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CONTENTS OF NITRATE AND NITRITE IN SOME NIGERIAN FOOD GRAINS AND THEIR POTENTIAL INGESTION IN THE DIET – A SHORT REPORT

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Nitrate and nitrite levels were determined in three varieties of food grains. Nitrate in cereals varied from 120.0 in rice to 1000.0 mg/kg in maize, while nitrite was from 0.026 in rice to 0.106 mg/kg in maize varieties. Their levels in cowpea varied between 710 and 1845 mg/kg for nitrate and 0.033 and 0.062 mg/kg for nitrite. On cooking, nitrate levels decreased in maize and cowpea varieties while an increase occurred in the rice samples. Nitrite levels increased in all the food grains on cooking. Daily intake estimates indicate that the nitrate and nitrite contents of the food grains seem to satisfy the current acceptable daily intake.

INTRODUCTION

The relationship of nitrate and nitrite to infant methaemoglobinemia and to the possibility of formation of carcinogenic nitrosamine has been well reviewed and appreciated [Walker, 1990; Meah *et al*., 1994]. Nitrite is reported to arise from microbiologic reduction of nitrate in foods or drinking water when such foods are stored at room temperature [Heisler *et al*., 1974; Ezeagu, 1996]. Hence if nitrate ions were not reduced to nitrite, little or no concern should be felt about its level in foods and drinking water [Lutynski *et al*., 1996].

The problem is particularly acute in infants since they are more sensitive to the effects of nitrite [Betke, 1953]. Age of a child is of the most important considerations in evaluating nitrate toxicity. Usually breast milk serves as the major source of nutrients and a unique source of food during the first months of life. But most infants in Nigeria are still fed some infant formula and traditional weaning foods by the time they are 2 or 3 months old [Igbedioh *et al*., 1995]. Most of these infant formulas are derived from plants and are mainly beans- or cereal-based formulations, which could contain appreciable amounts of nitrate and nitrite [Bisazz *et al.*, 1978; Ezeagu & Ibe, 2004]. The agronomic practice of large application of nitrogenous fertilizers to obtain heavier yields and improper disposal of human and animal waste may lead to accumulation of nitrate in food plants [Walker, 1990]. In this regard, high amounts of nitrate and nitrite could possibly be present in foods and could pose health risks especially to infants.

In view of the health implications of these factors and the need to safe guide the public health, this study seeks to determine and evaluate the nitrate and nitrite contents of some commonly consumed food grains from Nigeria.

MATERIALS AND METHODS

Treatment of samples. Four varieties of rice (*Orhiza sativum*), two each of maize (*Zea mays*) and cowpea (*Vigna unguiculata*) were collected from the National Cereals Research Institute, Ibadan, Nigeria. Cooking was done by boiling 20 g of each sample under practical conditions in distilled water for approximately 30 min and separated from the cooking water. Twenty grains each of both raw and the cooked samples were macerated with 80 mL of double distilled water until fine slurry was formed. The slurry was then centrifuged. A spatula full of mercuric chloride was added to the supernatant as a deproteinizer. The mixture was allowed to stand for 15 min and then it was filtered through Whatman No. 32 filter paper to obtain a clear sample extract.

Determination of nitrate. Nitrate was determined essentially by the colourimetric method of Harper [1924] as modified by Bassir & Maduagwu [1978]. To 25 mL of each clarified sample solution 1 mL of nitrate-free silver sulphate (4 g/L) was added to remove any interfering chloride ions. Precipitated chloride was removed by filtration. Loss of nitrate was prevented by the addition of 0.2 g of magnesium oxide to 1 mL of filtrate. The optical density of yellow nitrophenolic colour developed was measured in an ELL photoelectric colourimeter using a blue filter. Double distilled water was used as blank and levels of nitrate were extrapolated from a standard curve prepared from 1-mL aliquots of potassium nitrate standard solutions containing 0.0–20.0 μg nitrate N/mL.

Determination of nitrite. The nitrite contents of the

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clarified extracts solutions were determined by the method of Montgomery & Dymock [1961]. Absorbances of the pink-coloured solutions developed were measured at 550 nm using a reagent blank. Levels of nitrite were extrapolated from a standard curve prepared from 1-mL aliquots of sodium nitrate standard solutions containing 0.0–2.0 μg nitrite N/mL.

All determinations were done in duplicate and Analar Grade reagents were used throughout.

RESULTS AND DISCUSSION

Table 1 shows the nitrate and nitrite levels in both the raw and cooked food grains. Nitrate levels in raw cereals (rice and maize) varied from 120.0 mg/kg in Faro rice to 1000.0 mg/kg in WC UI maize varieties. These are much higher values than the 500.0 mg/kg nitrate limit recommended by WHO/FAO [WHO, 1973]. Gilbert *et al*. [1946] reported similar high concentrations in air-dried samples, ranging from 12200.0 mg/kg in millet to 30000.0 mg/kg in oats. However, it is speculated that these high figures are artifact and probably reflect contamination during drying rather than actual levels. Relatively lower levels were reported for *ogi*, a processed maize product and most common vegetables and vegetable products [White, 1975; Ezeagu & Fafunso, 1995; Ezeagu, 1996]. Nitrate contents of cowpea samples were 710.0 and 1845.0 mg/kg, respectively. These are much higher than the range of values of 54.0–89.0 mg/kg reported by Gundimeda *et al.* [1993] for some pulses. Generally, low levels of nitrate/nitrite are reported for grains and seeds [McNamara *et al*., 1971]. Differences in species, strain and agrotechnical operations as well as environmental pollution could account for these wide differences.

Nitrite levels in the cereals range from 0.026 in rice to 0.106 mg/kg in maize, while in cowpea the range is between 0.033 and 0.062 mg/kg. These are low levels and within the limits of the recommended normal acceptable daily intake (ADI) level (0.1 mg/kg body weight). Dietary exposure to nitrite is normally very low. Exceptionally, higher levels may result from microbial reduction of nitrate in hygienically poor quality well water or in foods rich in nitrate stored under inappropriate conditions [Heisler *et al.*, 1974; Ezeagu, 1996].

While cooking process increased the nitrite contents in all the samples (Table 1), the nitrate levels only increased in the maize and cowpea samples. Similar changes in levels of nitrate and nitrite in food after cooking were observed for vegetables by Ezeagu & Fafunso [1995]. Czarniecka *et al*. [1993] also reported reduction in nitrate and increased nitrite on cooking some food items. An increase in nitrite levels could be ascribed to nitrate conversion into nitrite during the cooking process. However, Wieczorek *et al*. [1994] reported that on cooking these compounds decreased in carrots. An increased nitrate level in cooked rice was observed in this study. One is tempted to speculate that this was as a result of consistency of samples, quantity of heat applied, or systematic error. On the other hand some intrinsic factors such as nitrogenous compounds, may have decomposed into nitrates.

The daily intakes of the various food grains are 18.5, 17.5 and 38.1 g respectively for rice, cowpea and corn [Udoessien & Aremu, 1991]. Based on the mean nitrate/nitrite contents of each grain type, the potential daily intake of nitrate from the cooked food grains ranges from 2.48 in maize to 43.91 mg/day in rice (Table 2). For an average consumer (70 kg body weight) [Bowen, 1966] therefore, the total daily intake of nitrate would be 58.72 mg (0.84 mg/kg body weight) which is quite below the limit of WHO/FAO [WHO, 1974] ADI of 3.7 mg (5 mg $NaNO_3$)/kg body weight allocated to nitrate, though a later study has recommended 18.5 mg (25 mg $NaNO_3$)/kg body weight [Walker, 1990]. Conversely, the daily total nitrite intake from the grains of 26.58 μg (0.38 μg/kg body weights) appears to be insignificant relative to the recommended ADI of 0.2 mg $NaNO_2$/kg body weight.

TABLE 2. Estimated daily nitrate/nitrite intake from cooked food grains.

	Daily consumption[1] (g)	Estimated daily intakes[2]	
		Nitrate (mg)	Nitrite (μg)
Rice	18.5	12.33 (0.18)	1.72 (0.03)
Maize	17.7	2.48 (0.04)	2.00 (0.03)
Cowpea	38.1	43.91 (0.63)	22.86 (0.33)
Total	**74.3**	**58.72 (0.84)**	**26.58 (0.38)**

[1]Udoessien & Aremu [1991]; [2]Data in parenthesis indicates intake per kg body weight. Average man: 70 kg [Bowen 1966]

TABLE 1. Levels of nitrate and nitrite in raw and cooked food grains (mg/kg)[1].

		Nitrate			Nitrite		
		Raw	Cooked	% Changes	Raw	Cooked	% Changes
Rice	Faro 5	120.0	170.0	(+)41.7	0.054	0.108	(+)100.0
	Faro15	308.0	940.0	(+)205.2	0.0062	0.1107	(+)72.6
	Faro17	195.0	890.0	(+)421.2	0.026	0.063	(+)142.3
Mean		**207.67**	**666.67**	**-**	**0.047**	**0.093**	**-**
Maize	WC UI	1000.0	140.0	(-)86.0	0.106	0.119	(+)12.3
	TBZ Kotopo	355.0	140.0	(-)21.5	0.063	0.107	(+)69.8
Mean		**677.5**	**140**	**-**	**0.085**	**0.113**	**-**
Cowpea	AC 68000	1845.0	1725.0	(-)6.5	0.033	0.104	(+)215.2
	West Breed	710.0	580.0	(-)18.3	0.062	0.600	(+)867.7
Mean		**1277.5**	**1152.5**	**-**	**0.048**	**0.35**	**-**

[1]means of two independent determinations; (+) increase; (-) decrease

CONCLUSIONS

From the standpoint of nitrite toxicity based on its levels before ingestion, the food grains in this study will make very little contribution to nitrate and nitrite intake by adults or infants and thus pose no hazard. However, it must also be noted that the food grains are cooked in water before consumption and are, most often, consumed with other food crops. The nitrate and nitrite contents of the water and the other food items that make up the diet add up to the total intake. The findings in this study therefore need further verification by more detailed studies, which should include a wider volume of food materials. Due to the high sensitivity of young infants, nitrates and nitrites should be determined more often particularly in water and plant foods.

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