

Benzoic acids (1-6)

Gallic acid (1): $R_1=H, R_2=R_3=R_4=OH$

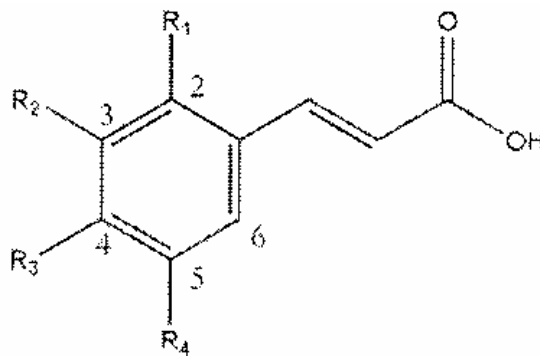
Gentisic acid (2): $R_1=R_4=OH, R_2=R_3=H$

Salicylic acid (3): $R_1=OH, R_2=R_3=R_4=H$

p-hydrobenzoic acid (4): $R_1=R_2=R_4=H, R_3=OH$

Syringic (5): $R_1=H, R_2=R_4=OCH_3, R_3=OH$

Protocatechuic (6): $R_1=R_4=H, R_2=R_3=OH$



Cinnamic acids (7-11)

Caffeic acid (7): $R_1=R_4=H, R_2=R_3=OH$

Ferulic acid (8): $R_1=R_4=H, R_2=OCH_3, R_3=OH$

o-coumaric acid (9): $R_1=OH, R_2=R_3=R_4=H$

p-coumaric acid (10): $R_1=R_2=R_4=H, R_3=OH$

Sinapic (11): $R_1=H, R_2=R_4=OCH_3, R_3=OH$

Figure 1. Some phenolic acid monomers identified in sorghum (adapted from Awika and Rooney, 2004).

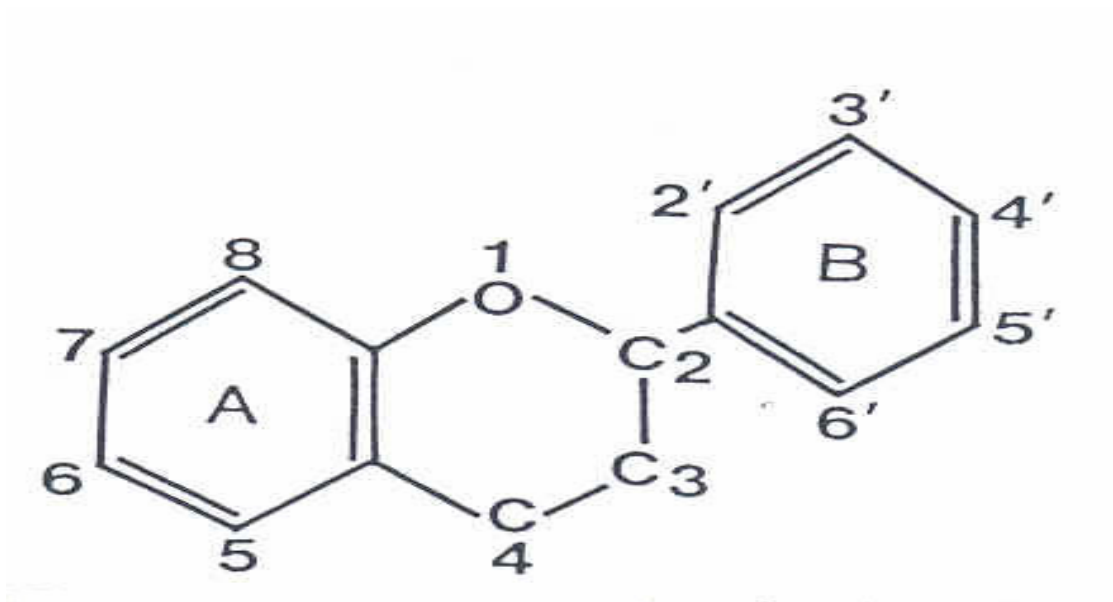
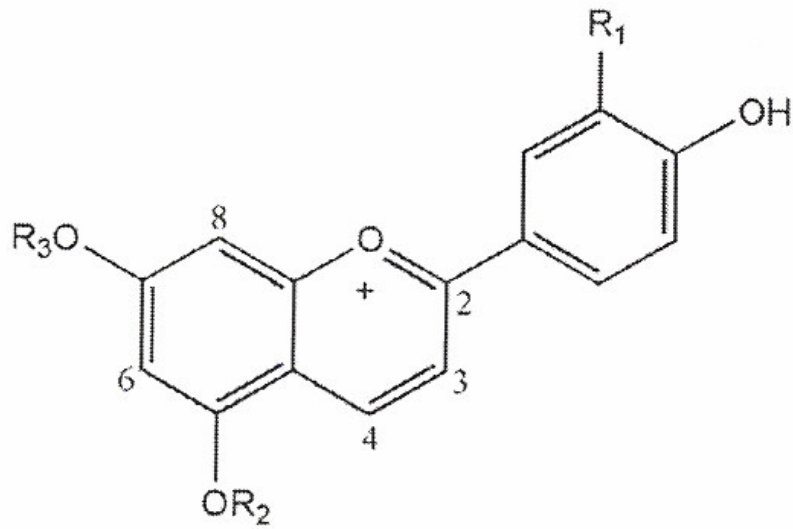


Figure 2. Basic flavonoid ring structure (Hahn *et al.*, 1984).



$R_1 = H, R_2 = H, R_3 = H$: apigeninidin
 $R_1 = OH, R_2 = H, R_3 = H$: luteolinidin

Figure 3. The 3-deoxyanthocyanidins in sorghum (adapted from Awika and Rooney, 2004).

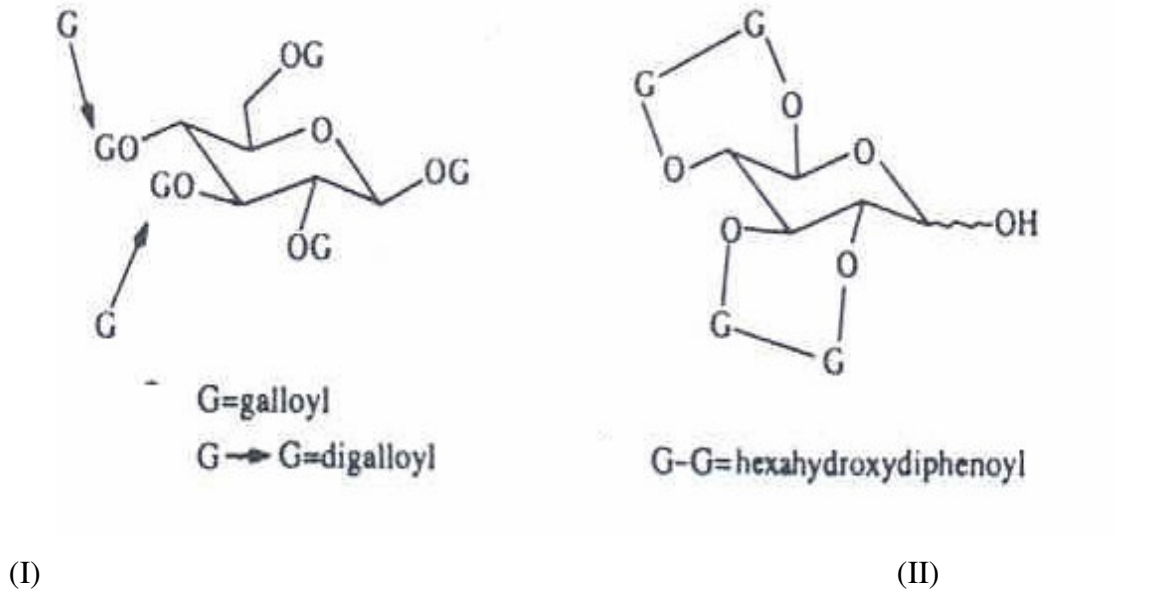


Figure 4. Chemical structures of hydrolysable tannins, galloyl and hexahydroxydiphenoyl (Scalbert, 1991).

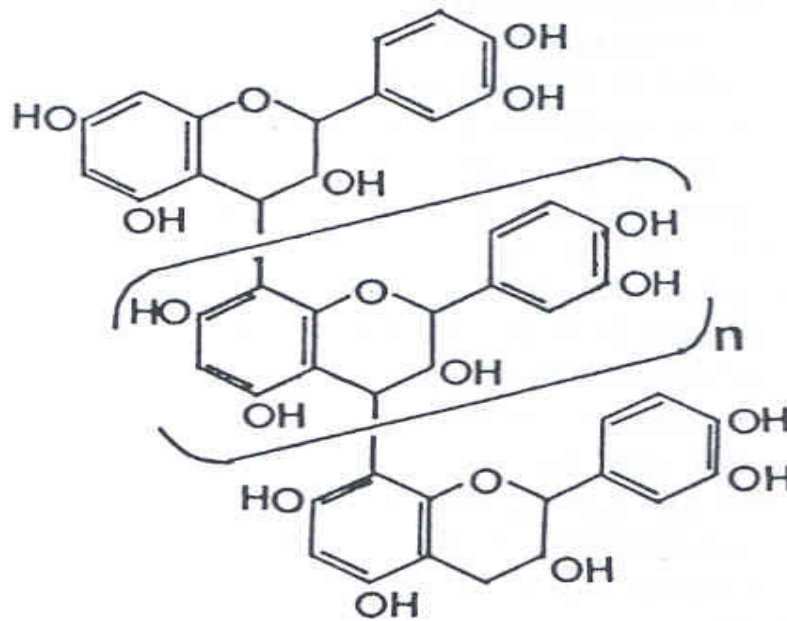


Figure 5. Structure of proanthocyanidin (tannin) polymer; (n=5-7) (Hahn *et al.*, 1984).

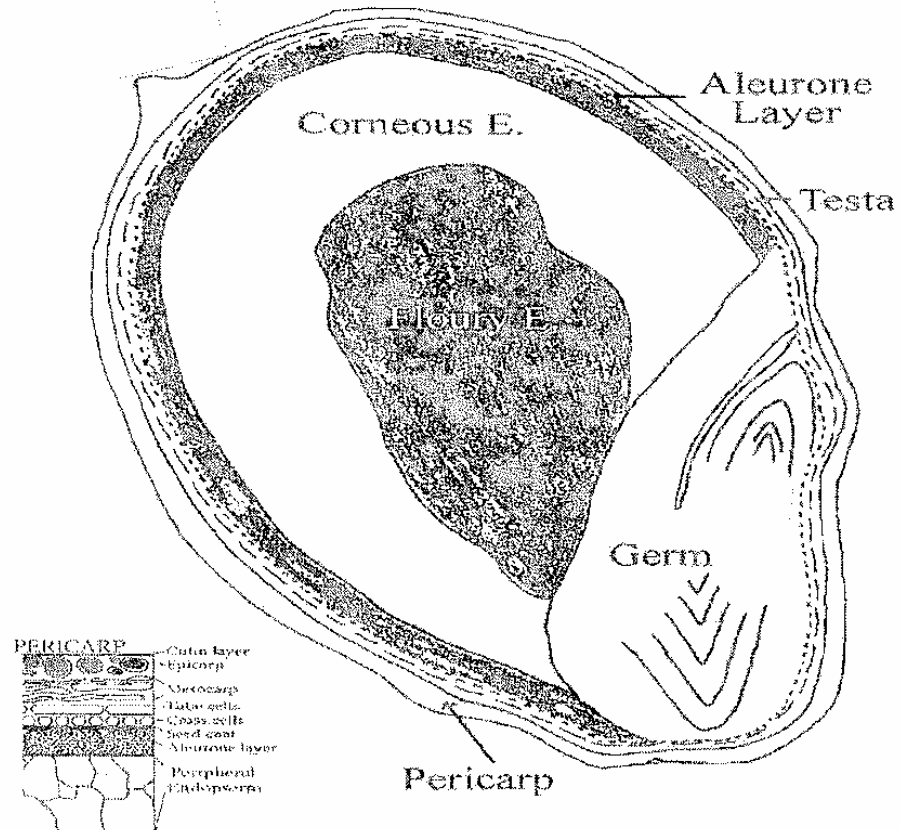


Figure 6. Diagram of sorghum caryopsis showing the pericarp [epicarp, mesocarp, testa] where phenolic compounds are found, endosperm (E) (aleurone layer, corneous, and floury) and the germ (adapted from Waniska, 2000).

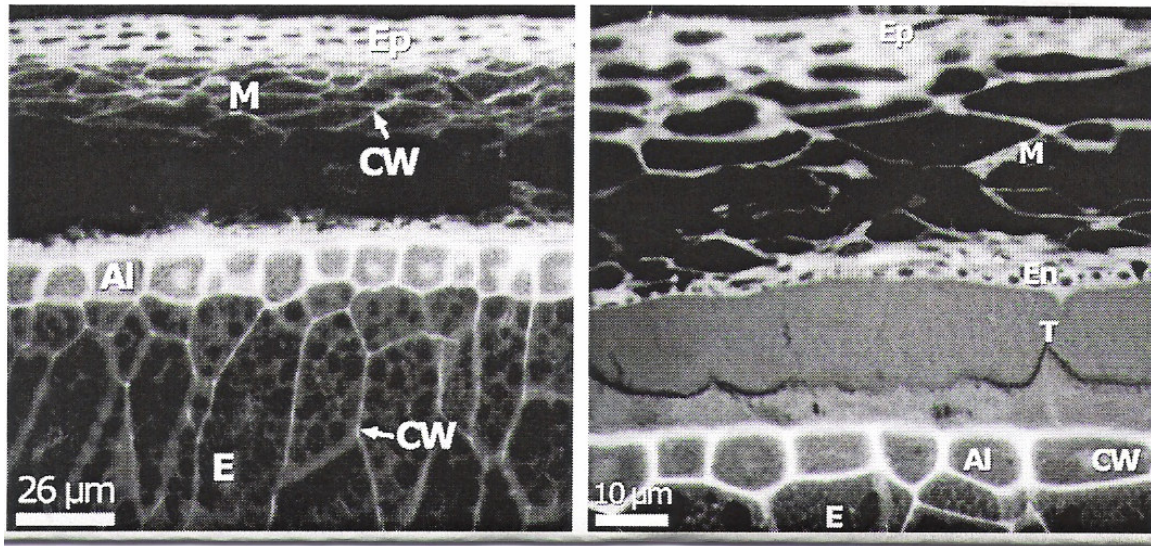


Figure 7. Fluorescence photomicrograph of sorghum bran cross-section, showing structural differences between a non-tannin sorghum without a testa (left) and a tannin sorghum with a pigmented testa (right). Al, aleurone layer; CW, cell wall; E, endosperm; En, endocarp; Ep, epicarp; M, mesocarp; T, pigmented testa (Awika and Rooney, 2004).

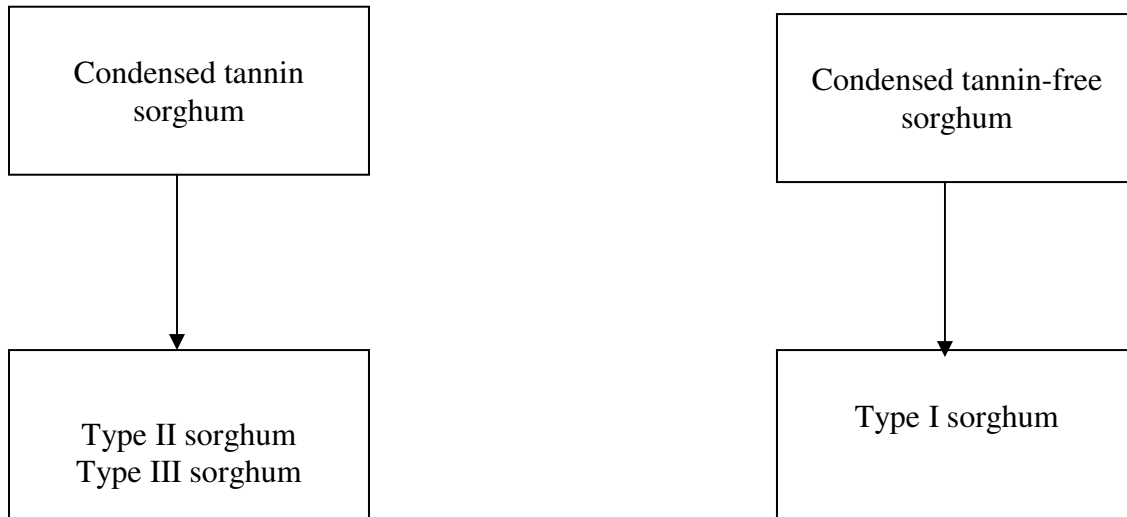


Figure 8. Relationship between the modes of classification of sorghums based on phenolic content.

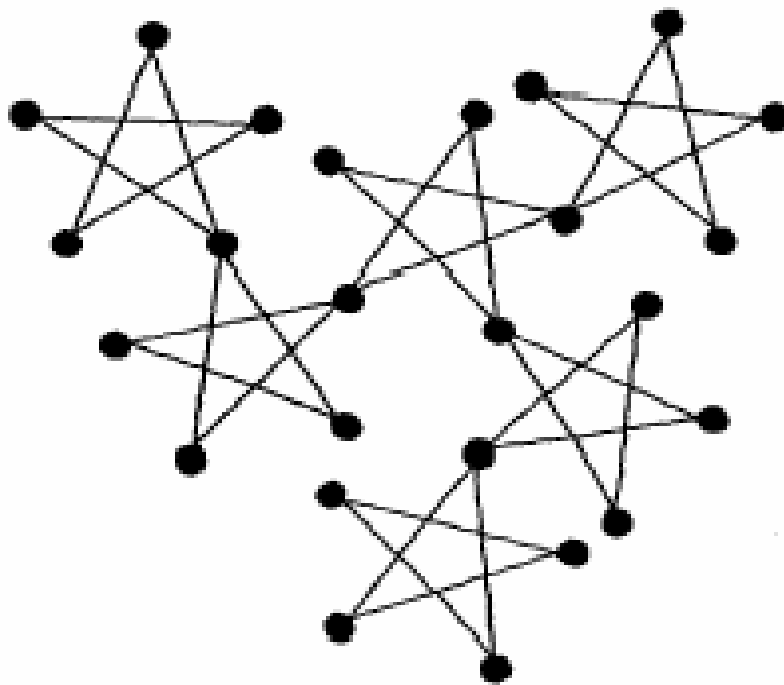


Figure 9. Polyphenol/iron (III) lattice formed upon complexation of iron (III) (dark spot) by polyphenol (star) containing five *o*-dihydroxyphenyl functional groups (triangles) (Mila *et al.*, 1996).

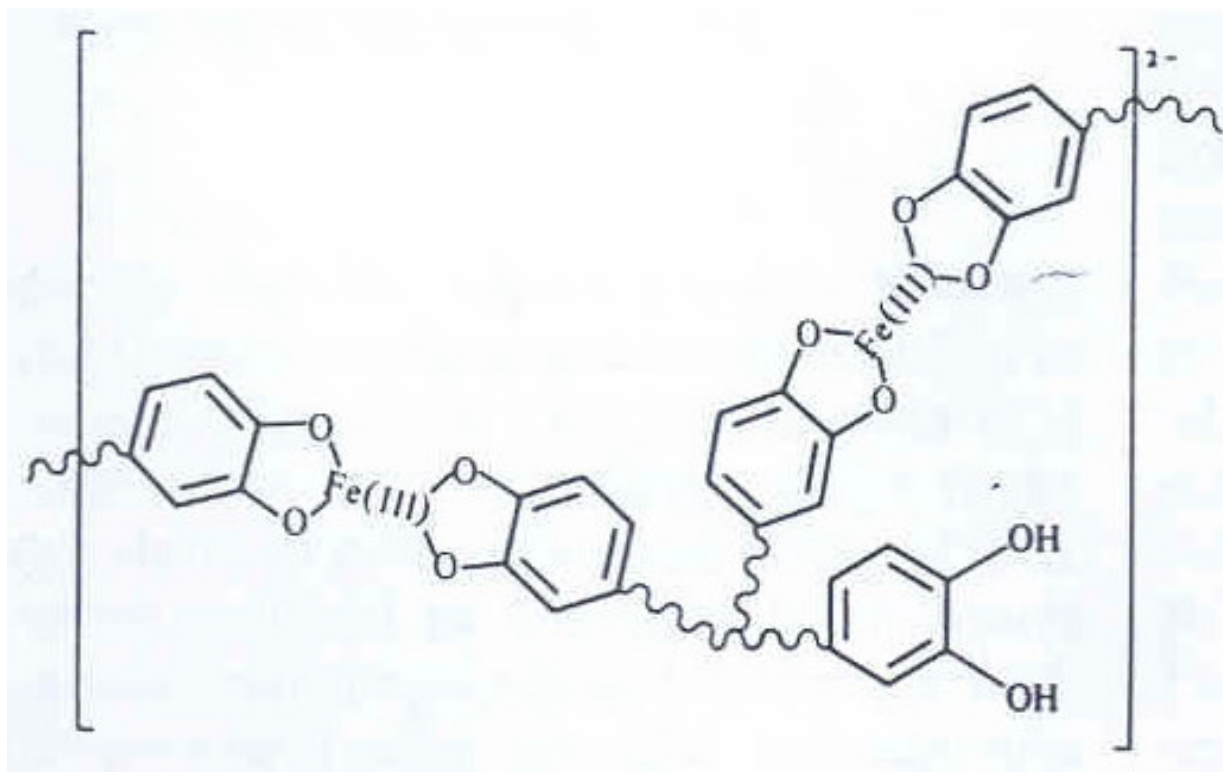


Figure 10. Insoluble tannin-ferric ion complexes (Scalbert, 1991).



Figure 11. Appearance of sorghum grain samples before and after the chlorox bleach test.

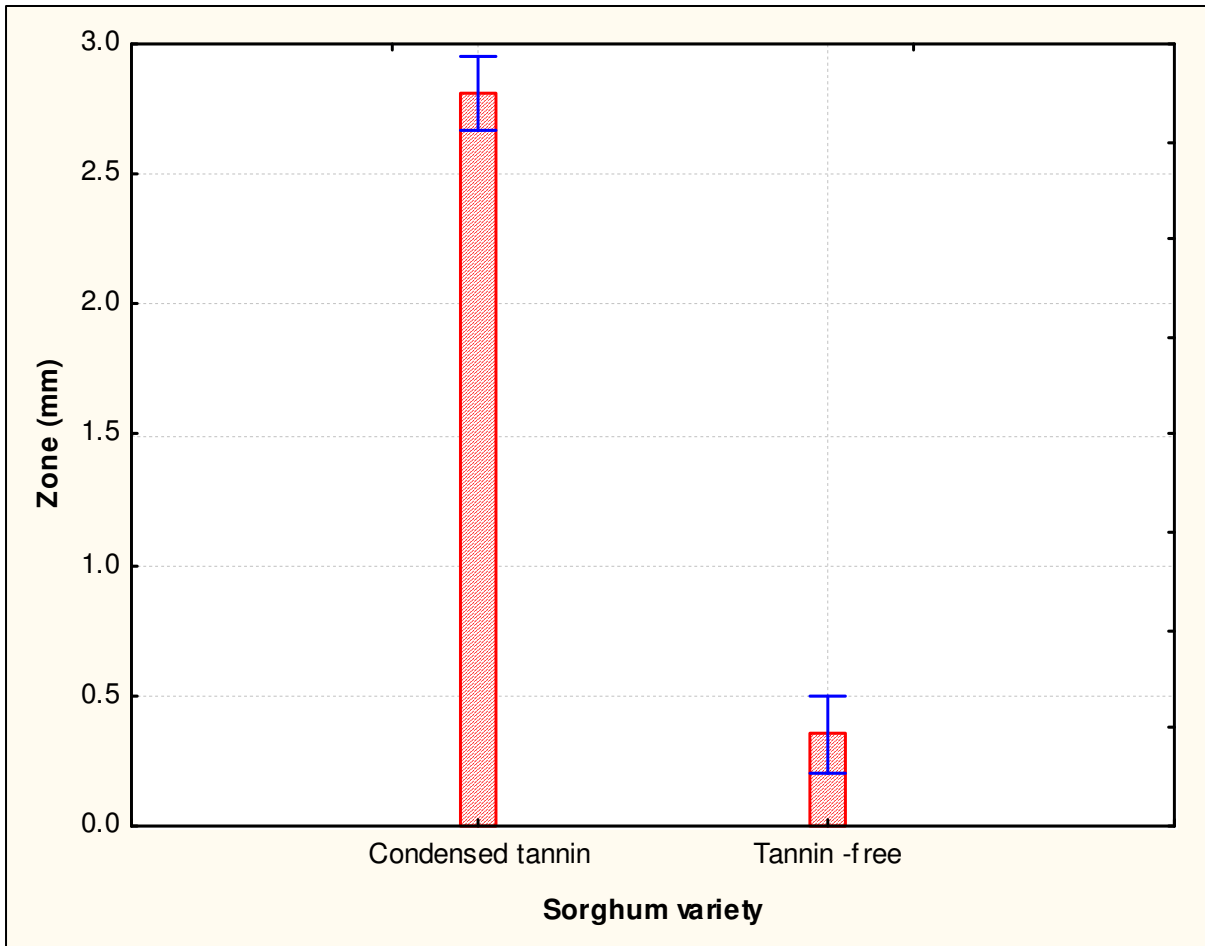


Figure 12. Effect of sorghum crude phenolic extracts from bran fractions of condensed tannin and condensed tannin-free sorghum varieties on growth inhibition.

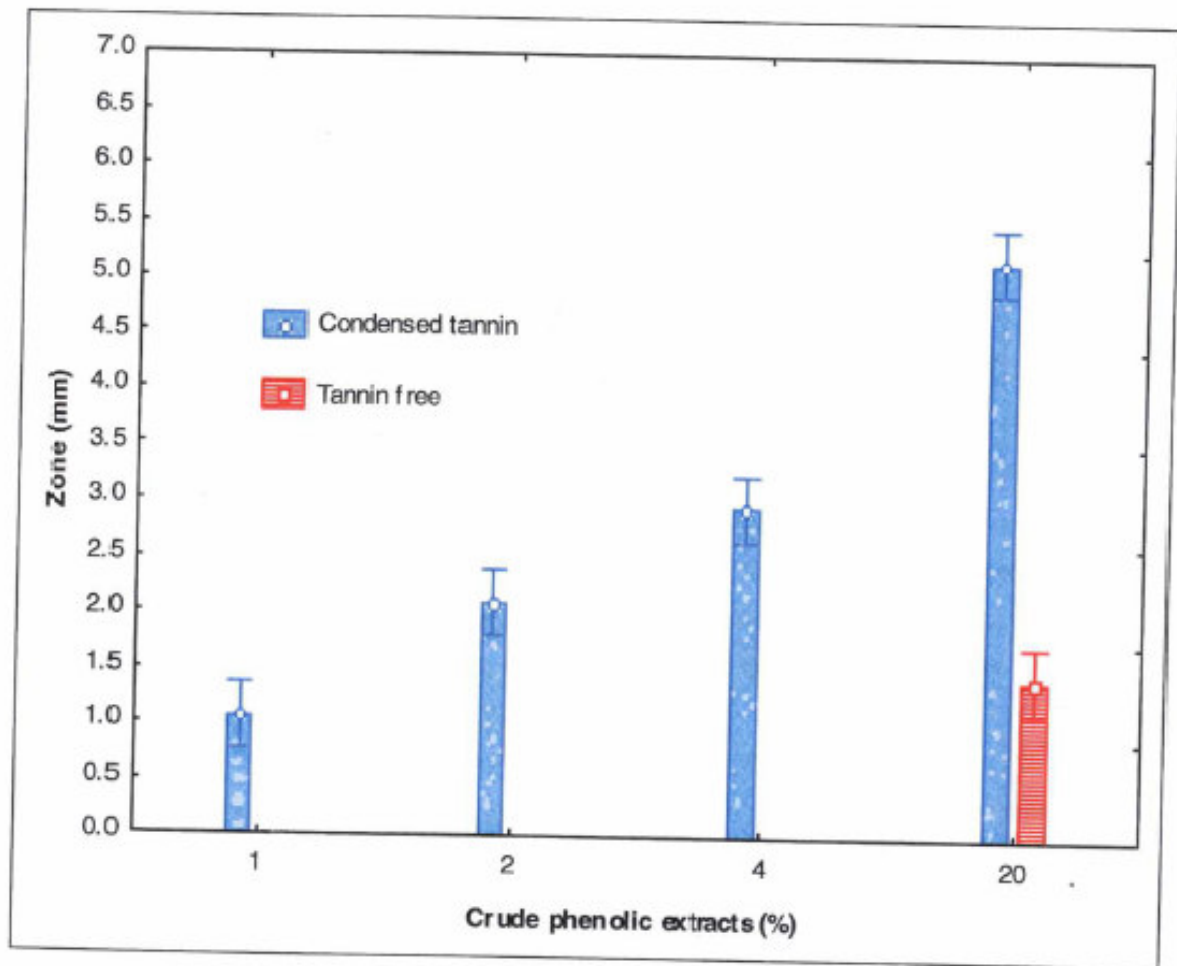


Figure 13. Effect of sorghum crude phenolic extract from bran fractions of condensed tannin vs. condensed tannin-free sorghum varieties on bacterial inhibition at 1, 2, 4 and 20 % concentrations.

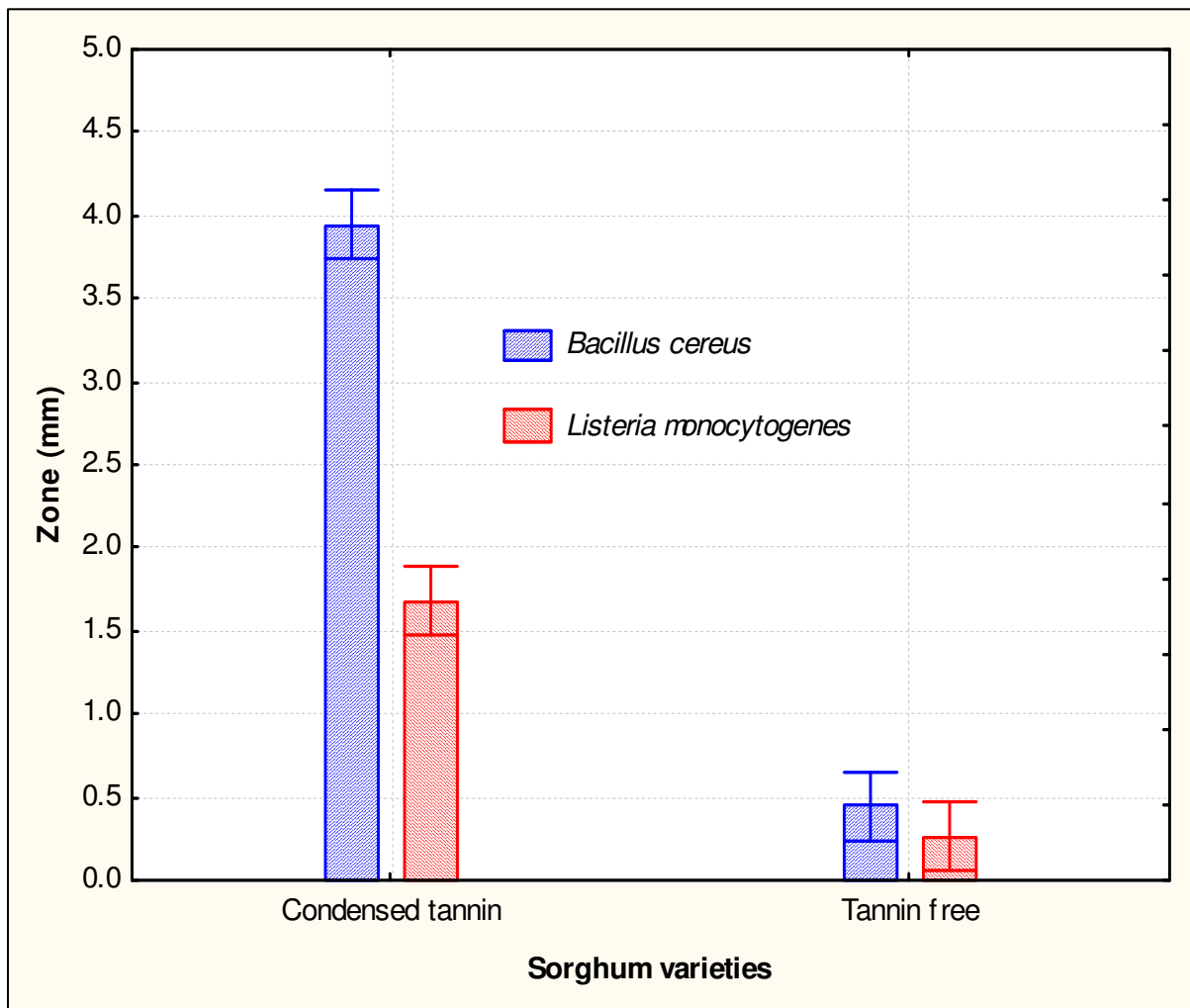


Figure 14a. Effect of condensed tannin and condensed tannin-free sorghum crude phenolic extract on inhibition of *B. cereus* and *L. monocytogenes*.

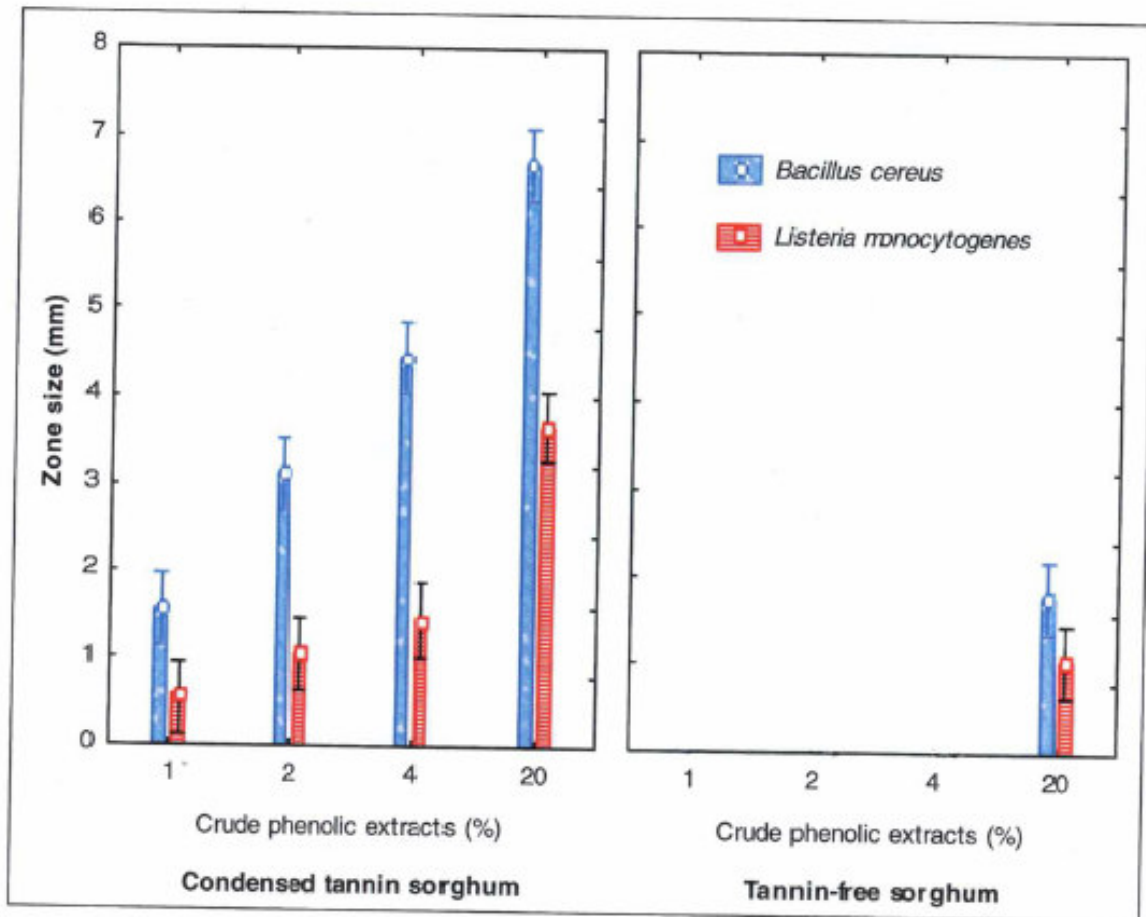


Figure 14b. Effect of increase in concentration (1, 2, 4 and 20 %) of sorghum crude phenolic extract from condensed tannin and condensed tannin-free sorghum on growth of *B. cereus* and *L. monocytogenes*.

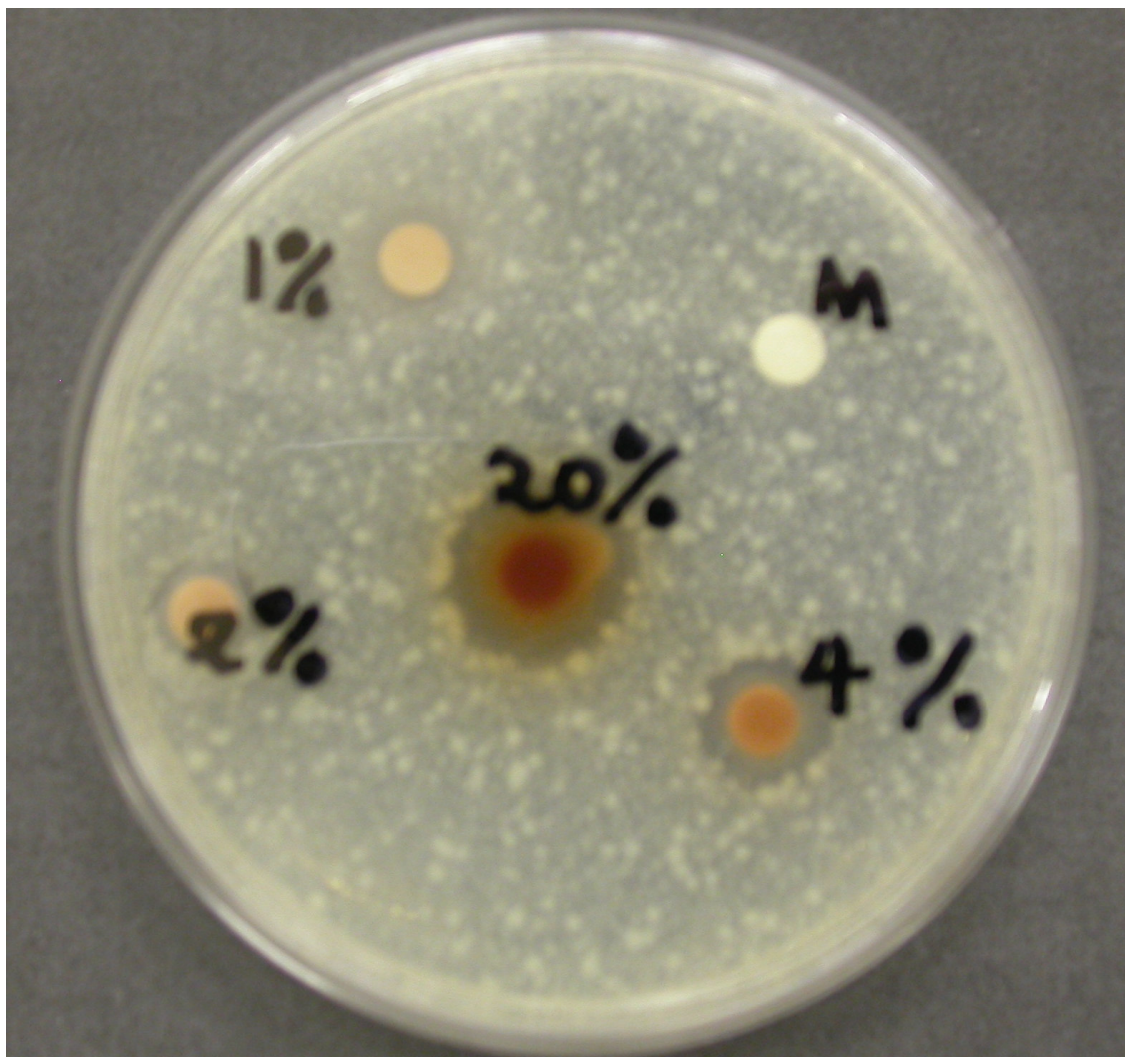


Figure 15. Inhibitory effect of condensed tannin sorghum CPE on *B. cereus* ATCC 1178.

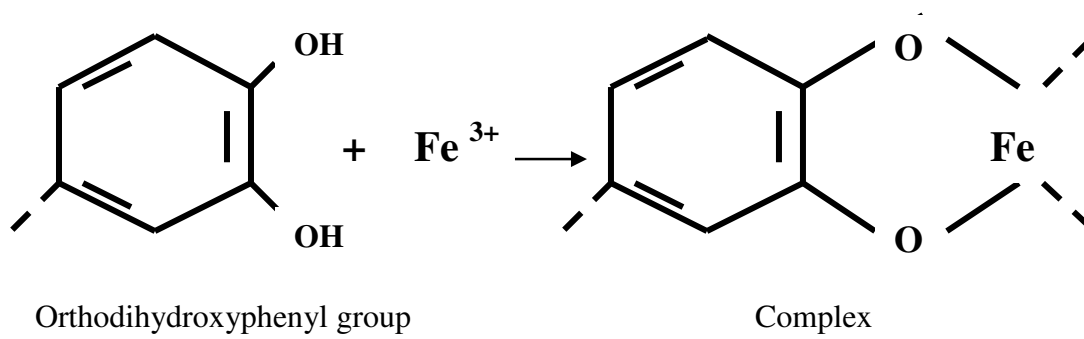


Figure 16. Possible reaction between orthodihydroxyphenyl group of phenolic compound and Fe^{3+} ions (adapted from McDonald *et al.*, 1996).