EFFECT OF SPROUTING MEDIUM ON CYANIDE AND TANNIN CONTENTS OF SORGHUM AND FONIO SEEDS HYDROPONIC FODDERS

[1]Okoli, I.C., [1]Etuk, Nneka U., [1]Giwa, L.A., [2]Achonwa, C.C., [3]Ukwadinamor, J.U., [1]Ohanaka, A.U.C. and [1]Etuk, E.B.

[1]Department of Animal Science and Technology, the Federal University of Technology Owerri, PMB 1526 Owerri, Imo State, Nigeria

[2]Department of Animal Science, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria

[3]Precision Food and Feed Analysis Laboratory, Iyanan Agbala, Ejikeye, Ibadan, Nigeria

Corresponding author: *C.C. Achonwa, Email: chukwumaachonwa@gmail.com*

ABSTRACT

Hydroponic fodders produced from local seeds may contain high levels of anti-nutrients, which may be harmful to livestock. This study compared the effects of water and partially decomposed banana pseudo-stem meal (BPM) as sprouting media on cyanide and tannin concentrations in hydroponic fodders produced from sorghum (Sorghum bicolar) and fonio (Digitaria exilis) seeds. Banana pseudo-stem was dried and pulverized to produce BPM. Triplicate samples of seeds and BPM were analyzed for their cyanide and tannin contents, and thereafter, 250g of each seed type was soaked in clean water for 6 hours to activate them. They were spread directly on perforated plastic trays (12x16x1 inches) containing 250g of BPM and arranged on a wooden rack in a naturally lit room and watered three times daily for eight days to produce hydroponic fodder. The fodder samples were dried and analyzed for their cyanide and tannin concentrations. The BPM recorded significantly ($p<0.05$) higher cyanide and tannin concentrations than sorghum and fonio seeds (3.17, 1.4, and 1.31 mg/kg cyanide and 594.37, 372.50 and 431.27 mg/kg tannin respectively). Their concentrations in the fodders were significantly ($p<0.05$) reduced by the use of BPM/water as the sprouting medium (77.12 and 50.62% for cyanide, and 57.33 and 51.11% for tannin in sorghum and fonio fodders respectively). The values were 101.23 and 23.16 mg/kg cyanide, 3089.19 and 1318.05 mg/kg tannin in the water and BPM/water media produced sorghum fodders respectively; and 8.91 and 3.68 mg/kg cyanide, 1784.48 and 872.42 mg/kg tannin in the water and BPM/water media produced fonio fodders respectively, indicating lower concentrations in the fonio fodders. Sprouting of sorghum and fonio seeds on a BPM/water medium, therefore, reduces the concentrations of cyanide and tannin in their hydroponic fodders.

Keywords: Sorghum, fonio, cyanide, tannins, hydroponic fodder

INTRODUCTION

Hydroponic fodder production in greenhouses under controlled environmental conditions without soil is increasingly being adopted in many high-income countries as an innovative method for sustainable livestock feeding using limited space, water, electricity, and labor involvement. Hydroponic fodder can be produced within a short period, usually, less than 10 days, throughout the year, does not require fertilizer and pesticides application, is of high nutritional quality, and is more palatable than the conventional green fodders (Naik *et al.,* 2015; Sriagtula *et al.,* 2021). The hydroponic fodder production system can therefore help to overcome the challenges of fodder availability due to climatic change and also helps in the management and efficient utilization of natural resources (Santosh *et al.,* 2021). Under this system, seeds are soaked in water on trays inside a greenhouse and allowed to germinate and are irrigated with water or nutrient-rich solutions by sprinkling or fogging for about 7 days. Usually, the greenhouse is a hi-tech, highly advanced, fully automated, and costly structure that may be too expensive and difficult to integrate into the smallholder production system common to sub-Saharan Africa. Several low-cost greenhouse designs made from readily available wood, plastic, and brick materials are currently used in place of the hi-tech greenhouses both for crop and hydroponic fodder production in many developing countries. In these designs the irrigation of the hydroponic fodder is also low-tech and is achieved with the aid of micro-sprinklers, knapsack sprayers, or rose can at desired intervals (Naik *et al.,* 2013).

Several cereal grains such as maize, wheat, barley, oat, rye, sorghum, and millet and legumes like alfalfa, soybean, cowpea, and clover are used in hydroponic fodder production in different regions of the world based mostly on their availability and other socioeconomic factors (Naik *et al.,* 2015; Chana *et al.,* 2021). The physical and chemical reactions that occur during seed germination and early growth culminate in the formation of primary and secondary metabolites which exert varied biological effects on the growth and health of animals compared to non-germinated seeds when consumed. Cereal seeds such as sorghum (*Sorghum bicolor*), although widely grown in Africa produces high concentrations of cyanogenic glycosides, dhurrin, and amygdalin, among other factors in the immature leaves, with the levels decreasing with plant age (Nyirenda, 2020), indicating the need for caution when using sorghum seeds for hydroponic fodder production.

Limited studies have been carried out in Nigeria on hydroponic fodder production with the few available ones focusing on the use of rice, wheat, and maize (Odedire *et al.,* 2019) and sorghum (Chana *et al.,* 2021) mostly for feeding ruminants and pigs. None of these studies determined the concentrations of phytochemical and anti-nutrient compounds in the hydroponic fodders, especially sorghum. This study compared the effects of water and partially decomposed banana pseudo-stem meal (BPM) as sprouting media on the cyanide and tannin concentrations in hydroponic fodders produced from sorghum (*Sorghum bicolar*) and fonio (*Digitaria exilis*) seeds.

MATERIALS AND METHODS

Partially decomposed banana pseudo-stem was cut into pieces and sun-dried for 5 days to reduce its moisture content before being pulverized to produce banana pseudo-stem meal (BPM). Red sorghum and fonio seeds were purchased from a local market and sorted to remove foreign materials. Samples of the seeds and the BPM were analyzed for their cyanide and tannin concentrations in triplicates using the methods described by AOAC (2010). Triplicate samples of 500 g of each seed type were soaked in clean borehole water in plastic buckets for 4 hours to prime or activate them (FAO, 2014). The seeds were then divided into two groups of 250 g in triplicates in a randomized complete block design (RCBD), and transferred either directly to plastic trays measuring approximately 12 x 16 inches and depth of 1 inch, and perforated at one end to allow for draining of excess water or to similar plastic trays containing 250 g of BPM as a sprouting medium. The trays were arranged on a wooden rack in an airy naturally lit room and watered three times daily for 8 days to produce the hydroponic fodders. The fodder samples including the roots and BPM mat were thereafter dried in the sun, ground into powder, and analyzed for their cyanide and tannin concentrations using the methods described by AOAC (2010).

Data generated on seeds and BPM analysis were subjected to analysis of variance (ANOVA) and where significant differences exist, means were separated using the Duncan Multiple Range Test method (SPSS, 2012). The data generated from the fodder analysis were analyzed using the Student t-test method (SPSS, 2012).

RESULTS AND DISCUSSION

The results in Table 1 showed that dried partially decomposed banana pseudo-stem meal recorded significantly higher cyanide and tannin concentrations ($p<0.05$) than cereal seeds, although fonio seeds also recorded significantly higher values of two phytochemicals than sorghum seeds. Ramu *et al.* (2017) reported a tannin value of 07.86±0.21 mg/kg in banana pseudo-stem from India, which is much lower than value obtained in the present study.

Table 1: Cyanide and tannin contents of banana pseudo-stem meal, sorghum, and fonio used in producing hydroponic fodder

Parameters (mg/kg)	Banana stem meal	Sorghum seed	Fonio seed	SEM
Cyanide	3.17^{a}	1.4^{c}	1.31^{b}	0.32
Tannin	594.37^{a}	372.50^{c}	431.27^{b}	33.25

abc means in the same row with different superscripts are significantly different ($p<0.05$)

Nigeria millet cultivar (*P. americanum*) seeds were reported by Salami (1994) to contain 1.38 - 1.43 mg/kg of potential ionic cyanide, which is higher than the value recorded in this study. Nkafamiya *et* *al.* (2015) in their study reported a range of 265.00 - 315.00 mg/kg in sorghum seeds, while Ukam *et al.* (2013) reported 0.05 mg/100g cyanide concentration in fonio seeds, and the tannin concentration of 0.18 mg/kg. The cyanide concentrations in the seeds are therefore relatively low and safe for both human and animal consumption.

Tables 2 and 3 showed cyanide and tannin concentrations in hydroponic fodders produced from sorghum and fonio seeds respectively. The fodder produced on the BPM/water medium recorded significantly ($p<0.05$) lower concentrations of the anti-nutrients across seed types. Figure 1 showed that the decrease in cyanide concentrations was 77.12 and 50.62 percent in the sorghum and fonio fodders respectively, while for tannin, the values were 57.33 and 51.11% respectively.

Table 2: Effect of media on the cyanide and tannin contents of fodder production from sorghum seeds

Parameters (mg/kg)	Water	BPM/Water	P value
Cyanide	101.23	23.16	0.000*
Tannin	3089.19	1318.05	0.000*

Table 3: Effect of media on the cyanide and tannin contents of fodder production from fonio seeds

Parameters (mg/kg)	Water	BPM/Water	P value
Cyanide	8.91	3.68	0.000*
Tannin	1784.48	872.42	0.002*

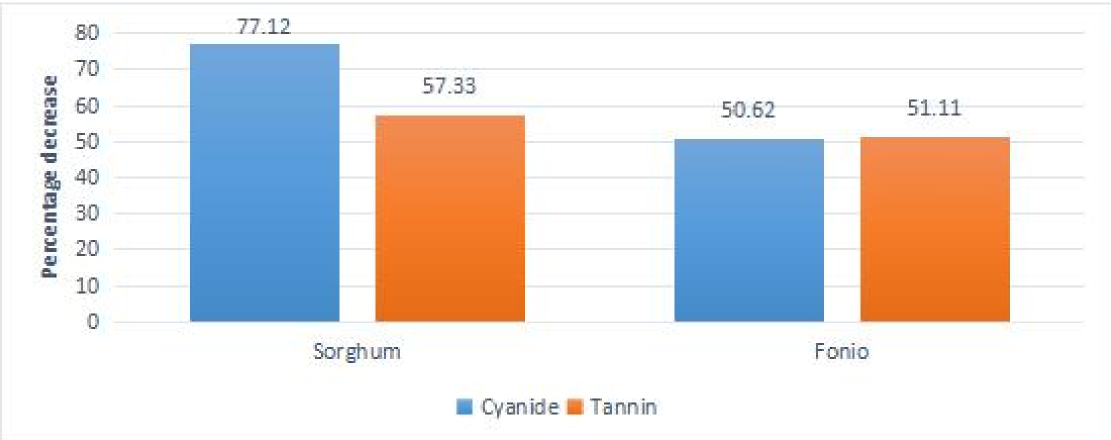

Fig. 1: Percentage decrease in cyanide and tannin concentrations in sorghum and fonio fodders produced on BPM/Water medium

Water stress, which causes oxidative stress in germinating seeds has been reported to lead to the increase concentrations of phenols and flavonoids in leaves (Larson, 1988) and also influence the ratio of chlorophyll a and b and carotenoids in barley leaves (Anjum *et al.,* 2003). Sher *et al.* (2014) reported that the main factors responsible for cyanide accumulation are plant species, tillers, and fertilizer. Sriagtula *et al.* (2021) also reported that cyanide content of hydroponic sorghum fodder specifically increased with nutrient solution addition and harvest age. This increase in cyanide is due to the rate of enzymatic activity during germination, which results in the conversion of cyanogenic glycoside to hydrogen cyanide. The decrease in the tannin and cyanide contents could therefore be attributed to better hydration provided by the BPM/water medium. Begum *et al.* (2021) reported that banana fiber has a water absorption capacity range of 448 - 495%, while Ruchi (2014) reported the hydration properties of banana pseudo-stem powder to be 3.95 g/g, 3.76 g/g and 11.51 ml/g for water holding capacity, water binding capacity, and swelling capacity respectively. These values are relatively high and therefore indicate that BPM/water medium may have created a superior hydrated environment for growth of the fodder throughout sprouting period, thereby aborting the water stress that may have occurred in between the watering periods.

According to Karthika and Kalpana (2017), the safe limit of hydrogen cyanide in green forage for livestock is 500 ppm on a dry basis, and higher levels in sorghum fodder will be toxic to animal health. The hydrogen cyanide content of the 8th day sorghum fodder is therefore within the safe limit for livestock. Some common sorghum varieties in Australia have been shown to record relatively high cyanide concentrations of between 400 and 900 mg/kg. Ikeobi *et al.* (1988) reported that sprouted sorghum from four Nigerian sorghum varieties recorded 4000 - 7000% cyanide after 2 - 6 days of sprouting. It would seem that the sorghum varieties used in this study have a low cyanide production capacity in their sprouts.

CONCLUSION

Sprouted sorghum and fonio seeds on BPM/water medium reduced cyanide and tannin contents in the hydroponic fodders. The fonio fodder contained lower cyanide and tannin concentrations the sorghum fodder across the two treatments. Hydroponic fonio fodder may serve as a better feedstuff for livestock since they contain lower concentrations of the antinutrients. The hydrogen cyanide content of the hydroponic sorghum fodder is however within the safe limit for livestock.

REFERENCES

Anjum, F., Yaseen, M., Rasul, E., Wahid, A., Anjum, S. (2003). Water stress in barley. (Hordeum vulgare L.) H. Effect on chemical composition and chlorophyll contents. *Pakistan Journal of Agricultural Science,* 40:45 - 49.

Begum, H., Tanni, T. and Shahid, M. (2021). Analysis of water absorption of different natural fibers. *Journal of Textile Science and Technology,* 7: 152 - 160.

Chana, Z.M., Abubakar, M., Kalla, D.J.U. and Bello, K.M. (2021). Growth performance of Balamin rams fed four varieties of hydroponic sorghum fodder (HSF) with supplements in the semi-arid environment. *Journal of Agriculture and Environment,* 17(2): 63 - 70.

FAO (2014). Soaking seeds (seed priming) to improve crop yields. Technologies and practices for small agricultural producers. Food and Agricultural Organization of the United Nation, Rome, Italy.

Ikeobi, C.O., Olugboji, O. and Okoh, P.N. (1988). Cyanide profile of parts of sorghum (*Sorghum bicolar* L. Moech) sprouts. *Food Chemistry,* 27(3): 167 - 175.

Karthika, N. and Kalpana, R. (2017). HCN content and forage yield of multi-cut forage sorghum under different organic manures and nitrogen levels. *Chem. Sci. Rev. Lett.,* 6(23): 1659 - 1663.

Larson, R.A. (1988). The antioxidants of higher plants. *Phytochemistry,* 27: 969 -978

Nyirenda, K.K. (2020). Toxicity potential of cyanogenic glycosides in edible plants. IntecOpen DOI: http://dx.doi.org/10.5772/intechopen.91408

Naik, P.K., Swain, B.K. and Singh, N.P. (2015). Production and utilization of hydroponics fodder. *Indian J. Anim. Nutr.,* 32: 1–9.

Naik, P.K., Gaikwad, S.P., Gupta, M.J., Dhuri, R.B., Dhumal, G.M. and Singh, N.P. (2013). Low-cost devices for hydroponic fodder production. *Indian Dairyman,* October 2013. Pp: 68 - 72.

Odedire, J.A., Akinropo, T.F. and Oyarinde, O.D. (2019). Yield and nutritive value of hydroponic fodders as influenced by the frequency of watering. *Nigerian Journal of Animal Production*, 46(3): 298 - 304.

Ramu, R., Shirahatti, P.S., Anilakumar, K.R., Nayakavadi, S., Zameer, F., Dhananjaya, B.L. and Prasad, M.N.N. (2017). Assessment of nutritional quality and global antioxidant response of banana (Musa sp. CV. Nanjangud Rasa Bale) pseudo-stem and flower. *Phcog. Res.,* 9: S74-83.

Ruchi, M. (2014). Characterization of banana pseudo-stem fiber and its functional properties. Institutional Repository of CSIR- Central Food Technology Research Institute (CFTRI), Mysore, Karnataka, India.

Salami, L.I. (1994). Cyanide content of two Nigerian local sprouted millet cultivars. *International Journal of Food Science and Nutrition,* 45(1): 1 - 3.

Santosh, N.N., Thimmegowda, M.N., Mudalagiriyappa, S.T. and Vasanthi, B.G. (2021). Hydroponics fodder production: An innovative approach for sustainable livestock production under varied climatic distress. *Mysore J. Agric. Sci.,* 55(2): 1-11.

Sher, A., Ansar, M., Manaf, M., Qayyum, A., Saeed, M.F. and Irfan, M. (2014). Hydrocyanic acid and sugar content dynamics under nitrogen and sulfur application to forage sorghum cultivars. *Turkish Journal of Field Crops,* 19(1): 46-52.

Sriagtula, R., Martaguri, I., Sowmen, S. and Zurmiati, (2021). Evaluation of nutrient solution dose and harvest time on forage sorghum *(Sorghum bicolor* L. Moench) in hydroponic fodder system. *IOP Conf. Series: Earth and Environmental Science,* 888 (2021) 012068

SPSS (2012). Statistical package for social sciences. Version 20.0 SPSS Inc., Illinois, USA.

Ukam, C.I., Ojewole, G.S. and Out, O.C. (2013). Nutrition and replacement value of hungry rice acha (*Digitaria exilis*) grain for maize grain in broiler starter chicks. Doi: 10:4814/gjass.v1211.8.