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Vitellaria paradoxa Wood as a Potential Source of Dietary Fibre

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Abstract

In the tropical developing countries, diseases such as diabetes, tuberculosis, cancer, obesity have been a continuous cause of mortality. In recent times, nutrition experts have come up with new ideas for food recipe, with a view to improving human health. One of these ideas is to enhance dietary fibre content to improve food digestibility and bowel movement. In this study the effect of the processed insoluble wood fibres on the blood system of albino rats was studied by feeding the rats with the processed *Vitellaria paradoxa* wood fibres added to the animals' normal diet for a period of 28 days across four treatments namely the control, 10%, 15% and 20% processed wood fibres.. These cellulosic materials incorporated into normal diet of the albino rats did not cause a reduction in the live weight of the experimental animals. A paired sample t-test conducted on the two sets of data indicated no significant difference ($P = 0.8390 > 0.05$) in the mean initial and final haematocrit. Therefore the wood fibre supplemented diet did not have had any deleterious effects on the quality and quantity of the rats' blood. Thus there is also a possibility that the cellulosic fibres did not reduce the plasma cholesterol level concentrations of the rats. Processed wood was also used in baking bread. The addition of cellulosic fibres did not negatively affect the physical, chemical and baking properties of bread, but it prolonged the shelf-life of the bread.

Keywords: food recipes, haematological analysis, insoluble dietary fibres, nutrition, nutritional diseases, wood of *Vitellaria paradoxa*

Introduction

A living organism is the product of nutrition and nutrition is the science of food values (Begum, 1991). Nutrition is relatively a new science and the effect of food on our body is explained in nutrition. In other words, nutrition is defined as food that work in the body but in a broader sense, it is defined as the combination of processes by which the living organism receives and utilizes the material necessary for the maintenance of its functions and for the growth and renewal of its components. When all essential nutrients are present in a correct proportion as required by our body, it is called optimum nutrition or adequate nutrition. Signs of good nutrition include clear complexion, fresh skin and correct posture, good inquisitive and alert eyes, confident deeds, pleasing personality, correct height and weight for the age.

Since diseases such as obesity is mainly caused by excessive calorie consumption, as such, foods with low calorific values and high dietary fibre contents should be consumed. Reduction in high calorie foods and diet will result in the maintenance and restoration of good nutrition along with gradual reduction in body weight. Hence, high fibre and low calorific foods must be included in dietary pattern. Of such high fibre foods is the use of wood fibres (dietary fibres) as food additives since dietary fibres aim at providing a sense of satisfaction and well-being to its consumers.

The plant kingdom represents a vast emporium of untapped medicinal potentialities and this had led to the resurgence of interests in ethnomedicine, ethnobotany, plant anatomy and taxonomy and ethnopharmacology (Fadeyi *et al.,* 1998). In the areas of plant anatomy especially wood anatomy, researches propose the consumption or use of wood fibres as food additives and this can be linked to an hypothesis relating several diseases common in affluent societies to lack of dietary fibres. And as a result, the concept of taking dietary fibres to improve food digestibility and bowel movement has generated some interests in medical circles. There is an increased interest in alternative therapies globally (WHO, 2003) and a constituent increase in the use of plant derived products as they are convenient alternatives or are complementary to the use of orthodox or synthetic drugs. This is due to adverse side effects of conventional drugs and to the drift towards consuming natural products as opposed to synthetic ones as well as the increasing awareness of the beneficial effects of natural products (Duke, 1990).

Fibres have been found to considerably modulate hepatic, blood and intestinal lipids and lipoprotein profiles (Vahouny, 1982). Therefore the increasing awareness in nutritional therapy towards avoiding the various diseases associated with overweight (Damon, 1979). The concept of taking regular exercise and avoidance of high calorie foods in order to keep the body weight down has gained some considerable popularity in the last decade (Oladele, 1991). Dietary fibre is a major constituent of plant food and it is important in nutrition and health and in the prevention of cardiovascular diseases, cancer, diabetes and

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obesity (Spiller, 2005; Sungso and Diche, 2001). Dietary fibre has been defined as the plant polysaccharide and lignin which are resistant to hydrolysis by the digestive enzymes of man (Trowell, 1976). Dietary fibre can also be referred to as food materials particularly of plant origin that are not hydrolyzed by enzymes secreted by the human digestive tract but that may be digested by microflora in the gut (Anonymous, 2001).

Dietary fibres as indigestible part of plant food guard against heart diseases, certain cancers, Type 2 diabetes, obesity and premature death. It also get low the cholesterol, improves blood sugar levels, reduces blood pressure; promote weight loss and keep the body regular at all times. Dietary fibre consists of two main components: soluble and insoluble fibres. The soluble fibre is that which is readily fermented in the colon into gases and physiologically active byproducts while the insoluble fibre is that which is metabolically inert, absorbing water as it moves through the digestive system and hence making defecation easy (Anonymous, 2005). Dietary fibres act by changing the nature of the contents of the gastrointestinal tract, and by changing how other nutrients and chemicals are absorbed (Eastwood and Kritchevsky, 2005). Chemically, dietary fibres consist of non-starch polysaccharides such as cellulose and many other plant components like resistant dextrins, inulin, lignin, chitins, beta-glucans and oligosaccharides (Anonymous, 2005). Dietary fibre is found in plants although in varying degrees. Fibre-rich plants can be eaten raw or can be alternatively used to make supplements (i.e. food additives) and fibre-rich processed foods. Dietary fibre has been used as a collective term for a complex mixture of substances with different chemical and physical properties which exert different types of physiological effects and are therefore recognized by the fact that they are either nutritionally useful or have the potential for consumption . Increase in dietary fibre intake, will increase post-meal satiety and decrease subsequent hunger. It also increases body weight loss and greatly suppress energy intake in obese people (Howarth *et al*., 2001). One of the possible cheapest means of dietary fibre administration is to add processed fibres to regular foods (Damon, 1979).

Vitellaria paradoxa commonly known as shea tree, shea butter tree, shi tree, vitellaria or *karité*, is a tree of the *Sapotaceae* family indigenous to Africa, occurring in Mali, Cameroon, Congo, Côte d'Ivoire, Ghana, Guinea, Togo, Nigeria, Senegal, Sudan, Burkina Faso and Uganda. The shea fruit consists of a thin, tart, nutritious pulp that surrounds a relatively large, oil-rich seed from which shea butter is extracted. The shea tree has been claimed to have potential to improve nutrition, boost food supply in the "annual hungry season" (Masters *et al*., 2011), foster rural development and support sustainable land care (National Research Council, 2006). The shea butter tree is a wild plant species thriving abundantly in the Guinea and Derived savannas' woodlands of Nigeria, even on poor soil was used in this study. Meanwhile, species such as *V. paradoxa, Milicia excels, Anogeissus leiocarpus* and others were earlier identified by AbdulRahaman *et al.* (2009) as most exploited species as firewoods in 6 Local Government Areas (Asa, Ilorin-East, Ilorin-South, Ilorin-West and Moro) of Kwara State, Nigeria. Therefore drastic efforts must be taken to stop this problem. One of these efforts may be using the plant, *V. paradoxa* as dietary fibre in baking foods. The tree is medicinal and it is widely used in different areas of medicine. Lipid in shea butter is digested easely and serves as a better source of energy for protein sparing than carbohydrates as well as sources of essential fatty acids. The wood fibres from *V. paradoxa* are potential dietary fibres and considering its wide distribution, it will serves as a cheap source of fibres.

Soluble fibres have been added to some baked food for human consumption especially in the United States of America (Anonymous, 2001); insoluble fibres have not been exploited for the same purpose. Therefore, this study is a preliminary one to determine the potentiality of *V. paradoxa* wood, which is an insoluble fibre, as a source of dietary fibre, to examining the blood and live weight responses of laboratory animals fed on diets containing the wood fibres and also to bake and assess the physical characteristics of laboratory-baked loaves of bread from fibre-supplemented wheat flour.

Materials and methods

Study materials

Wood of sheanut tree, *Vitellaria paradoxa* was used as a source of insoluble dietary wood fibre. Its wood is also a good source of energy as firewood. Sixteen laboratory animals, albino rats of about eight weeks old were purchased from Biochemistry Department of the University of Ilorin, Ilorin, Nigeria.

Wood anatomical studies

From freshly collected wood discs samples, a shorter wood disc of about 4 cm were cut by means of a hand saw. The circumference of the latter disc was divided into four equal sectors by drawing a cross sign with its origin at the centre. Four blocks of wood each of about 4×2×2 cm were cut out from the sectors and immediately fixed in formal-acetic-alcohol (FAA) contained in a labelled specimen bottle (Jane, 1970). Thin transverse sections (TS) and tangential longitudinal sections (TLS) of about 10 μm were cut from the wood blocks using a freezing stage microtome.

Tissue maceration

Tissue maceration was done by boiling a small block of wood for 5 min in concentrated nitric acid (HNO_3) to which a few crystals of potassium chlorate was added (Ademiluyi and Okeke, 1975). The softened tissue was washed in several changes of water, transferred onto a microscopic slide and teased out by tapping gently with a glass rod. Staining was done in safranin and mounting in glycerine.

Feeding trials of albino rats with wood fibres as a supplement

Sixteen albino rats of about eight weeks old were obtained along with their normal compounded feed. The rats were marked for the purpose of identification and were acclimatized for two weeks in wooden cages with access to their normal feed and water. After two weeks, the rats were divided into four diet groups; each containing two males and two females. The initial live weight of all the rats was determined weekly in grams with the aid of a weighing balance. The first group which was fed on normal diet without fibre served as control. The second group was placed on 10% wood fibre mixed with 90% normal feed; the third on 15% wood fibre mixed with 85% normal feed and the fourth on 20% wood fibre mixed with 80% normal feed. Each of the groups was supplied with the same quantity of feed in powdered form and water for a period of four weeks.

Diet's preference index

The percentage feed intake per week was achieved as the diet's preference index for each of the four treatment levels. This was determined as a percentage using formula of Ogunkunle *et al*. (2003):

T_c-T_1/T_c×100

Where:

T_c = cumulative weight of rat meal supplied to a group in one week;

T_1 = left over of the meal at the end of the week.

Live weight of the rats

The live weight of each albino rats in each feeding group was determined by weighing them weekly, basis for the period of four weeks.

Blood Packed Cell Volume (PCV)

The percentage blood Packed Cell Volume (PCV) of each rat was determined with the aid of a heamatocrit centrifuge (Barrelet, 2004). Their percentage blood PCV was observed at the beginning of the first week and at the end of the fourth weeks of feeding them with diets containing wood fibres.

Baking of bread (fortified and non-fortified)

About 1 kg of the commercial wheat flour was obtained and flour dough was prepared from it. Four different kinds of dough were prepared, one control and three experimental. The stem of the plant was debarked and the woody stem pulverized. Each of the experimental dough, 0.25 g, 0.5 g and 1.0 g of the pulverized wood fibres was added and mixed thoroughly with 50 g of wheat flour before dough preparation. Each of the four set-ups was prepared in four replicates and then placed in oven at 120°C for about 1 hour (Ogunkunle *et al*., 2003).

Assessment of the loaves of bread

The breads were assessed through questionnaires administered to some selected individuals on the acceptability of their colour, texture and flavour. The selected people commented on the acceptability or/and suitability of bread. Mean dimensional characteristics such as mean weight (g), mean height (cm), mean area (cm^2) and mean volume (cm^3) of breads were also determined. Weight of a loaf of bread was determined using a weighing balance and the height determined by inserting a long needle into the loaf and determining the extent on a metre rule. The shelf lives of the four categories of breads were determined by exposing the loaves to laboratory conditions and the number of days before any noticeable fungal infestation was achieved.

Statistical analysis

A paired-sample T-test was conducted on the initial and final haematocrit values for all the rats. The data from albino rat feeding trail was analyzed using one-way ANOVA at three different levels (Bailey, 1995).

Results and discussion

Wood structure of V. paradoxa

The wood is brownish yellow in colour and diffuse porous. The fibres are relatively long with thin cell wall and moderate lumina. The fibres are elongated and have simple pit with pointed ends. The vessel members are elongated and cylindrical in nature with fairly thin cell wall, bordered pit and wide lumina. The tracheids are also elongated, have narrow cells each with tape ring pointed end. The rays are uniseriate and there are more tracheids and fibres present, compared to vessel members (Fig. 1 and Fig. 2).

The fibres are sufficiently thin-walled with a relative length of 9.23 μm and mean length of 200 μm (Tab. 1). The fibres are not as flexible as indicated by the low coef-

Tab. 1. Several dimensional characteristics of *Vitellaria paradoxa* wood

Mean values	Fibre dimensions (μm)	Vessel dimensions (μm)
Length (μm)	200.00±0.05	_
Diameter (μm)	21.72±0.43	14.93±0.05
Fibre lumen width (μm)	10.6±0.05	18.55±3.55
Wall thickness (μm)	5.01±0.05	5.96±0.05
Relative fibre length = Fibre length/ Fibre diameter (μm)	9.23±0.16	_
Coefficient of flexibility = Fibre lumen width/ Fibre diameter	0.49±0.01	_

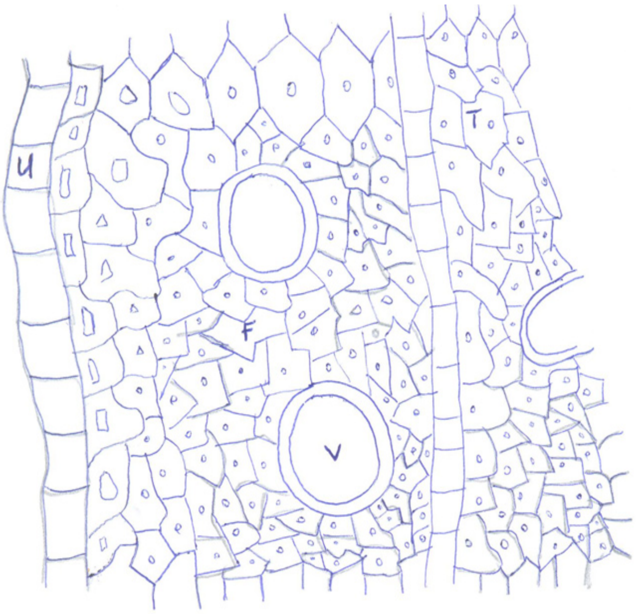

Fig. 1. Transverse Section (TS) of *Vitellaria paradoxa* wood

U = Uniseriate ray; F = Fibre; V = Vessel; T = Tracheid; B = Bordered pit; S = Simple pit ×40

ficient of flexibility (i.e. 0.49). Furthermore the vessels are fairly thick walled and cylindrical in nature and so the vessels would not collapse readily and blend with the fibres during the mechanical processing.

Responses of albino rats to fibre supplemented diets

The behavioural and biological responses of albino rats to four feeding trials are displayed in Tab. 2 and Tab. 3. The preference index of the rats' diet increased with increasing wood fibre content in their meal.

Although the preference index of all the rats increased throughout the period of feeding with increasing wood fibre supplements in their meal, the statistics between their means show a significant difference between them, P being < 0.05. This implies that the fibre-free diet is the most preferred to the rats and the other treatment levels were not that acceptable to them. The mean live weight of all the rats increased throughout the four weeks of experiment (Tab. 2). At the end of the first week, the lowest mean weight of 134.50 g was recorded in the rats fed at 20% fibre level while the highest, 140.75 was in those fed at 15% fibre level. But at the end of the fourth week, the lowest (158.25 g) was recorded at 15% level and the highest mean weight (179.75 g) recorded was in the control group. The results of the ANOVA conducted on the live weights responses of the rats did not show a significant difference (Tab. 3) at the three factor levels namely, treatments, weekly responses and replication at P>0.05. Therefore it can be conclude that the fibre added to the rats' meal does not have any effect on the live weights of the rats.

Osilesi *et al.* (1992) observed that cellulose (an insoluble fibre) did not determine lower plasma cholesterol nor did it bind bile acids *in vitro* or *in vivo*. Findings from

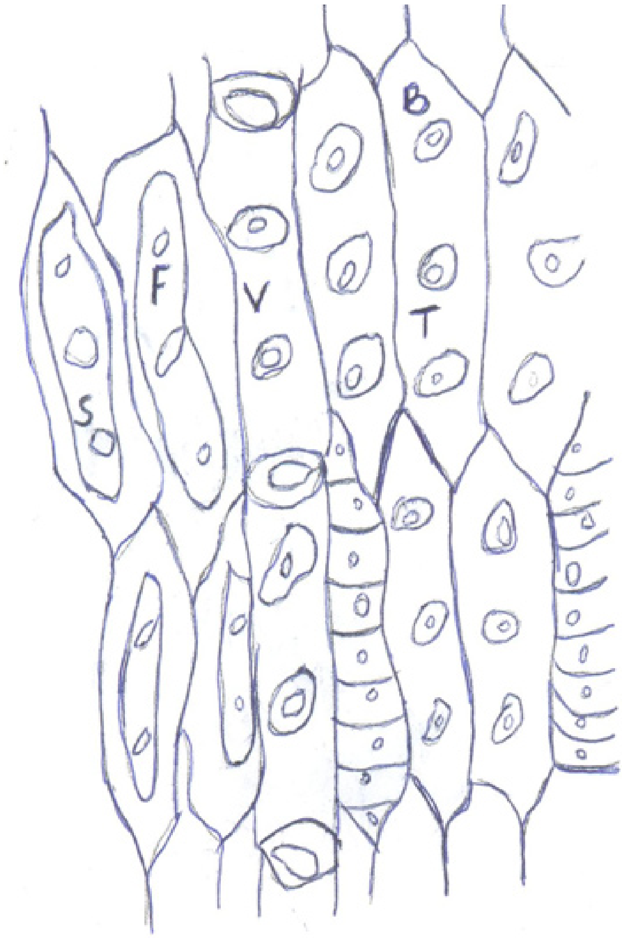

Fig. 2. Tangential Longitudinal Section (TLS) of *Vitellaria paradoxa* wood ×40

F = Fibre; V = Vessel; T = Tracheid; B = Bordered pit; S = Simple pit ×40

the present research work corroborate this observation. A paired sample T-test conducted on the two sets of data indicated no significant difference (P=0.8390 > 0.05) in the mean difference between mean initial and final haematocrit (Tab. 2). The confidence interval is between 43% and 45% which is within the acceptable standard. The haematocrit or packed cell volume (PCV) or erythrocyte volume fraction (EVF) is the percentage of blood volume that is occupied by red blood cells. It is normally about 45% for men and 40% for women (Purves *et al*., 2004). It is considered an integral part of a person's complete blood count results, along with haemoglobin concentration, white blood cell count, and platelet count. In mammals, haematocrit is independent of body size. Thus the PCV figures obtained are positive signs of good health. This is because condition of elevated or lower figure of EVF or PCV indicates danger. In cases of dengue fever, a high haematocrit is a danger sign of an increased risk of dengue shock syndrome and a Lower haematocrit can imply significant haemorrhage. Therefore the wood fibre supplemented diet could not have had any deleterious effects on the quality and quantity of the rats' blood.

Characteristics of laboratory-baked bread

The flavours of both the control and the experimental loaves of bread was 100% acceptable to all the respondents (Tab. 4).

The colour of the loaves of bread ranged from light brown with cream tint in the control to pale brown in the 1.00 g fibred loaves (Tab. 4). Of all the 30 respondents whose opinions on assessment was sought, 13 (i.e. 45%) preferred the light brown colour of the 0.25 g fibre loaves and pale chocolate brown colour of the 0.50 g fibred loaves while the remaining, 55% preferred the cream-tinted light brown colour of the control loaves. The flavours of both the control and experimental loaves were 100% acceptable to all respondents (Tab. 4). These results show that the colour and flavour of fibre-supplement bread were accepted to bread consumers.

The control loaves have the shortest shelf life of 4 days and a shelf life of 5 days each was recorded for 0.5 g and 1.0 g of fibred loaves. However, a shelf life of 6 days was recorded for the 0.25 g fibred loaves. This result therefore

Tab. 2. Blood and live weight responses of albino rats to four feeding trial diets over a period of four weeks

Feeding trial	Parameter	Initial value	First week	Second week	Third week	Fourth week	Mean
Control (100% normal diet)	Preference index (%)		71.43	69.64	64.12	66.43	67.91
	Weight (g)	119.25	137.75	153.00	166.00	179.75	
	% weight increase					50.73	
	PCV (%)	39.5				41.5	
10% wood fibre	Preference index (%)		69.29	78.57	71.61	74.82	73.57
	Weight (g)	120	137.75	145.5	159.75	158.75	
	% weight increase					32.29	
	% weight reduction					63.65	
	PCV (%)	43.25				42.75	
15% wood fibre	Preference index (%)		73.39	78.04	73.57	73.93	74.73
	Weight (g)	123.75	140.75	151.50	162.25	158.25	
	% weight increase					27.88	
	% weight reduction					54.96	
	PCV (%)	46.25				45.25	
20% wood fibre	Preference index (%)		69.12	78.39	79.82	78.75	76.52
	Weight (g)	112.75	134.50	144.75	176.75	172.75	
	% weight increase					53.22	
	% weight reduction					104.91	
	PCV (%)	47				47.5	

Tab. 3. The results of ANOVA conducted on the mean live weights of the rats

Sources of variation	Degrees of freedom	Sums of squares	Mean Squares	F	P-values
Treatment	3	734.4219	244.8073	2.30	0.0877
Weeks	3	9885.9219	3295.3073	30.95	0.0000
Replications	3	91.5469	30.5156	0.29	0.8348
Error	54	5749.0938	106.4647	-	-
Total	63	16460.985	-	-	-

Tab. 4. Several qualitative and quantitative characteristics of the baked bread

Type of loaf	Colour	Flavour	Mean weight (g)	Mean height (cm)	Mean area (cm^2)	Mean volume (cm^3)	Shelf life (days)
0 g fibre content (Control)	Light brown with cream tint	Acceptable	471.50	9.53	264.57	2521.35	4
0.25 g fibre content	Light brown	Acceptable	612.00	9.75	278.20	2712.45	6
0.5 g fibre content	Pale chocolate brown	Acceptable	623.75	9.63	269.52	2595.48	5
1.0 g fibre content	Pale brown	Acceptable	696.75	9.8	270.35	2649.43	5

shows that fibred loaves of bread can effectively compare with those commercially available loaves.

From the dimensional characteristics, it can be observed that the 1.0 g fibre loaf was the heaviest and the highest with 696.75 g and 9.80 cm respectively. The control loaves have the lightest mean weight of 471.5 g and the lowest mean height of 9.53 cm and occupying the lowest mean area of 264.57 cm^2. The mean volume of the bread loaves ranged between 2521.35 cm^3 in the control to 2649.43 cm^3 in the 0.25 g fibred loaves. Therefore, experimental loaves are generally of larger sizes than the control. From these results and the ANOVA conducted, it can be inferred that the addition of cellulose fibres to wheat flour dough does not adversely affect its baking properties but instead, it enhances and improves the quality, size and shelf-life of the loaves.

Conclusions

The fibres of *V. paradoxa* are potential insoluble dietary fibre with the prospect for human consumption. These cellulosic materials incorporated into normal diet of the albino rats did not cause a reduction in the live weight of the experimental animals. Therefore, there is a possibility that the cellulosic fibres did not reduce the hepatic or reduce the plasma cholesterol level concentrations of the rats. Also, the addition of cellulosic fibres does not negatively affect the physical, chemical and baking properties of bread. Instead the fibre prolong the shelf-life of the breads than those of control ones.

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