonio grain	10	5	2
ARS 1757:2024, Fonio flour	10	5	2

Current strategies used in controlling Aspergillus flavus and aflatoxins



Physical Methods

1. Irradiation Methods: produce reactive oxygen species (ROS), which can damage many cellular components and biomolecules such as DNA, proteins, lipids, amino acids, and carbohydrates
2. Low Oxygen Atmosphere Used in Controlling A. flavus and Aflatoxins: UltraHermetic storage method

Chemical Agents for the Control of *A. flavus* and Aflatoxins

Compounds	Effects
Carboxymethylation, sulfation and phosphorylation of lentinan derivatives	Lentinan at 200 µg/mL completely inhibits aflatoxin production. Sulfated derivatives led to reduced inhibition compared to lentinan. The phosphorylated derivatives showed complete inhibition of aflatoxins biosynthesis at 50 µg/mL.
5-azacytidine (5-AC)	5-AC, a DNA methylation inhibitor, decreased aflatoxin production and changed fungal cell morphology.
Vitamins A, C, and E	Vitamins A, C, and E can prevent sclerotium formation in A. flavus. High concentrations of these vitamins in the medium resulted in a small number of sclerotia.
Potassium sorbate and sodium benzoate	Inhibited A. flavus growth and its infection of peanut and other crops.
Citral	Citral caused transient transmembrane secretion of H_2O_2 and led to the inhibition of aflatoxin production.
L-Cysteine hydrochloride (L-CH)	L-CH induced glutathione (GSH) synthesis to clear intracellular reactive oxygen species (ROS), leading to hyphal dwarfing. L-CH inhibited hyphal branching by preventing the expression of cell wall and spore development-related genes.
Sub3	Sub3, over 0.15 g/L, prevented the germination of A. flavus spores in a potato dextrose broth medium.
Thymol	200 µg/mL thymol induced conidial apoptosis in A. flavus.
1-Octanol	1-Octanol can inhibit A. flavus spore germination in a dose-dependent manner, and 300 µL/L 1-octanol vapor could completely inhibit the growth of A. flavus in wheat, maize, and rice with a 20% moisture content.
Carvacrol (CV)	The spore germination rates of A. flavus at 50 µg/mL, 100 µg/mL, and 200 µg/mL CV treatments were reduced to 84.0%, 26.7%, and 11.3%, respectively.

The novel natural plant products used in controlling *A. flavus* or aflatoxins since 2014

Plant	Products	Mechanism
Seaweed	Alginate oligomer	Could disrupt fungal biofilm formation, increase cell surface roughness to disrupt fungal growth.
Litsea cubeba	Essential oil containing (Z)-limonene oxide (30.14%), (E)-limonene oxide (27.92%) and D-limonene (11.86%)	Controlled A. flavus growth and aflatoxin B1 production in licorice.
Callistemon citrinus* and *Ocimum canum	Major components in C. citrinus are 1,8-cineole (60.6%), α-pinene (18.5%). O. canum containing 1.8-cineole (20.8%), linalol (14.3%), and eugenol (11.9%)	Used as a fumigant in Ethmalosa fimbriata preservation against A. flavus.
Neem and bitter kola seeds	Methanolic and ethanolic extracts	Inhibited the growth of A. flavus with antifungal compounds in the extraction.
Pistachio nut	Carvacrol and allyl isothiocyanate	Controlled conidia germination and mycelial growth of A. flavus.
Curcuma longa	Curcumin	Curcumin inhibited the mycelial growth and sporulation of A. flavus, inhibited the biosynthesis of ergosterol, and enhanced the permeability of cell membranes.
Oregano variety Mendocino (OMen), Cordobes (OCor), and Compacto (OCom)	Essential oils	The compounds of thymol in OCor (18.66%), OMen (12.18%), and OCom (9.44%) showed the best antifungal activity.
Zanthoxylum schinifolium pericarp	Linalool	Linalool vapor at 800 µL/L prevented A. flavus growth, and linalool at 10 µL/mL caused A. flavus spore death.
Pterocarpus indicus Willd., Vaccinium sp p. and Vitis vinifera L.	Pterostilbene	Pterostilbene inhibited mycelial growth of A. flavus with EC50 (the concentration that causes inhibition by 50%) at 15.94 µg/mL. Pterostilbene at 250 and 500 µg/mL effectively inhibited A. flavus infection in peanuts.
Buckwheat hull	Polyphenols, tocopherols, phytosterols, and fatty acids	Lipophilic extract at 10 µg/mL and polyphenol extract at 100 ng/mL inhibited the growth of A. flavus by 74% and 38%, respectively. A mixture of the two inhibited the growth of A. flavus by 86%.

The micro-organisms used in controlling *A. flavus* and aflatoxins since 2014.

Micro-Organisms	Habitat	Antifungal Effects
Lactobacillus plantarum	Fermented Kenyan milk and maize products, etc. (Is this Aflasafe??)	(a). Produces antifungal biomolecules and other metabolites, inhibits fungal growth. (b). Adheres to the olive surface, produces a biofilm, competes for oxygen with A. flavus, and finally inhibits growth.
Pseudomonas sp. 4B	Effluent pond of a bovine abattoir located in southern Brazil.	Reduced fungal growth by 53.8–69%. The aflatoxin concentration reduced from 1472 ng/mL to 42.3 ng/mL.
Saccharomyces cerevisiae	The Western and Eastern Ghats of India	Produces ethyl acetate, hexanal, 1-propanol, 1-heptanol, 1-butanol, benzothiazole, and other volatiles to inhibit the growth of A. flavus mycelia and AFB1 production.
B. megaterium and Pseudomonas protegens	Stored rice grains in Korea	Produces volatile organic compounds to inhibit the growth of A. flavus and aflatoxins production.
Candida nivariensis DMKU-CE18	Leaves of rice, sugarcane, and corn in Thailand	Produces the volatile compound 1-pentanol to inhibit mycelial growth (64.9% inhibition) and conidial germination (49.3% inhibition) of A. flavus.
Streptomyces philanthi RL-1-178	Chili pepper rhizosphere soil in southern Thailand	Produces the volatile compounds geosmin (13.75%), L-linalool (13.55%), 2-mercaptoethanol (9.71%), and heneicosane (5.96%) to inhibit the growth of A. parasiticus and A. flavus.
Streptomyces yanglinensis 3-10	Rice (Oryza sativa), Huazhong Agricultural University, Wuhan, China	Produced 19 volatiles, including methyl 2-methylbutyrate, 2-phenylethanol, and β-caryophyllene, which can inhibit mycelial growth, sporulation, conidial germination, and expression of aflatoxin biosynthesis genes in A. flavus and A. parasiticus in vitro.
Enterobacter asburiae Vt-7	Rhizosphere of tea plants (North: 32°11′56.03″, East: 113°46′36.95″)	Produces 1-pentanol and phenylethyl alcohol to inhibit the growth of A. flavus.

Novel aflatoxin detoxification agents since 2014.

Aflatoxin Detoxification Agents	Detoxification Effects
Vasaka leaf extract (Adhatoda vasica Nees)	Alkaloid extracted from leaves showed strong aflatoxin B1 (AFB1) detoxification activity. The degradation rate was ≥98%.
Manganese peroxidase from white rot edible mushrooms Pleurotus ostreatus	The degradation efficiency of AFB1 was the highest (90%) when incubated under 1.5 U/mL enzyme activity for 48 h.
Ozonation	The detoxification rates of ozone (6 mg/L applied for 30 min at room temperature) to the total aflatoxins and AFB1 were 65.8% and 65.9%, respectively.
Ultraviolet irradiation	The optimal enzymatic reaction occurred in 0.1 M of citrate buffer containing 20% dimethyl sulfoxide at 35 °C, a pH of 4.5, and a laccase activity of 30 U/mL.
Ultraviolet irradiation	AFB1 was decreased from 51.96 to 7.23 μg/kg in 10 min and reduced by 86.08% in peanut oil.
Pulsed light (PL)	PL treatment (80 s) reduced AFB1 and aflatoxin B2 (AFB2) in rough rice by 75.0% and 39.2%, respectively; treatment for 15 s reduced AFB1 and AFB2 in rice bran by 90.3% and 86.7%, respectively.
Extracellular extract of Cladosporium uredinicola	Thermostable enzyme in the extract of C. uredinicola can eliminate AFB1 by 84.5% at 37 °C.
Nitrogen gas plasma	Nitrogen gas plasma degrades AFB1 (200 ppb) by 90% within 15 min.
Ozone	In red pepper samples containing AFB1 treated with ozone 80 mg/L for 40 min, the reduction in AFB1 was 74.1%. Additionally, the mesophilic bacteria and mold/yeast counts decreased by 7–22.1% and 27.2–33.7%, respectively.
Magnetic carbon nanocomposites	The equilibrium times at pHs 7 and 3 were 96 and 180 min, respectively, and nearly 90% of AFB1 was removed in both adsorbents.
Fifty-nine Streptomyces isolates and Mycostop®'s Streptomyces griseoviridis K61	After 10 days of culture, most strains in 59 Streptomyces isolates were able to degrade AFB1 on solid medium (mean = 33%, median = 32%), while the Streptomyces griseoviridis strain degraded it to undetectable levels.
Aspergillus oryzae M2040 strain	In peanuts, the 1% inoculation level of A. oryzae M2040 could secrete inhibitory compounds and effectively inhibit AFB1 production and A. flavus growth.

Advantages and disadvantages of the methods of inhibiting *A. flavus* infection

Approach	Advantages	Disadvantages
Irradiation	It leaves no residue, has no legal restrictions, is easy to use, and is lethal to a wide range of hazardous micro-organisms (143).	The application of irradiation in long-term storage is laborious and uneconomic. The effect is not obvious in dry crops (21).
Low oxygen atmosphere	Minimizes the use of chemical preservatives and integrated control of both microbial growth and insect infestation (144).	May not control or prevent fungal growth and possible production of mycotoxins because some fungi can grow under facultatively anaerobic conditions (144).
Chemical agents	It has great antifungal efficiency (145).	Some of these agents can adversely affect the nutritional, sensory, and functional properties of foods, produce harmful toxic residues, contaminate the environment, and create resistant fungal pathogens (146,147).
Phyto materials	A variety of compounds are present in essential oils, and their antibacterial activities may be due to the interaction of several mechanisms of action in different parts of microbial cells, which may result in the bacteria not developing resistance (148).	The application of these essential oils from plants is always dose-dependent (149). These substances are difficult to produce in a short period of time owing to large planting areas needed, long growth cycles, daily management, etc. (149).
Animal derivatives	Cheap and natural origins (75).	Often results in a strong taste that can change the character of the food (75). These substances are also difficult to produce in a short period of time owing to livestock scales, standardized management, and long breeding periods. (75).
Microbial agents	Low in toxicity, biodegradable, and environmentally friendly (150); they also have high efficiency and specificity (151).	The method is in the research and experimentation stage; there are still many questions to answer, and currently few microbe strains can commercially be used in practice for aflatoxin degradation (11).

Thank you!

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