

LISHE

FOOD AND NUTRITION JOURNAL OF TANZANIA



ISSN No. 0856 0528

Volume 9 Number 1, January 1998

LISHE

FOOD AND NUTRITION JOURNAL OF TANZANIA

Editors

Dr. Godwin D. Ndossi - Tanzania Food and Nutrition Centre.
H. Missano - Tanzania Food and Nutrition Centre.

THE FOOD AND NUTRITION JOURNAL
OF TANZANIA is published twice a year by
Tanzania Food and Nutrition Centre,
Ocean Road No. 22
P.O. Box 977, Dar es Salaam
Telex: 41280
Tel: 118137-9
Fax: 255-51-116713
E-Mail: tfnc@costech.gn.apc.org
ISSN 0856-0528

Annual subscription fee per issue:

- Tanzania: US \$ 3 or equivalent to Tsh. 1,800
- Developing Countries US \$ 6
- The rest of the World US \$ 15

Cheques to be payable to:
Managing Director,
Tanzania Food and Nutrition Centre.
Full details must accompany the payment

Typeset by Inter Press of Tanzania Ltd.

Printed by Inter Press of Tanzania Ltd.
P.O. Box 6130
Tel: 700564/5
Fax: (010 255 51) 116601
Dar es Salaam.

Copyright ©

Tanzania Food and Nutrition Centre, 1997.
Authorization to photocopy items for internal or
personal use may be granted by the Managing
Director of Tanzania Food and Nutrition Centre.

Enquiries concerning advertising space should be
addressed to:

The Editor
LISHE,
Tanzania Food and Nutrition Centre,
P.O. Box 977,
Dar es Salaam,
TANZANIA.

FOOD AND NUTRITION JOURNAL OF TANZANIA

VOL. 9 Number 1

January 1998

CONTENTS

	Page
Investigation on the Hygienic and Nutritive Qualities of Street Foods Locally Produced and Sold by "Mama Ntilie" in Tanzania	1
Iron Availability in Weaning Foods as Affected by Nutrient Inhibitors	8
Protein Bio-Availability in Bulrush Millet	13
Effect of Soaking Cow Peas and Sorghum-udo Grains in Different Solvents/Media on Phenolic Content	22

EDITORIAL

Street foods are the ready to eat foods and beverages sold and sometimes prepared in public places. The street foods which are normally low in cost and offer an attractive alternative to home - cooked foods, often reflect traditional local cultures and exist in an endless variety.

Vendors' stalls are usually located outdoors or under a roof which is easily accessible from the street. They have low-cost selling facilities which are sometimes rudimentary. Their market success depends exclusively on location and word of mouth promotion.

Women have an important role in this sector and that it has invaded areas of busy economic activity and heavy population concentration and hence an indirect contribution to the national economic development. Statistics for some places do exist. In the Indonesia City of Bogor annual sales of street foods amount to US\$ 67 m (Cohen, 1986). In Malaysia, annual street food sales amount to US\$ 2.2 billion (Allain, 1988). In Africa and Asia, urban households spend 15 to 50 percent of their food budgets on street foods (Cohen 1986). This is a relatively significant figure considering that most of the earnings are generated locally and thereby promote economic self - sufficiency.

Nutritionally, Street foods have shown to constitute the largest part of total energy intake (78%) accounting for 82 and 79 percent, respectively of total protein and iron intake.

In Tanzania, meal portions served by vendors ranged between 600 and 800 g and contribute between 9.4 - 11.9 g protein with calorific values of 171 - 270 Kcal/100g on dry matter basis. (Nnko, 1998).

Although the sector has come to symbolize street life, income generating and feeding a reasonable portion of the urban population in both developing and developed countries, its contribution to the economies remains to be vastly underestimated, neglected and ignored. Due to this situation, its operators live in unsuitable and insecure state because the sector lacks legal recognition. This explains the deplorable sanitary conditions and lack of hygiene which result in food contamination, disregard for environmental conservation and the use of force and even violence among the sector's practitioners.

A number of activities need to be done to shed light on the situation, to identify the problems and to suggest strategies that will mitigate the negative aspects of street food operations while safeguarding the positive features, which are mainly socio-economic and nutritional. It is a priority that a multisectoral approach be considered vital to understanding and managing street food activities.

Such integration requires a reappraisal of the functions, organizations and administration of towns and cities.

Before any regulation can be established for street vendors, the local authorities need to recognize the importance of street foods. The ability of vendors to produce cheap, nutritious, traditional and hygienic meals must be safeguarded, encouraged and assisted. Rules and regulations for safe food for human consumption need to be enforced and information and education must provide the basis for enforcement. Safety and controls would be more attractive and better implemented if vendors who exercised particular care were rewarded. Small credit funds could help vendors review or improve their stalls.

INVESTIGATION ON THE HYGIENIC AND NUTRITIVE QUALITIES OF STREET FOOD LOCALLY PRODUCED AND SOLD BY *MAMA Ntilie* IN TANZANIA

Siphuel A. Nnko, Andrew B. Gidamis and Salehe Abdallah

Sokoine University of Agriculture, Department of Food Science and Technology

Abstract

A cross-sectional survey was carried out to identify the types and prices of street foods locally known as *Mama Ntilie* in Tanzania. Similarly, laboratory analyses were conducted to assess the hygienic and nutritive quality of these foods. This was done with a view of promoting consumer awareness on the prevailing quality standards of such foods.

One hundred respondents consisting of food vendors and customers in the ratio of 50:50 were interviewed. Two types of foods commonly prepared and served were identified as rice (wali) and stiff porridge (ugali). These foods were served in different meal combinations with meat stew, green leafy vegetables and cooked beans. The data obtained showed that foods prepared and sold by street food vendors were nutritionally acceptable.

Meal portions served by vendors ranged between 600 and 800 g and contributed between 9.4 - 11.9g protein/100g with caloric values of 171-270kcal/100g on dry matter basis.

These values meet the recommended daily protein intake and contributed about half of the calories recommended for a moderately working man.

The microbial contamination of water and some food samples surpassed the level that is generally accepted as safe. Total aerobic count of water samples as log 3 CFU/ml whereas coliform levels of the same were about log 2 CFU/ml.

The presence of *Escherichia coli* was also confirmed in drinking water and in food samples. Total aerobic count of some food samples surpassed acceptable standards of $\leq \log 5$ CFU/g

food material. All food samples investigated had coliform count above log 2CFU/g.

These findings indicate faecal contamination of water and food samples. The presence of *E. coli* suggests the possibility of contamination with faecal matter. This situation demands that sanitary quality should be improved and the water should be treated prior to use. Food prices were affordable for many office and non-office workers.

**Key words: Street foods, protein quality, caloric value, hygienic quality.*

Introduction

Street food business, locally known in Tanzania as *Mama Ntilie* makes one of the largest source of employment especially for women in the informal sector. These traditional establishments which serve a wide range of ready-to-eat foods and beverages in public places (Allain, 1988), are recognised to be a way of traditional food conservation, sustaining local agricultural production (FAO, 1992; Barth, 1983).

In recent years, urban population growth has stimulated a rise in number of street food vendors in many cities and towns throughout the world (Winarmo, 1988). In Africa, the processing, preparation, marketing and consumption of street foods is important, as a survival strategy for the poor. Street food vending has been vital for the economic planning and development of many towns (FNA, 1991). Studies conducted in Africa and Asia, indicate that the street food industry employs a large number of people directly or indirectly (FNA, 1991; FAO, 1992; Cohen, 1986).

In Tanzania, street food vending goes hand in

hand with trading of other goods. According to Ndossi (1992), this trade has in the past few years tremendously mushroomed as a result of unemployment and rural - urban migration. Vending of such foods which is carried out mainly by women from low income families (Ndossi, 1992) is usually practised in most city streets, around construction sites and in industrial areas. Meals sold by the vendors are usually cheaper than those sold in hotels making them affordable for many people (FAO, 1990). It has been reported that, street foods contribute to urban dwellers at least one meal daily, and hence increasing the importance of these foods (FAO, 1990).

Notwithstanding the contribution of street foods to the national economy of developing countries, these foods have been widely associated with food poisoning outbreaks (FAO, 1989; Malijani and Kambaila, 1992). Most of the food poisoning incidents in the developing countries are directly related to the high microbial contaminations of the food. Various levels of microbial food contamination have been reported in different studies (FAO, 1989; Akinyele, 1992 and FAO, 1987). Further surveys have established that foods sold by ambulatory vendors were generally unsafe than those sold by stationary vendors (FNA, 1991).

Although street food vending is common in most cities in Tanzania, very little has been done to enhance a better understanding of these foods with regards to its nutritive and hygienic qualities. Most of the consumers who are attracted by the availability and accessibility of street foods, often tend to overlook aspects of quality, hygiene and sanitation. A concern over the low level of education of most of the street food vendors was once raised by Ndossi (1992). Coupled with this concern is unawareness of appropriate food handling practices on the part of food vendors and consequently raising the potential of food borne intoxications.

The main objective of this study was, therefore, to analyse the nutritive and microbial qualities of street foods sold by *Mama Ntilie* with the view of establishing their safety and health hazard risks involved.

Methodology

The Study Area

The study was conducted in Kinondoni area which is located in Dar es Salaam, a major commercial city on the east coast of Tanzania. The population of Dar es Salaam is reported to be around 2.7 million with an annual growth rate of 4.8% (URT, 1989). The economic activities in the area are differentiated into industrial, agricultural, administration and commercial sectors. The commercial sector is further subdivided into formal and informal sectors. It is estimated that over 48,000 people are involved in informal sector (URT, 1991), and many of them are involved in food vending activities.

Experimental Design

Administration of the Questionnaire

A questionnaire consisting of both closed and open ended type of questions was prepared in English and administered in *Kiswahili*. The questionnaire consisted of 43 questions which focused on demographic issues, types of street foods, food prices, food handling, sources and quality of raw materials and water, fuel source and sanitary situation of the vending places.

A cross sectional survey was conducted in which a total of 100 respondents, comprising of street food vendors and customers in the ratio of 50:50 were interviewed. Secondary data were derived from various documentations. Information related to existing food laws and regulations regarding street foods was obtained from government offices in the Kinondoni district.

Chemical Analysis

Chemical analysis of the food samples was done in order to quantify their caloric and protein value. Proximate composition of the food samples was done in duplicate according to AOAC (1991). The moisture content was determined by drying to a constant weight in the oven at 105°C. The micro Kjeldahl method was used for the estimation of protein ($6.25 \times \%N = \% \text{ protein}$). Crude fat was extracted with petroleum ether (Kirk and Sawyer, 1991). Ash content was

determined after ashing the samples in a muffle furnace at 550°C. Crude fibre was determined according to the method of Van Soest and Wine (1967). The caloric value was obtained by multiplying protein, fat and carbohydrates by factors 4, 9 and 4 respectively and the resulting values were then added to get the total caloric contribution of the meal.

Microbial analysis

Food and water samples were randomly but aseptically sampled into sterile plastic bags and weighed. Preparation of serial dilutions was done as described by Refai (1979). Ten grams of food sample was thoroughly mixed with peptone water. Dilutions ranging from 10^{-1} to 10^{-4} in duplicates were made for total plate counts. For coliform counts, dilutions of 10^{-1} to 10^{-3} were prepared and inoculated into 3 test tubes containing McConkey broth. A three test tube MPN procedure as described by De man (1975) was used. The presumptive test was done by using Brilliant Green Lactose Bile Broth (BGLBB; Merk). Eosin methylene blue agar was used to detect the present or absence of *E. coli* in the samples (Sirockin, 1969). Microbial levels in the food samples were then classified as recommended by Jay (1986).

Results and Discussion

Results of the demographic survey showed that nearly half of the vendors (49%) were those of the age group between 30 - 39 years (Table 1). Only 13% of the vendors were either teenagers or above 50 years of age. It has been reported that the age of street food vendors usually fall between 30 and 50 years and the majority are women (FAO, 1991). The results of this study show that 73% of the vendors fall in this age group. About 79% of the street food vendors were women and only 21% men. Similar observations were also reported in some African countries such as Senegal and Nigeria (Akinyele, 1992; FAO, 1990).

This study has undoubtedly confirmed the observation that in the African setting, women are mainly involved in food preparation and

serving. Contrary to this observation, other studies conducted by FAO (1989) showed that in Asia men were more involved in food vending activities than women. This study has further revealed that the majority of the vendors (92%) have not attained the education level of above primary school. The low level of education among the women food vendors has also been reported by Akinyele (1992) and Ndossi (1992).

According to these authors, women who are usually from low income families, enter this business to supplement the household income.

The main customers of food vendors are single men (68%), students (12%) and low income people (20%) (Table 2). The significance of street foods to low income workers has been reported by FAO (1989). Foods offered by street vendors are not only affordable but are also convenient meals which are available where and when they are needed.

The quality of the prepared foods depends on the raw materials used. The results in Table 2 show that 42% of vendors use either fresh produce from the market or from vendors own farms. Since food vendors go for fresh raw materials it can be expected that prepared foods are also of high nutritional quality (FNA, 1991). Firewood and charcoal were the main source of energy for food preparations (Table 2). This practice definitely raises a lot of concerns over its impact on the environment.

The survey identified cooked rice and stiff porridge (*ugali*) as the two types of foods mainly prepared and served by the vendors. These foods were served in different meal combinations; either with meat stew, cooked beans or cooked green leafy vegetables or a combination of these (Table 3). The most preferred meal by the customers was, however, *ugali* with green leafy vegetables and meat stew (27%) followed by *wali* with beans (17%).

The prices of similar meal combination did not vary significantly from one vendor to the other. The prices of food combinations lied between 200 and 280 TShs. (US \$0.4-0.6). By comparing the

prices of different meals and the number of customers preferring a particular meal, it would seem that prices have no influence over the consumers preference. However, when the consumers were asked to give reasons for preferring a certain meal to another, majority (54%) cited portion size and price as the decisive factors (Table 3). Meal portions served ranged from 600-800g contributing energy and protein of between 171-270 kcal/100g and 9.4-11.9 g protein/100g respectively (Table 3). By comparing protein values with those recommended in the literature (King and Ann, 1992) it is evident that street foods provide more than the recommended daily intake of protein for a normal working man.

However, the amount of calories provided by these meals contributed only about 50% of the recommended calories for a normal working man. The established energy contribution is again much lower than that reported in a similar study by Allain (1991) in which street foods contributed between 500 and 679 kcalories per 100 g food. The results of microbiological examinations showed high levels of contamination in both food and water samples (Table 5 and 6). Some food samples surpassed permissible level of $\leq \log 5$ CFU/g total aerobic counts (Jay, 1986). All food samples investigated had coliform above the acceptable level of $\leq \log 2$ CFU/g food materials (Table 5). *E. coli* was detected in all food samples. High microbial contamination of street food samples were also reported by Akinyele (1992). According to the same author major sources of contamination could be the food materials themselves, contaminated water, poor storage, high storage temperatures and poor food handling and holding practices. The time lapse between food preparation and consumption as well as the temperature at which food is kept are important factors which determine the level of contamination of the food. Carrying of cooked foods from home to the food stalls as practised by 46% of the vendors (Table 2), increased the chances of food contamination. Vendors have different ways of treating the food prior to selling. Only a small portion (18%) of street food vendors sold their foods while hot otherwise the majority (48%) sell their foods cold (Table 2). Many food

vendors (52%) were observed to lack important facilities such as toilets and drainage systems. In a similar study conducted by Monyo (1996), food samples collected from vendors without toilet and drainage facilities were found to be highly contaminated as compared to those collected from stalls with these facilities. Shortage of water supply was common to many stalls. Water supply is mainly from National Urban Water Authority (NUWA) distribution system. The water is often collected from nearby taps and stored in open buckets. This practice increase chances of water becoming contaminated with dust and air borne microorganisms. This possibly explains why water samples taken from the vendors showed high total colony counts of about $\log 3$ CFU/ml (Table 6).

Lack of adequate supply of water vendors has been cited as a major contributing factor to food poisoning (FAO, 1989). The presumptive coliform test gave a contamination of water. In another study conducted by Jiwa et al, (1991), potable water in Tanzania was found to be highly contaminated with coliform bacteria, faecal coliforms, faecal streptococci and clostridium perfringens. The possibility of treated water undergoing deterioration before reaching consumer tape has been reported (Laila et al., 1982).

Table 1: Vendor distribution according to demographic aspects

Demographic aspects	Classification frequency % (N=50)	
Age group (years)	15-20	7.0
	21-29	14.0
	30-39	49.0
	40-49	24.0
	50	6.0
Sex	Male	21.0
	Female	79.0
Marital status	Single	23.0
	Married	61.0
	Divorced	9.0
	Widowed	7.0
Education Level	None	4.0
	Primary	88.0
	Secondary	8.0

Table 2: Vendors response

Characteristic	Frequency (N=50)	%
Cooking	23	46
At home	12	24
At working place	15	30
At home or working place		
Target groups	34	68
Singlemen	6	12
Students	10	20
Low income people		
Source of raw material		
From vendors' farm only	5	10
From farmers only	7	14
Market or vendors' farm	21	42
Farm of market only	17	34
Condition of food prior to selling	24	48
Cold	9	18
Hot	17	34
Cold and Hot		
Toilet and drainage facilities		
Both present	13	26
Both absent	26	52
Drainage only	4	8
Toilet only	7	14
Source of energy	7	14
Fire wood only	6	12
Wood charcoal only	33	66
Fire wood and charcoal	4	8
Electricity and wood charcoal		

Table 3: Consumers' preference and gastrointestinal complains

Characteristic	Frequency % (N=50)	
Consumers preference	27	54
Low price and big volume	16	32
Big volume only	2	4
Low price only	5	10
High quality food		
Gastrointestinal problems after eating street foods		
Experienced	2	4
Not experienced	48	96

Table 4: Favourite meal combinations, cost per portion, protein and caloric contribution/100g (dwb)

Food combination	Price (Tshs.)	Prot. 100g	Kcal. 100g	% (N=50)
Ugali + meat stew + green vegetables	200 ± 9	11.0	270	27.0
Rice + beans	220 ± 10	10.4	171	17.0
Rice + beans + meat stew	260 ± 20	11.9	176	16.0
Rice + meat stew	240 ± 10	9.4	186	10.0
Other combinations	200 ± 10	-	-	30.0

Table 5: Microbial levels per gramme of food samples

Food	Aerobic	Count	Colifor	Count	E. coli	
	≤ 105	> 105	≤ 102	> 102	+	-
	%	%	%	%	%	%
Ugali	60	40	40	60	80	20
Kachumbavi	100	0	20	80	80	20
Meat stew	100	0	85	15	85	15
Bean stew	90	10	30	70	90	10
Leafy veg.	66	33	78	22	89	11
Rice	71	29	43	57	93	7

* classification according to Jay (1986)

Table 6: Microbial levels of water samples

Incubation Temp	CFU/ml on CPA ¹
20	7.6 x 10 ³ 8.4 x 10 ³ (8.0 x 10 ³)
37	3.6 x 10 ³ 3.2 x 10 ³ (3.4 x 10 ³)

Mean values in parenthesis
1 PCA Plate count agar

REFERENCES

1. Akinyele, O. (1992) Background Paper on Street Foods in Africa. Food Basket Foundation International. Ibadan. Nigeria pp 1-40.
2. Allain, A. (1988). Street Foods, the Role and Needs of Consumers. Expert Consultation on Street Foods. Jugjakarta, Indonesia FAO vol 18 No. 4.
3. AOAC (1991). Official Methods of Analysis. Washington, DC Association of Official Analytical Chemists.
4. Burth, g. (1983). Street Foods Informal Sector. Food Preparation and Marketing in the Philippines. Chevychase, Maryland, USA. Equity Policy Centre Vol. 28 No. 5 & 6.
5. Cohen, M. (1986). The Influence of the Street Food Trade on Women and Children Health. In Jellife: Advances in International Maternal and Child Health. Vol 6. Oxford Clarendon Press.
6. DeMan, J. (1975). The Probability of Most Probable Number Europ. J. App. Microb. 1,67.
7. FAO, (1987). Study on Street Foods in Ibadan. Characteristics of Food Vendors and Consumers Implications for Quality and Safety. University of ibadan, Ibadan, Nigeria.
8. FAO, (1992). Background on Street Foods in Africa. International Workshop on Street Foods in Africa, Accra, Ghana.
9. FAO, (1991). Study on Street Foods in Nigeria. Comparative Study of the social Economic Characteristics of Vendors and Consumers in Ibadan, Lagos and Kaduna, FAO/FBFI Nigeria, pp 1-56.
10. FAO, (1990). Street Foods. FAO Food and Nutrition Paper 46. FAO, Rome pp 1-24.
11. FAO, (1989). Street Foods. A Summary of FAO Studies and Activities Related to Street Foods, AO, Rome pp 1-28.
12. FNA, (1991). Street Foods in Developing Countries, Lessons from Asia. FAO, Rome Italy.
13. Jay, J.M. (1989). Modern Food Microbiology, 3rd Ed Van Nostrad Reinhold Company NY, p 409-508.
14. Jiwa, S. Mugula, K. and Msangi, J. (1991). Bacteriological Quality of Potable Water Sources Supplying Morogoro Municipality and Its Outskirts: A Case Study in Tanzania. J. Epidemiol. Infect. 107, 479-484
15. King, F.S. and Ann, B. (1992). Nutrition for Developing Countries, 2nd Ed Oxford University Press pp 24-25.
16. Kirk, R. and Sawyer, R. (1991). Pearson's Composition and Analysis of Foods. 9th Ed. ongman Group UK.
17. Laila, E. Aleya, A., Amal, E., (1982). Olfat E. The Sanitary Contamination of Drinking Water in a Nile Delta Village. J. Hyg 88:63-7.
18. Malijani, A. and Kambaila, J. (1992). Country Paper on Street Foods in Zambia. Paper Presented at Inter country Workshop on Street Foods in Africa. Accra, Ghana, 27 April - 1 May 1992 FAO Regional Office Accra, Ghana.
19. Mony, H.M. (1996). Microbiological Quality, Protein and Caloric Values of Street Food Sld in Industrial Areas in Dar es Salaam M. Sc. Thesis, Nairobi (Unpublished.)
20. Ndossi, J.P.N. (1992) Country Paper on Street Foods in Tanzania. Paper Presented at Inter country Workshop on Street Foods in Africa Accra, Ghana 27 April - May 1992, FAO Regional Office Accra, Ghana pp 1-69.

21. Rauscher, K. (1996). Untersuchung von Lebensmitteln, VEB Leipzig, Germany.
22. Refai, M.K. (1979). Manual of Food Quality Control 4. Microbiology Analysis. Food and Agriculture Organisations of UN, Rome, pp D1 - D7.
23. Sirockin, G. (1969). Practical Microbiology, MacGraw - Hill London, Pg 103 - 105.
24. The URT, (1989). The 1988 Population Census: Preliminary Report Planning Development pp 77-82.
25. The URT, (1989). The Informal Sector. Planning Commission and Ministry of Labour and Youth Development, Gov. Printer, Dar es Salaam pp 10-20.
26. Van Soest, P.J. Wine, R.H. (1967). Use of Detergents in the Analysis of Fibrous Foods. The Determination of Plant Cell Wall Constituents. J. Assc. Agric. chem 50:50-55.
27. Wirnamo, F. (1988). Street Foods and Its Problems with Special Reference to Indonesia. Expert Consultation Street Foods. Jugjakarta, Indonesia. FAO, Vol. 6 No. 3.



COURSE ON MANAGEMENT OF FOOD AND NUTRITION PROGRAMMES FOR DISTRICT MANAGERS MAY - JUNE EVERY YEAR

The Tanzania Food and Nutrition Centre (TFNC) conducts a course on Management of Food and Nutrition Programmes for district level personnel who deal with food and nutrition or related programmes. The course runs for six weeks from May to mid June every year. For further information on the course, contact:-

The Managing Director,
Att: Management Course Coordinator,
P.O. Box 977,
Dar es Salaam.

Fax: . 051 - 116713
Telex: 41280

IRON AVAILABILITY IN WEANING FOODS AS AFFECTED BY NUTRIENT INHIBITORS

Towo, E. and Tatala, S.

Tanzania Food and Nutrition Centre

RUNNING HEAD: IRON SOLUBILITY AND TANNIN CONTENT

Abstract

Cereals and legumes are extensively used to prepare weaning foods in developing countries like Tanzania. Tannins are known to inhibit iron bio-availability by forming complex iron ligands in the gut thereby making the iron unavailable for absorption. The long term effect of this is a contribution to the causation of iron deficiency and then to anaemia. The effect of tannins is higher in foods of plant origin particularly those based on cereals and legumes.

The tannin and iron content, in cereal-legume based weaning blends collected from local markets in Dar es Salaam were analysed in the Food Science laboratory at TFNC and Gothenburg, Sweden. The results showed that tannin content ranged between 164mg and 359mg per 100gram sample. Total iron ranged from 1.6 to 20.7mg per 100gram sample. Percentage soluble iron ranged from 2.2 to 45%. There was significantly ($p < 0.001$) high correlation between low iron solubility and high tannin content in the samples. The correlation coefficient was negative 0.89.

Samples with high iron content were observed to have high amount of tannins and with a low percentage of soluble iron. It is concluded that iron solubility depends much on the amount of tannin compounds present in the food mixtures and does not depend on the total iron content. Suggestion is, therefore, made to subject cereal or legume grains with high amount of tannin compounds into various pre-treatments such as soaking, germination and or fermentation to reduce these compounds into minimal level before mixing to produce weaning food blends.

Key words: Cereals, legumes, tannin, iron solubility, anaemia.

Introduction

Many of the diets consumed in developing countries are of plant origin which contain non-haem iron. Absorption of non-haem iron is very poor since it depends on various food components which may enhance or inhibit its absorption in the gut. Among the enhancers of iron absorption are ascorbic acid and meat, and the main inhibitors are phytic acid and phenolic compounds like tannins (Radhakrishnan and Sivaprasad, 1980; Brune et al., 1989; Sulunkhe et al., 1990; Siegenberg et al., 1991; Svanberg et al., 1993). Cereals and legumes which are the main food staples in developing countries contain various amounts of phytic acids and phenol compounds occur widely (Deshpande et al., 1984; Salunkhe et al., 1990). These food grains are widely used in the preparation of weaning foods.

Iron deficiency anaemia is a problem in both developed and developing countries, affecting about 1,000 million people worldwide, including 370 million women of child bearing age (West, 1996). In developing countries like Tanzania, iron deficiency is primarily a problem of women and young children. Among the causes of iron deficiency, anaemia is the low dietary iron availability for absorption. Community based processing/treatment techniques which have been shown to have reducing effect on tannin compounds and phytates include grain dehulling, soaking, germination and fermentation (Udayasakhara-Rao and Deosthale, 1987; Khetarpaul and Chauhan, 1989; Uzogora et al., 1990; Obizoba and Atii, 1991; Babiker and El-Tinay, 1992; Sharma and Sehgal, 1992; Obizoba and Egbuna, 1992; Mukuru et al., 1992; Svanberg et al., 1993; El-Khalifa and El-Tinay, 1994; Yadav and Khetarpaul, 1994). These methods have been recommended by various researchers as a means

of producing more nutritious food ingredients in the community. Combination of these methods may be more effective in reducing tannin content in food grains. This paper reports on a study conducted to investigate the amount and effect of tannin in cereals and legume based traditional weaning food blends prepared at small scale and sold in Dar es Salaam markets on iron availability for absorption.

Materials and methods

Sample collection and storage

The common cereal or legume flour blends used in preparation of weaning foods were purchased from local markets and shops in Dar es Salaam. The samples were brought to the laboratory for storage. The samples for iron content and iron solubility were first freeze dried and later subjected to appropriate tests.

Analysis of tannin content

Tannin content was analysed by the Prussian Blue Test method (Price and Butler, 1977). The method is based on the reducing of phenolic compounds to the p-phenol.

A weighed sample of about 60mg of the grounded food (flour) was taken and 5ml of the extraction solvent (water/salt solution) was added and homogenized by shaking vigorously using laboratory shaker for one minute. The mixture was centrifuged for 10 minutes at 5,800 r.p.m. and the clear solution was collected. The remainders in the test tubes were rinsed by 5ml of the solvent with vigorous shaking, centrifuged for 5 minutes at the same speed and the clear solution was collected and added with the first (making up a total of about 10ml). The volumes were raised to 50 ml by distilled water in a volumetric flask and the Prussian Blue reagents were added as described above. Optical density (absorption) was measured at 720 nm after 10 minutes. The results were expressed as gram tannin acid equivalent (T.A.E.) per 100g sample.

Analysis of iron solubility

Physiological simulation system based on papin

and pancreatic activities was used to analyse the iron solubility of the samples (Svanberg et al, 1993). Samples were freeze dried and digested using a simulated physiological system with pepsin and pancreatin. Atomic absorption spectrophotometry was used to analyse the soluble iron in the samples.

Statistical analysis

Microsoft excel package for windows was used to determine the correlation coefficients between iron status and tannin content and their respective p-values.

Results

Tannin and iron content in various groups of cereal-legume based weaning blends purchased from local markets and shops in study areas are summarized in Table 1.

Table 1: Iron content, solubility and tannin content in groups of weaning blends

Weaning blend group	Total iron (mg/100g)	Soluble iron (mg/100g)	Soluble iron (%)	Tannin (mgTAE/100g)
Group (a)	5.1 - 8.5	0.64 - 0.99	11.6 - 13.7	304.0 - 322.5
Group (b)	2.9 - 20.7	0.45 - 0.61	2.2 - 21.0	234.5 - 359.0
Group (c)	1.8 - 2.2	0.40 - 0.46	22.0 - 24.2	185.0 - 185.5
Group (d)	1.4 - 1.8	0.66 - 0.76	41.6 - 48.4	160.0 - 168.0
Group (e)	5.6 - 7.6	0.58 - 0.64	8.9 - 9.9	285.0 - 325.0
Average	6.0	0.63	17.2	271.8

- a) cereals, beans, groundnuts; b) cereals, beans, groundnuts, rice; c) cereals, groundnuts, fish, d) wheat only; e) finger millets only.

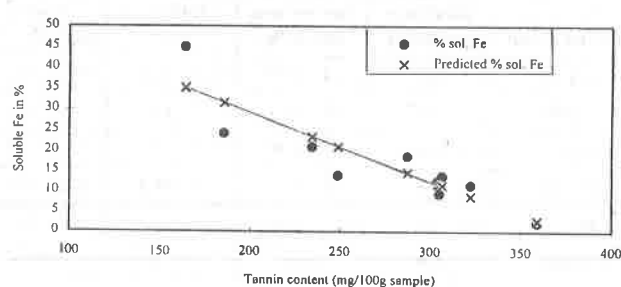
The average total iron was 6.0mg/100g dry matter and tannin was 271.8mg T.A./100g while the mean soluble iron was 17.2%. For all the mixtures, groups of cereal/legume weaning food blends with highest percentage soluble iron had a relatively lower concentration of tannins (c). On the other hand, food blends with high iron content contained a similarly high amount of tannins but with a relative low percentage of soluble iron (a, b). The blend with finger millet only (e) also contained relatively high amount of iron and of tannin but low percentage of soluble iron. The blend formulated by wheat only (d) contained the lowest amount of tannin and iron

but had the highest percentage soluble iron (41 - 48%). The correlation coefficient between iron status and tannin content in the analysed weaning food blends were highly significant ($p < 0.001$) when tannin content was associated with percentage soluble iron (correlation coefficient was 0.89) (Table 2). The relationship between total iron content and tannin content shows a correlation coefficient of +0.74. The associations between percentage soluble iron and tannin content in the analysed weaning food blends are further illustrated in Figure 1.

Table 2: Correlation coefficient between iron status and tannin content in cereal/legume weaning blends and their respective P-values

Parameters	Correlation coefficient	P-value
Total iron and tannin	0.738	<0.02
Total iron and % soluble iron	-0.6741	<0.05
Tannin and % soluble iron	-0.8935	<0.001

Fig. 1: Correlation between tannin content and iron solubility



Discussion

From the results of this experiment, it is evident that inhibitory effects of tannin on soluble iron is relatively high. Food blends with high tannin content were shown to have low percentage soluble iron. Similar results have been indicated by other researchers (Radhakrishnan and Sivaprasad, 1980; Brune et al., 1989; Salunkhe et al., 1990; Siegenberg et al., 1991; Svanberg et al., 1993). Siegenberg et al., (1991) showed that by adding 12mg tannin acid reduced absorption by almost 70%. Similar results were earlier reported by Brune et al., (1993) indicating poor availability of *in vitro* iron from high-tannin cereals as compared to low-tannin cereals.

The groups of the foods analysed are very common in the markets and shops in Tanzania and are sold for the purpose of feeding the weaning children. Most of the blends are formulated by mixing one or several cereal grains with legume(s) and grind them into flour. Very often used cereals are the finger millets which are known to contain a significant amount of tannins (Khetarpaul and Chauhan, 1989; Svanberg et al., 1993). Red beans are the extensively used legume in formulating the weaning food blends. Legumes like red beans are known to contain significant amount of antinutritional factors like tannins (Bressani et al., 1982; Khetarpaul and Chauhan, 1990; Obizoba and Atii, 1991; Alzueta et al., 1992; Obizoba and Egbuma, 1992; Sharma and Sehgal, 1992; Towo and Svanberg, 1997).

It is, therefore, vivid that consumption of the weaning food blends formulated from high tannin ingredients will contribute significantly in lowering the amount of soluble iron from such mixtures and hence contribute to the problem of nutritional anaemia in the country. In formulating these blends efforts have to be made in improving iron availability for absorption from such blends. Inhibitory effect of tannins can be reduced by mixing grains having low tannin content during formulation of the blends.

Another possibility of reducing the inhibitory effect of tannin to iron solubility is subjecting the high tannin food grains into various pre-treatments which are known to have reducing effect on tannin content. Community based processing/treatment techniques which have shown to have reducing effect on tannins include germination (Bressani and Elias, 1980; Udayasakhara-Rao and Deosthale, 1987; Khetarpaul and Chauhan, 1990; Obizoba and Atii, 1991; Obizoba and Egbuna, 1992; Sharma and Sehgal, 1992), soaking (Uzogora et al., 1990; Obizoba and Atii, 1991; Bakiker and El-Tinay, 1992; Mukuru et al., 1992) and fermentation (Khetarpaul and Chauhan, 1989; Obizoba and Atii, 1991; Obizoba and Egbuna, 1992; Mukuru et al., 1992; Svanberg et al., 1993; El-Khalifa and El-Tinay, 1994; Yadav and Khetarpaul, 1994).

Conclusion

Focusing on these study results, it can be said that iron solubility of the analysed cereal and legume locally prepared weaning blends depends significantly on the tannin content rather than total iron content. This calls for proper pre-treatment of these grains to reduce tannin compounds and improve the iron solubility. Methods suggested for the pre-

treatment of the grains with high tannin content before mixing to formulate weaning food blends include soaking, germination and fermentation processes which have been indicated to have reducing effect on tannin compounds.

References

1. Alzueta, C. Trevino, J. and Ortiz, L. (1992). Effect of Tannins from Faba Beans on Protein Utilization in Rats. *J. Sci. Food Agr.* 59:551.
2. Babiker, E.E. and El-Tinay, A.H. (1992). Effect of Alkali on Tannin Content and In-vitro Protein Digestibility of Sorghum Cultivars. *Food Chem.* 45:55.
3. Bressani, E.; Elias, L.G.; and Braham, J.E. (1982). Reduction of Digestibility of Legume Proteins by Tannins. *J. Plant Foods*, 4:43.
4. Brune, M. Rossander, L. and Hallberg, L. (1989). Iron Absorption and Phenolic Compounds: Importance of Different Phenolic Structures. *Europ. J. Clin. Nutr.* 45:545.
5. Deshpande, S.S. Sathe, S.K. and Salunkhe, D.K. (1984). Chemistry and Safety of Plant Polyphenols. *Adv. Exp. Med. Biol.* 177:457.
6. El-Halifa, A.O. and El-Tinay, A.H. (1994). Effect of Fermentation on Protein Fraction and Tannin Content of Low-and High-tannin Cultivars of Sorghum. *Food Chemistry*. 49:265.
7. Khetarpaul, N. and Chauhan, B.M. (1989). Effect of Fermentation by Pure Cultures of Yeasts and Lactobacilli on Phytic Acid and Polyphenol Content of Pearl Millet; *J. Food Sci.* 54:780.
8. Mukuru, S.Z; Butler, L.G. Rogler, J.C; Kirleis, A. W; Ejeta, G; Axtel, J.D. and Mertz, E, T. (1992). Traditional Processing of High-tannin Sorghum Grain in Uganda and its Effect on Tannin, Protein Digestibility, and Rat Growth. *J. Agric. Food Chem.* 40:1172.
9. Obizoba, I.C. and Atii, J.V. (1991). Effect of Soaking, Sprouting, Fermentation and Cooking on Nutrient Composition and Some Anti-nutritional Factors of Sorghum (Guinea) Seeds; *Plant Food for Human Nutrition*, 41:203.
10. Obizoba, I.C. and Egbuna, H.I. (1992). Effect of Germination and Fermentation on the Nutritional Quality of Bambara Nut (*Voandzeia Subterranea L. Thouars*) and its Product (milk). *Plant Food Human Nutr.* 42:13.
11. Price, M.L. and Butler, L.G. (1977). Rapid Visual Estimation and Spectrophotometric Determination of Tannin Content of Sorghum Grain; *J. Agric. Food Chem.* 25:1268.
12. Radhakrishnan, M.R. and Sivaprasad, J. (1980). Tannin Content of Sorghum Varieties and Their Role in Iron Bioavailability. *J. Agric. Food Chem.* 28:55.
13. Salunkhe, D.K. Chavan, J.K. and Kadam, S.S> (1990). *Dietary Tannins: Consequences and Remedies*, C.R.S. Press Inc. Boca Raton Florida.
14. Sharma, A. and Sehgal, S. (1992). Effect of Domestic Processing, Cooking and Germination on the Trypsin Inhibitor Activity and Tannin Content of Faba Bean (*Vicia faba*); *Plant Food for Human Nutrition*, 42:127.

15. Siegenberg, D. Baynes, R.D. Bothwell, T.H. Macfarlane, B.J. Lamparelli, R.D. Car, N.G. MacPhail, P. Schmidt, U. Tal, A. and Mayet, F. (1991). Ascorbic Acid Prevents the Dose-dependent Inhibitory Effects of Polyphenols and Phytates on Nonhaem-iron Absorption. *Am. J. Clin. Nutr.* 53:537.
16. Svanberg, U. Lorri, W. and Sandberg, A.S. (1993). Lactic Fermentation of Non-tannin and High Tannin Cereals: Effects on In-vitro Estimation of Iron Availability and Phytate Hydrolysis. *J. Food Sci.* 58:408.
17. Towo, E. and Svanberg, U. (1977). Polyphenol Content of Various Legumes and Cereals as Determined by the Prussian Blue Test Method. *Food and Nutrition Journal of Tanzania*, Vol. 8: 2: 19 - 23.
18. Udayasakhara Rao, P. and Deosthale, Y.G. (1987). Polyphenoloxidase Activity in Germinated Legume Seeds; *J. Food Sci.* 52: 1549.
19. Yadav, S. and Khetarpaul, N. (1994). Indigenous Legume Fermentation: Effect of Some Antinutrients and In-vitro Digestibility of Starch and Protein. *Food Chem.* 50:403.
20. Uzogora, S.G.; Morton, I.D. and Daniel, J.W. (1990). Changes in Antinutrients of Cow Peas (*Vigna unguiculata*) Processed with *kanwa* Alkaline Salt. *Plant Foods Hum. Nutr.* 40:209.
21. West, C.E. (1996). Iron deficiency: The Problem and Approaches to its Solution. *Food and Nutrition Bulletin*, 17:1:37-41.



PROTEIN BIO-AVAILABILITY IN BULRUSH MILLET

Kingamkono, R.R.

Tanzania Food and Nutrition Centre

Abstract

Dietary fibre, phytic acid, *in-vitro* and *in-vivo* protein availability in bulrush millet were studied in relation to germination, traditional dehulling and cooking. Flour samples were prepared either by dehulling the grains to produce flour of 80%, 71% or 63% extraction rate or by germinating the grains for 48 or 72 hours. Whole flour from ungerminated bulrush millet was used as control. Weaning male Sprague-Dawley rats aged 23 days weighing between 52-63.2g were used to test the bio-availability of the flours. Both cooked and uncooked flour samples were tested and casein diet was used as control.

Germination increased dietary fibre but reduced phytic-phosphorus (phytic-P) and tannin. Dehulling decreased dietary fibre, phytic-P and increased tannin. Only the highly refined uncooked flour showed a slight increase in-vitro protein digestibility (86.3 to 89.8%). Bran showed the least digestibility and cooking lowered digestibility of all samples by about 12 to 35%. Total digestibility (TD), biological value (BV) and net protein utility (NPU) of all diets were significantly lower ($p < 0.05$) than casein diet. Germination improved BV and NPU in cooked diets. Dehulling improved protein digestibility but adversely affected BV and NPU. Cooking lowered BV and NPU of ungerminated whole flour. TD was lowered only in 80% extracted flour after cooking.

Introduction

Bulrush millet is one of the main staple foods in drought prone regions in Tanzania where together with sorghum, it provides more than 70% of the total energy intake (Mosha, 1985). This cereal is reported to be equal or sometimes superior to other cereals in nutrient content (Badi et al., 1976; Hulse et al., 1980; Desai & Zende 1979).

However, the utility of such nutrients may be physiological limited by the interactions of food constituents in the meal during food processing and preparation. Dehulling of grains normally results in reduce dantinutritional factors such as dietary fibre, tannin and phytic acid and germination improve the quantity and quality of some of the nutrients in grain foods (Hulse et al., 1980). No study reports the effect of traditional dehulling or germination of bulrush millet on antinutritional factors and protein bio-availability in Tanzania. This study was carried out to determine the effect of traditional dehulling and germinating bulrush millet on dietary fibre, tannin, phytic acid and protein bio-availability.

Materials and Methods

A commercial sample of local bulrush millet variety was obtained from a food market in Dar es Salaam. After careful cleaning and washing some grains were directly air dried at 50°C and the rest were soaked overnight. Germination was then done at room temperature (20°C) and samples drawn after 48 hours and 72 hours germination followed by air drying.

Sample processing and preparation

Ungerminated grains were traditionally dehulled in a laboratory using a traditional mortar and pestle to produce 80%, 71% and 63% dehulled grains. These were washed before air drying. The bran from the 80% extraction rate was air dried and kept for analysis. All the samples were then milled using a plate mill (Falling number AB, Stockholm, Sweden). Flour obtained from ungerminated whole grain was used as controls.

Samples for protein digestibility were cooked in glass beakers using distilled water and immersed in boiling water of about 100° for 20 minutes. The porridges were then freeze dried before analysis or diet formulation.

Determination of dietary fibre, tannin and phytic acid

Dietary fibre was determined according to Theander, (1983). Phytic-phosphorus was determined according to Nordic Committee on Food Analysis, Method 57 and 17 (1965). Tannin was determined as catechin equivalent by vanillin assay (Burns, 1971) and as modified by Price et al., (1978).

Determination of nutrient bio-availability

In-vitro protein digestibility was determined using bovine pepsin as described by Axtell et. al., (1981) and modified by Mertz et al., (1984). In-vivo protein digestibility was done according to Eggum (1973) and modified by Forsum (1975). The diets were formulated to contain 9.3% protein, 10% oil, 5% minerals and 1% vitamins. The minerals and vitamins mixture were formulated as described by Forsum et al. (1973). Weaning male Sprague-Dawley rats aged 23 days and weighing between 52-63.2g were used. Feeding of test diets was done for 9 days including 5 last days as balance period.

Data analysis

Data for the dietary fibre, tannin, phytic acid, in-vitro bio-availability was analysed using simple calculations and means presented. The in-vivo data were subjected to a statistical analysis using Student-Newman Keuls test.

Results

Dietary fibre, tannin, and phytic acid

Table 1 presents the results for dietary fibre, tannin and phytic-acid after dehulling or germination of the millet grains. Crude dietary fibre was reduced from 6.3% in the ungerminated whole flour to 4.2% and 3.6% in the dehulled flours (80% and 63% extraction rate respectively.) Germination increased dietary fibre from 6.3% in the ungerminated whole flour to 7.8% in the 48 hours germinated sample.

Dehulling reduced the tannin content 55 mg/100 g to 30mg/100 in the ungerminated whole flour

and in the 80% extraction flour respectively (a 45.5% reduction). There was also a considerable reduction of tannin from 55mg/100g in the ungerminated whole flour to 42mg/100g in the 72 hours germinated flour (a 23.6% reduction).

Phytic-P was lowest in the dehulled flour (133mg/100g) and highest in the bran fraction (501.7mg/100g). Dehulling resulted in a substantial reduction of phytic-P from 169mg/100g in the ungerminated whole flour to 133mg/100g and 109mg/100g in the dehulled flours (80% and 63% extraction rate respectively). Germination caused a slight reduction in phytic-P from 169mg/100g to 160mg/100g in the germinated flours. The ratio of phytic-P to the total-P was reduced from 0.61 in the ungerminated whole flour to 0.55 after 48 hours germination and 0.59 after dehulling to 80% extraction.

Protein bio-availability

Table 2 summarizes results for in-vitro and in-vivo protein bio-availabilities. In uncooked samples, digestibility ranged from 74.7% in the bran fraction to 89.8% in the most refined flour (63% extracted flour). Dehulling increased digestibility slightly. Cooking lowered the digestibility of all samples considerably with dehulled flours being the most affected (reduction of over 30%).

Food intake was lower in the diets made of refined flours compared to the reference (casein) and whole flour diets. Protein efficiency ration (PER) was highest in the casein diet (3.8%) and lowest (1.2) in the cooked most refined flour. The PER in the whole flour diets ranged from 1.9 to 2.6 being slightly higher in the uncooked diets and the germinated diets.

Total digestibility (TD), biological value (BV) and net protein utility (NPU) of all tested diets were significantly lower ($p < 0.05$) than casein diet. In the uncooked diets dehulling significantly improved TD but lowered BV and NPU ($p < 0.05$). Dehulling significantly improved TD in the highly refined diet (71% extracted flour) only ($p < 0.05$).

Discussion

There was no data available on dietary fibre content in whole ungerminated bulrush millet to which the value, (6.3%, Table 1) observed in this study could be compared with except for crude fibre which in most cases underestimates the total fibre. However, compared to other cereals, the value obtained in this study was lower than the value obtained in wheat (11.5%, rye (14.6%), barley (18.6%), sorghum (9%) and maize (9.3%) as reported by Nyman et al., (1984).

Removal of bran which contains big proportions of fibrous material and ligning accounts for the reduced dietary fibre after dehulling. On the other hand, the increase in dietary fibre after germination can be attributed to the reduction in starch which gets catabolized to supply energy for the growing seedling, resulting into increased total dry matter loss. This, in turn, increased the proportion of the less catabolizable components such as dietary fibre (Wu, 1982). Opoku et al., (1981) observed an increase of lignin by 3-4 times and crude by 44% after germinating bulrush millet for 84 hours.

Phytic acid values observed in this study correspond with values in some varieties of bulrush millet reported by Simwemba et al., (1984). However, Ifon (1981), observed lower values (104mg/100g) and Opoku, (1981) higher values (264mg/100g) than what was observed in this study. The differences are largely due to varietal and agronomical differences. Simwemba et al., (1984) obtained values ranging between 179 and 360mg/100g when studying four varieties of bulrush millet grown in two different locations.

The increase in phytase activities during germination (Reddy et al., 1982) is responsible for the 5% drop in phytic acid content recorded after germination. Sankara Rao et al., (1983) recorded a 60% reduction in phytic acid after germinating bulrush millet for 72 hours.

According to Reddy et al., (1982), phytic acid in bulrush millet is concentrated in the aleurone layer, germ and pericarp. Dehulling which leads to removal of such portions is, therefore,

responsible for the reduced phytic acid (Reddy et al., 1982) in dehulled flours. The high recovery of phytic acid in the bran supports the above argument. Simwemba et al., (1984) also recovered high phytic acid in the bran compared to the whole grain much of which was associated with germ.

The value for tannin (55mg/100g) obtained in the ungerminated whole flour (Table 1) is very low compared to 1600mg/100g as reported by Opoku et al., (1981). The difference can also be attributed to varietal and agronomical differences.

Tannin is also concentrated in the outer layer of seeds accounting for the reduction in the dehulled flour. Reduction in tannin was also reported by Chibber et al., (1980) and Mosha, (1985) in high tannin cereals.

There was also a considerable reduction of tannin by 23.6% after germination which agrees with Opoku et al., (1981) who reported a 48% reduction in tannin after germinating bulrush millet for 84 hours. The in-vitro digestibility of 86.3% obtained in the ungerminated uncooked diet (Table 2) is slightly higher than (74.8% to 63.2%) in sorghum as reported by Mertz et al., (1984) using the same method. It, however, compares well with (82-88%) as reported by Ramachandra et al., (1977).

The increased digestibility after dehulling may be due to low content of dietary fibre, phytic acid and possibly polyphenols (Table 1). The bran which contained high concentration of dietary fibre and phytic acid (Table 1) showed the least digestibility. Numerous reports have indicated the same trend in other cereals (Ramachandra et al., 1977; Chibber et al., 1980; Mosha 1985).

Raw diets were used to compare the effect of cooking on the digestibility. Like in sorghum (Axtell et al., 1981; Mosha, 1985) cooking lowered digestibility (Table 2). Tannin and polyphenols in cooked sorghum (Mosha, 1985) and phytic acid (Reddy et al., 1982) adversely affected the protein digestibility.

The large drop in digestibility (33-35%) in the cooked refined flours compared to whole flours

and bran (Table 2) may be due to several factors. Protein denaturation particularly albumin-globulin during cooking (Banos et al., 1978) may have resulted in decreased protein digestibility. Previous studies on milled rice (Eggum, 1977) indicated selective effect of cooking on the digestibility of individual amino acids. Eggum (1977) observed that lysine in rice was the least denatured and showed the highest digestibility after related to lysine content. The protein of refined flours are normally lower in lysine content than whole flours and bran (Kingamkono, 1996). On the other hand, the endosperm structure of bulrush millet may also account for the observation. Eggum (1977) suggests that proteins in the protein bodies occurring in the endosperm may be selectively denatured during cooking and/or the protein bodies may remain intact after cooking. Protein bodies occurring in the vitreous endosperm of bulrush millet are embedded in protein and starch which may be facilitated even more during cooking accompanied with selective denaturation of proteins in the protein bodies, may hinder enzyme contact with their substrates thus leading to low digestibility.

The low digestibility in cooked samples can also be explained by the fact that prolamins and glutelins are the main protein fractions occurring in the bulrush millet endosperm (Nwasike et al., 1979; Hulse, 1980). Amino acid composition of indigested cooked protein in milled rice (Eggum, 1977) was found to be similar to that of prolamins. Moreover, prolamins of bulrush millet are devoid of lysine (Nwasike et al., 1979) which supports the lower digestibility upon commercially present preferentially hydrolyze lysine rich proteins than lysine low proteins, which also contributed to the observed results.

The BV and NPU of the ungerminated uncooked whole flour (Table 2) in this study were much lower than BV (83 to 85%) of bulrush millet reported by Desai et al., (1979). However, TD value of (90.4%) of the same sample agreed with TD (89%) reported by the same authors.

Compared to wheat, maize and sorghum the BV, TD and NPU of ungerminated whole uncooked

bulrush millet in this study compared well with corresponding values for wheat and maize but were relatively higher than for sorghum as reported by Eggum, (1973) using the same method.

Lysine is a limiting amino acid in cereals. The improved BV and NPU observed in cooked germinated diets compared to cooked ungerminated diets is due to improved lysine content in the germinated diets (Kingamkono, 1996). The lowered BV and NPU in dehulled diets both in uncooked and cooked diets compared to whole flour diets (Kingamkono, 1996). The same explanation can also be extended to the improved PER in germinated products as opposed to dehulled diets. Germinated bulrush millet was observed to have a high lysine chemical score than dehulled flours (Kingamkono, 1996).

Both dietary fibre and phytic acid contents were negatively correlated to the in-vitro digestibility in the uncooked samples ($r = -1$). The relationship was, however, weak ($r = -0.3$) with tannin content. Dietary fibre, phytic acid and tannin were also negatively correlated to TD ($r = -0.89$ to -0.98) in uncooked as well as cooked diets. The BV and NPU were also negatively correlated more by phytic acid and tannin ($r = 0.7$ to -0.88) but less with dietary fibre ($r = 0.56$ to -0.72). This implies that removal of dietary fibre, tannin and phytic acid is beneficial to protein digestibility, biological value and overall protein utilization.

The negative effect of dietary fibre to TD was also reported by Cornu and Delpenchi (1981); Bach Knudsen et al., (1983) and tannin and polyphenols in sorghum by Price et al., (1985). In-vivo animal assays have also revealed a negative influence of dietary fibre, phytic acid and tannin on protein digestibility (Reddy et al., 1982; Chibber et al., 1980). The whole flours contained relatively higher ash content than dehulled flours which may partly explain the lower digestibility in the whole flours.

The reduced BV after cooking the ungerminated whole flour is partly due to low metabolizable energy (Eggum, 1977; Englyst et al., 1981; Bach Knudsen et al., 1985) as a result of enzyme-

resistant-starch formation during the cooking process.

The reduced metabolizable energy, on the other hand, may have resulted in the available protein being used to supply energy to offset the energy deficit thus lower BV.

The formation of enzyme-resistant-starch upon cooking is less pronounced in the germinated samples probably due to the fact that some starch was already hydrolysed into simple sugars during germination prior to cooking thus being more available for energy metabolism thus sparing protein for growth. This argument is further supported by the significant higher BV in the germinated cooked diets than the ungerminated cooked diets. Fermented products were also found to have less formation of enzyme-resistant-starch upon cooking (Bach Knudsen et al., 1985) presumably due to starch hydrolysis during fermentation. Since NPU is a function of TD and BV, reduction in BV and TD in the cooked ungerminated whole flour has resulted in reduced NPU.

Conclusion

Content of antinutritional factors such as dietary fibre, tannins and phytates were high in the whole ungerminated flours, however, dehulling and germination reduced the contents substantially.

Germination was more useful in both reducing the antinutritional factors at the same time improving the protein quality. The increased lysine during germination subsequently increased the chemical score resulting in improved protein bio-utility. The high losses of lysine (the most limiting amino acid in cereals) in the highly refined flours results in poor protein quality and thus bio-utility. It is recommended that the germinated cereal flour is suitable for use in preparing porridges for child feeding.

Table 1: Dietary Fibre (DF), Tannin & Phytic Acid (PA) on Dry Weight (Crude %)^a

	DF	Tannin ^c	Phytic-P	Phytic-P/Total-P
Whole flour				
Ungerminated	6.3	55	169	0.61
48 hrs germination	7.8	54	160	0.55
72 hrs germination		42	160	-
Dehulled flour				
80% extraction	4.2	30	133	0.59
63% extraction	3.6	-	109	-
Bran fraction ^b	21.8	-	501.7	0.74

- a) Mean of duplicate
- b) bran from 80% extraction flour
- c) as catechin equivalent

Table 2 IN-VITRO AND IN-VIVO PROTEIN AVAILABILITY^{1,2}

	In-vivo protein availability						
	In-vitro protein digestibility	Intake (g)		Weight gain (g/100g) food intake	PER	%	
		food	protein			TD	BV
							NPU
Casein ³		46.0	4.5	37.0	3.8	99.9 ^a	91.1 ^a
<i>Whole flours uncooked</i>							
Ungerminated diet							
Germinated 48 hours	86.3	42.3	4.1	20.0	2.0	90.4 ^{de}	57.8 ^c
Germinated 72 hours	86.7	43.3	4.2	22.0	2.3	88.7 ^{ef}	58.3 ^c
<i>Whole flours cooked</i>							
Ungerminated diet	-	46.4	4.1	23.2	2.6	89.8 ^{de}	59.3 ^{bc}
Germinated 48 hrs.	68.0	40.3	3.7	17.4		89.1 ^{def}	52.2 ^d
Germinated 72 hrs.	76.8	43.5	4.4	20.0		86.9 ^f	58.1 ^c
	-	44.6	4.2	19.4		89.7 ^{de}	62.3 ^b
							91.2 ^a
							52.2 ^{bc}
							51.8 ^{bc}
							53.3 ^{bc}
							47.1 ^{de}
							50. ^{cd}
							55.9 ^b

cont. IN-VITRO AND IN-VIVO PROTEIN AVAILABILITY^{1,2}

	In-vivo protein availability						
	In-vitro protein digestibility	Intake (g)		Weight gain (g/100g) food intake	PER	%	%
		food	protein			TD	BV
							NPU
<i>Traditional dehulled uncooked</i>							
80% extraction flour	87.5	37.3	3.5	12.0	1.3	95.5 ^b	49.5 ^d
71% extraction flour	-	35.7	3.5	14.1	1.4	94.5 ^b	49.7 ^d
63% extraction rate	89.8	-	-	-	-	-	47.3 ^{de} 47.0 ^{de}
<i>Traditional dehulled cooked</i>							
80% extraction flour	56.9	35.3	3.3	16.7	1.8	92.0 ^{cd}	50.9 ^d
71% extraction flour	-	35.6	3.5	10.8	1.2	93.5 ^{bc}	48.1 ^d
63% extraction rate	60.3	-	-	-	-	-	46.7 ^{de} 45.1 ^e
Bran fraction uncooked	74.7	-	-	-	-	-	-
Bran fraction cooked	65.8	-	-	-	-	-	-

1) mean value of 5;2) means in the same column not followed by the same supescript are significant different (p<0.05);3) mean value of 6.

REFERENCES:

1. Axtell, J.D.; AM Kieleis; MM. Hassen;; NDC. Mason; Et. Mertz; L. (1981). Digestibility of Sorghum Proteins. **Proc. Natl. Acad. Sci.** 78: 1333-1335.
2. Bach Knudsen, K.E.; L. Munck (1985). Dietary Fibre Contents and Compositions of Sorghum and Sorghum Based Foods. **J. Cereal Sci.** (1).
3. Bach Knudsen, K. e.; Wolstrum, J.; Eggum, b.O. (1983). The Influence of Dietary Crude Fibre and Microbial Activity in Digestive Tract on True Protein Digestibility and Biological Value in Rats. **Z. Tierp Tier u Futt** 49:173-180.
4. Badi, S.M.; R.C. Hosene; A.J. Casady (1976). Pearl Millet Characterization by SEM Acid Analysis, Lipid Composition and Prolamine Solubility. **Cereal Chem.** 53:4.
5. Banos, L.; Laguna, P.; Eggum, B.O. (1978). Preparation and Properties of Destrached Milled Rice. **Nutr. rep Inter** 18(1): 17-25
6. Burns, R.e. (1971). Methods for Estimation of Tannin in Grain Sorghum. **J. Agric. food Chem.** 63:511-512.
7. Chibber, B.A.K.; E.t. Mertz; J.D. Axtell, J.D. (1980). In-vitro Digestibility of High Tannin Sorghum at Different Stages of Dehulling. **J. Agric. Food Chem.** 28: 160-161.
8. Cornu, a.; Delpenchi, f. (1981). Effect of Fibre in Sorghum on Nitrogen Digestibility. **Am J Clin Nutr.** 34:2454-2459.
9. Desai, B.B.; G.K. Zende (1979). Role of Bajra (*Pennisetum typhoides*) in Human and Animal Nutrition. **Indian J. Nutr. Dietet.** 16:10.
10. Eggum, B.O. A Study of Certain Factors Influencing Protein Utilization in Rats and Pigs (PhD Thesis). Royal Veterinary and Agricultural University, Copenhagen, Denmark, 1973.
11. Eggum, B.O. (1977). Effect of Cooking on Nutritional Value of Milled Rice in Rats. **Nutr. Rep. Intern** 16(5): 649-654.
12. Englyst, H. In the Analysis of Dietary Fibre in Foods (James WPT, Theander, O. eds.) Marcel Dekker, New York, 1981, p 71
13. Forsum, E.; L. Hambræus; I.H. Siddiqi (1973). Fortification of Wheat by Whey Protein Concentrates, Dried Skim Milk, Fish Protein Concentrate and Lysine Monochloride. **Nutr. Rep. intern.** 8:38-39.
14. Forsum, E. (1975). Effect of Dietary Lactose on Nitrogen Utilization of a Whey Protein Concentrate and its Corresponding Amino Acid Mixture, **Nutr. Rep. Intern** 11:419-428.
15. Hulse, J.H.; E.M. Laing; O.E. Pearson. Sorghum and Millets. Their Composition and Nutritive Value. Academic Press, London, 1980.
16. Ifon, E.T. (1981). Bio-availability to Rats of the Iron Contents in Selected Cereals and Pulses. **Nutr. Re. Intern.** 24:25-30.
17. Kingamkono, R.R. (1996). Effect of Traditional Dehulling and Germination on Nutritive Value of Bulrush Millet. **Food and Nutrition Journal of Tanzania** 7(1):3-7.
18. Mertz, E. et al. (1984). Pepsin Digestibility of Proteins in Sorghum and other Major Cereals. **Proc. Natl. Acad. Sci.** 81:1-2.
19. Mosha, A.C. Nutritional Evaluation of Sorghum as Affected by Germination with Main Reference to Dietary Bulk and Protein Quality. Phd Thesis, University of Sokoine, 1985.

20. Nordic Committee on Food Analysis, Method 57 and 17. Danish Technical Press, Copenhagen, Denmark, 1965.
21. Nwasike, C.; ET. Mertz; RC. Pickett; DV. Glover, BAK. Chibber; SV. Van Scoyok (1979).
22. Lysine Level in Solvent Fractions of Pearl Millet. **J. Agric. Food Chem.** 27(6):1329-1331.
23. Nyman, M.; M. Siljestrom; B. Pederson; K.E. Bach Knudsen; N-G. Asp; C-G Johnsson; B.O. Eggum (1984). Dietary Fibre Content and Composition in Six Cereals at Different Extraction Rates. **Cereal Chem.** 61(1): 14-19.
24. Opoku, A.R.; S.O. Ohenhen; N. Ejiofor (1981). Nutrient Composition of Millet (*Pennisetum Typhoides*): Grain and Malt. **J. Agric. Food Chem.** 29:6.
25. Price, M.L.; L.G. Butler (1978). Detoxification of High-Tannin Sorghum Grain **Nutr. Rep. Inte.** 7:229-36.
26. Ramachandra, G.; T.K. Virupaksha; M. Shadaksharaswamy (1977). Relationship Between Tannin Levels and In-vitro Protein Digestibility in Finger Millet (*Eleusine Coracana Gaertn*). **J. Agric. Food Chem** 25(5): 1101-1104.
27. Reddy, N.R.; S.K. Sathe; D.K. Salumke (1982). Phytates in Legumes and Cereals. **Adv. Food Chem.** 28:1-98.
28. Sankara Rao, D.S., J.G. Doesthale (1983). Mineral Composition, Ionisable Iron and Soluble Zinc in Malted Grains of Pearl Millet and Ragi. **Food Chem.** 11:217-223.
29. Simwemba, C.G; R.C. Hoseney; E. Varriano-Marston; K. Selezna (1984). Certain Vitamin B and Phytic Acid Contents of Pearly Millet. **J. Agric. Food Chem.** 32:31-34.
30. Theander, O. Dietary Fibre: Advances in the Chemical Characterization and Analytical Determination of Dietary Fibre. Components (Birth, GG.; Parker, KJ. eds). Parker 1983. Applied Science Publishers, London and New York.
31. Wu, Y.V. (1982). Lysine Content of Triticale Protein Increased by Germination of Normal and High-lysine Sorghums, **J. Agric. Food Chem.** 30:820-823.



Effect of Soaking Cow Peas and Sorghum-do Grains in Different Solvents/Media on Phenolic Content

Elifatio, E. Towo and Ulf Svanberg

Tanzania Food and Nutrition Centre; and
Department of Food Science, Chalmers
University Technology
Goteborg, Sweden

Abstract

the effect of soaking grains of sorghum-udo and cow peas in different soaking media like water, sodium bicarbonates and refined/unrefined local alkali solutions (*magadi soda*) were observed on their phenolic content. The phenolic compounds were classified into total phenols, tannin type phenols and non-tannin phenols and expressed as mg catechin equivalent (C.E.) per 100g sample.

It was observed that total phenol, tannins and non-tannin phenols were differently affected as a result of soaking the grains in different media as well as cooking. Soaking of the grains in water, sodium bicarbonates and local alkali solutions of *magadi-soda* reduced phenolic content significantly ($p < 0.001$) and subsequent cooking of the soaked samples in water resulted in a further reduction of the phenol content. There was no significant ($p < 0.05$) difference observed on phenolic reduction between different soaking media. The phenolic content in cereal sorghum-udo, a high-tannin variety, was reduced to the same level to that of legume cow peas when the soaked grains were cooked with discarding the soaking media. The percentage reduction of all types of phenol compounds were higher in the sorghum-udo compared to the cow peas. Soaking, an integral part of traditional method of processing food grains like cereals and legumes before cooking may thus offer the dual advantage of reducing the phenolic compounds and rendering the grains nutritionally superior.

Key words: Phenol, Tannin, Non-tannin phenols, Soaking media.

Introduction

Polyphenol compounds like tannins are known to possess some antinutritional and physiological effects to humans and animals. Their antinutritional effect are related to impaired availability of nutrients like proteins, starches, minerals and vitamin function in the body (Karrera et al., 1990; Yadav, Suschetet and Khetarpaul).

Vegetable tannins and other phenolic compounds occur in relatively high concentration in some foods, which may constitute the main staple meals in some areas of the world (Singleton and Kratzer, 1973; Salunkhe et al., 1990; Mayer and Harel, 1991). Cereal grains like sorghum and millet and various food legumes like cow peas and beans are among cultivars which have been shown to contain appreciable amount of tannins of nutritional importance. In Tanzania, like other developing countries, these food grains constitute the main meals of the rural community.

Due to the antinutritional effect associated with phenolic compounds, several attempts have been made either trying to remove these compounds from the food materials or to otherwise render it harmless. Soaking of grains in various solvents, including local alkali solutions like *magadi soda* (an alkali solution obtained in various parts of Tanzania) (Muindi et al; 1981), *kamwa* salt (local salt in West African households (Uzogora et al; 1990) and wood ash (Mukuru et al; 1992) is among the methods which have been attempted. The mechanism involved is the removal of phenol compounds through soaking in different water solutions and discarding the soaking medium together with the extracted phenol compounds

(Deshpande and Cheryang, 1983; Banda-Nyirenda and Vohra, 1990; Babiker and El-Tinay, 1992). It also involves deactivation of these compounds due to water, alkali or acidic treatments to the grains.

In Tanzanian rural community, soaking is an integral part of traditional methods of processing food grains of cereal and legumes. Various soaking media are used including water and *magadi soda* solutions. Investigation on the effect of soaking grains in the solvents used locally by the community in Tanzania on phenolic content is less documented.

This study is aimed at determining the effect of soaking grains of sorghum-udo and cow peas in different media/solvent namely water, sodium bicarbonate, refined and unrefined *magadi soda* solutions on phenolic compounds. The phenolic compounds were classified into total phenol, tannin typephenol and non-tannin phenols and expressed as milligram catechin equivalents (C.E.) per 100 gram of sample.

Methods

Materials

Sorghum-udo and cow peas as well as the refined and unrefined *magadi soda* powder were obtained from local market in Tanzania.

Grain soaking in different media (solvent) and cooking

Fresh, dry and clean food grains (sorghum-udo and cow peas) were soaked in different soaking media (distilled water, 0.2M NaHCO₃, refined and unrefined *magadi-soda*) in the ratio of 1:20 (W/V) for six hours. The samples were drained, washed with distilled water and divided into two equal portions. One portion was freeze dried, made into a fine flour using a mini-laboratory hammer mill and then packed in plastic container before analysis. The other portion was cooked (30 minutes of boiling in distilled water at 1:20 w/v ratio), followed by discarding the cooking media and treated the same way as the first portion before analysis.

Sample analysis for polyphenols

The Prussian Blue Test method (Price and Butler, 1977) was used to measure the change in phenolic content in the food grain/product samples treated according to the above processing/treatment techniques. The values were presented as milligram catechin equivalent (C.E.) per 100 gram sample. Distilled water was used as blank sample in the analysis.

Statistical analysis

Difference in mean values due to different treatment of the samples were tested statistically using the Turkey's HSD test with SYSTAT program (Wilkinson, 1990).

Results and Discussion

The polyphenol content in sorghum-udo and cow peas decreased significantly ($p < 0.001$) after soaking the grains in different media including water and alkali solutions (sodium bicarbonates, refined (R) and unrefined (U) *magadi soda*). Subsequent cooking of the soaked samples and discarding the cooking media resulted in a further reduction of the phenolic content.

Table 1: Effect of soaking in different media (solvent and cooking on phenolic content in sorghum-udo and cow peas.

Values within the same column followed by different letters (a - d) are significantly different ($p < 0.001$).

A combination of soaking in different media and cooking the grains followed by discarding the media, decreased the amount of total phenols in sorghum-udo into significantly ($p < 0.001$) lower level (76%). Soaking alone caused a reduction in the range of 30 to 45%. Cow peas showed similar results for total phenol reduction, 54 to 63% for combined soaking and cooking and 25 to 39% for the soaking alone. For sorghum-udo, the tannin-type phenols were significantly ($p < 0.001$) reduced when soaking was combined with cooking, average of 82%, compared to soaking alone with average of 34%. However, the amount of non-tannin phenols was less reduced on cooking. These types of phenols were much reduced during soaking (Table 2).

Table 2: Effect of soaking in different media (solvents) and cooking on phenolic content in sorghum-udo and cow peas: Mean Percentage Reduction and Range

Treatment	Mean Percentage Reduction on Phenols (Range)					
	Sorghum-udo			Cow peas		
	Total Phenols	Tannins	Non-tannin	Total Phenols	Tannins	Non-tannin
Soaking	38 (30 - 45)	34 (20 - 40)	47 (35 - 55)	30 (25 - 39)	27 (18 - 41)	32 (28 - 39)
Soaking + cooking	73 (69 - 76)	82 (76 - 87)	58.5 (58 - 60)	57 (54 - 63)	60 (55 - 70)	56 (53 - 57)

The reducing effect on polyphenols as a result of soaking in different media including local alkali solutions followed by cooking has been reported (Obizoba and Atii, 1991; Babiker and El-Tinay, 1992; Sharma and Sehgal, 1992).

Mukuru et al; (1992) indicated a decrease in assayable tannin of high-tannin sorghum down to the level of low-tannin sorghum as a result of treatment with a wood-ash slurry and Muindi et al; (1981) reported about 57% reduction of assayable tannin of high-tannin sorghum when treated with unrefined *magadi soda*. Uzogora et al; (1990) reported up to 67% reduction in polyphenols in cow peas as a result of treatment with *kanwa* salt. Likewise, the reducing effect of cooking on phenolic/tannin compounds has been reported (Udayasakhara-

Rao and Deosthale, 1987 Ziena et al; 1991; Lyimo et al., 1992). Attia et al; (1994) reported a range of 58.7 - 62.7% decrease in polyphenol content of chickpea as a result of cooking. Sharma and Sehgal (1992) observed 42% decrease in tannin compounds as a result of cooking *vicia faba* beans which was further reduced to 58% when combined with cooking.

The observed phenolic loss as a result of soaking and cooking may be due to the leaching out of phenolic compounds to the soaking/cooking media. Degradation and decomposition of phenolic molecules by the soaking media or by the heat treatment in the cooking process may also account for the decrease in phenolic content. It also might be attributed to the formation of insoluble complexes with other macromolecules which were not detected by the method employed. Similar reasons have been given by other researchers (Muindi et al., 1981; Udayasakhara-Rao and Deosthale, 1987; Deshpande and Cheryang 1983; Uzogora et al., 1990; Mukuru et al., 1992). Ziena et al. (1991) reported about 10% decomposition of tannin during cooking while up to 50% were leached to the cooking media. Likewise, Lyimo et al; (1992) observed an increase in amount of tannin in the bean broth with cooking time that was due to increased solubility of tannins in soaking and cooking liquors.

This study verifies, that a larger part of the phenolic reduction from leaching of phenolic compounds to the solvent during soaking/cooking which were discarded with the media. Soaking, an integral part of traditional method of processing food grains like legumes before cooking may thus offer the dual advantage of reducing the phenolic compounds and rendering the grains nutritionally superior. However, caution has to be taken due to the possible losses of other nutrients in the course of soaking and discarding the media.

References

- Attia, R.S; El-Tabey Shehata, A.M; Aman, M.E. and Hamza, M.A. (1994). Effect of Cooking and Decortication on the Physical Properties, the Chemical Composition and the Nutritive Value of Chickpea (*Cicer arietinum* L.). Food Chem. 50: 125.

Babiker, E.E. and El-Tinay, A.H. (1992). Effect of Alkali on Tannin Content and In-vitro Protein Digestibility of Sorghum Cultivars. *Food Chem.* 45:55.

Banda-Nyirenda, D.B. and Vohra, P. (1990). Nutritional Improvement of Tannin-containing Sorghum (*sorghum bicolor*) by Sodium Bicarbonate. *Cereal Chem.* 67:533.

Brune, M. Rossander, L. and Hallberg, L. (1989). Iron Absorption and Phenolic Compounds: Importance of Different Phenolic Structures. *Europ. J. Clin. Nutr.* 45:545.

Carrera, S. Mitjavila, S. and Derache, R. (1973). Effect of Tannin Acid on the Digestive Availability of Vit. B₁₂ in Rats. *Ann. Nutr. Aliment.* 27:73.

Deshpande, S.S. and Cheryang, M. (1983). Changes in Phytic Acid, Tannins and Trypsin Inhibitory Activity on Soaking of Dry Beans (*Phaseolus vulgaris* L.) *Nutritional Reports International*, 27:2:371-377.

Deshpande, S.S. Sathe, S.K. and Slunkhe, D.K. (1984). Chemistry and Safety of Plant Polyphenols. *Adv. Expt. Med. Biol.* 177:457.

Lyimo, M; Mugula, J. and Theresia, E. (1992). Nutritive Composition of Broth From Selected Bean Varieties Cooked for Various Periods. *J. Sci. Food Agric.* 58:535.

Mayer, A.M. and Harel, E. (1991). Phenoloxidas and their Significance in Fruits and Vegetables, *Food Enzymology*, Elsevier Applied Sci. 1:373.

Muindi, P.J.; Thomke, S. and Ekman, R. (1981). Effect of *Magadi Soda* Treatment on the Tannin Content and In-vitro Nutritive Value of Grain Sorghum. *J. Sci. Food Agric.* 32:25.

Mukuru, S.Z; Bultler, L.G., Rogler, J.C; Kirleis, A.W; Ejeta, G; Axtel, J.D. and Mertz, E. T. (1992). Traditional Processing of High-tannin Sorghum Grain in Uganda and its Effect on Tannin, Protein Digestibility, and Rat Growth. *J. Agric. Food Chem.* 40: 1172.

Obizoba, I.C. and Atii, J.V. (1991). Effect of Soaking, Sprouting, Fermentation and Cooking on Nutrient Composition and some Anti-nutritional Factors of Sorghum (*Guinesia*) Seeds; *Plan Food for Human Nutrition*, 41:203.

Price, M.L. and Butler, L.G. (1977). Rapid Visual Estimation and Spectrophotometric Determination of Tannin Content of Sorghum Grain; *J. Agric. Food Chem.* 25:1268.

Salunkhe, D.K. Chavan, J.K. and Kadam, S.S. (1990). *Dietary Tannins: Consequences and Remedies*, C.R.S. Press Inc, Boca Raton Florida.

Sharma, A. and Sehgal, S. (1992). Effect of Domestic Processing, Cooking and Germination on the Trypsin Inhibitor Activity and Tannin Content of Faba Bean (*Vicia faba*); *Plant Food for Human Nutrition*, 42:127.

Siegenberg, D. Bayness, R.D. Bothwell, T.H. Macfarlane, B.J. Lamparelli, R.D. Car, N.G. MacPhail, P. Schmidt, U. Tal, A. and Mayet, F. (1991). Ascorbic Acid Prevents the Dose-dependent Inhibitory Effects of Polyphenols and Phytates on Non Haem-iron Absorption. *Am. J. Clin. Nutr.* 53:537.

Singleton, V.L. and Kratzer, F.N. (1973). Plant Phenolics, In: *Toxicant Occurring Naturally in Foods*, National Academy of Science, Washington D.C. 2:1.

Suschetet, M. (1975). Influence of Tannic Acid on the Hepatic Content of Vit. A. in Rats Fed Vit. A. Containing Diet or a Vit. A Deficient Diet. *C.R. Scances Soc. Biol. Fil* 169.

Udayasakhara Rao, P. and Deosthale, Y.G. (1987). Polyphenoloxidase Activity in Germinated Legume Seeds; *J. Food Sci.* 52: 1549.

Yadav, S. and Khetarpaul, N. (1994). Indigenous Legume Fermentation: Effect of Some Antinutrients and In-vitro Digestibility of Starch and Protein. *Food Chem.* 50: 403.

Uzogora, S.G; Morton, I.D. and Daniel, J.W. (1990). Changes in Antinutrients of Cow Peas (*Vigna Unguiculata*) Processed with *kanwa* Alkaline Salt. *Plant Foods Hum. Nutr.* 40:209.

Ziena, H.M; Youssef, M.M. and El-Mahdy, A.R. (1991). Amino Acid Composition and Some Antinutritional Factors of Cooked Faba-beans (Medammi): Effect of Cooking Temperature and Time. *J. Food Sci.* 56:1347.

Wilkinson, L. (1990). *SYSTAT: The System for Statistics*. Evanston, I.L., SYSTAT Inc.



LISHE

THE FOOD AND NUTRITION JOURNAL OF TANZANIA



CONSULTANCY SERVICES

LOOKING FOR CONSULTANCY SERVICES IN FOOD AND NUTRITION??

Tanzania Food and Nutrition Centre offers consultancy services in the field of Food and Nutrition.

THE CENTRE HAS A UNIQUE MULTIDISCIPLINARY SPECIALIZATION IN:

- Nutrition Planning and Policy Development;
- Food Chemistry; Food Technology,
- Nutrition Training;
- Information Education and Communication;
- Public Health; Community Nutrition; Dietetics;
- Statistics and Computing Skills;
- Nutritional Epidemiology;
- Social Sciences; etc.

AVAILABLE ALSO ARE SUPPORTIVE SERVICES SUCH AS:

- Desk Top Publishing; Photocopying
- E-mail, Fax, Telex, Telephone
- Food and Nutrition Library with CD Rom facilities, Nutrition Laboratory
- Printing and Accountancy.

Tanzania Food and Nutrition Centre is the only World Health Organization Collaboration Centre for Nutrition Research and Training in Sub Sahara Africa.

COME ONE. COME ALL TO:

Tanzania Food and Nutrition Centre,
Consultancy Unit,
22 Ocean Road,
P.O. Box 977,
Dar es Salaam.

Tel: 255-51-116713 or 118137-9 or 24432-4

Fax: 255-51-116713

Telex: 41280

E-mail: tfnc @ costech.gn.apc.org.