

## WOOD OF *GLIRICIDIA SEPIUM* AS A POTENTIAL SOURCE OF DIETARY FIBER

A. A. ABDULRAHAMAN, O. O. BAMIDELE and F. A. OLADELE

*Department of Plant Biology, University of Ilorin, Ilorin, Nigeria*

**Abstract** - In recent years it has been established that several health problems common in developed societies are connected to a lack of dietary fiber content in the daily meal. Among such health hazards are excessive body weight and its secondary implications, such as atherosclerosis, cancers of the colon, hemorrhoids, appendicitis, colitis and diverticulosis. Therefore, due to the indispensable benefits of dietary fibers intake and the health hazards resulting from their deficiency, nutritional experts have come up with a number of new ideas for food recipes. One of these ideas is related to wood anatomy, i.e. addition of wood fiber to wheat flour to produce or bake breads of low caloric value and a high dietary fiber content. Intake by experimental rats of a feed-supplemented with insoluble wood fiber of *Gliricidia sepium* during four weeks revealed that wood fiber supplements were acceptable to the rats. There was no significant difference in the blood packed cell volume (PCV) between experimental and control animals. This result indicates that fiber intake did not have any side effect on the blood of experimental animals. Furthermore, incorporation of wood fibers into wheat flour did not adversely affect the physical and baking properties of bread. This study recommends use of the wood of *G. sepium* as a potential source of dietary fibers.

**Key words:** Food recipes, hematological analysis, insoluble dietary fibers, nutrition, nutritional diseases, *Gliricidia sepium*

### INTRODUCTION

The concept of using dietary fiber to improve food digestibility and gastro-intestinal movement has instigated interest in nutritional sectors. This is because the effect of dietary fiber has been implicated to considerably regulate hepatic, blood, intestinal lipid and lipoprotein profiles. Dietary fiber is a major constituent of plant foods and its importance has been widely recognized. Numerous clinical and epidemiological studies have in the past addressed the impact of dietary fiber in intestinal health and in the prevention of cardiovascular diseases, cancers, obesity and diabeties (Sungso and Diche, 2001; Spiller, 2005). In recent years, it has been established that several health problems common in developed so-

cieties are connected to a lack of dietary fiber in the daily meal. Among such health hazards are excessive body weight and its secondary implications such as atherosclerosis, cancers of the colon, hemorrhoids, appendicitis, colitis and diverticulosis. Dietary fiber does not constitute a defined chemical group but a combination of chemically heterogenous substances, such as plant polysaccharides and lignin that are resistant to hydrolysis by the digestive enzymes of man and animals (Trowel, 1976). These dietary fiber components are neither degraded nor absorbed during passage through the upper part of the gastrointestinal tract, and they can exert nutritionally important effects by slowing down gastric emptying and effecting nutrient assimilation in the small intestine. They are degraded by bacterial enzymes and completely or

partially fermented to produce short-chain fatty acids as well as gases and water (Begum, 1991).

Dietary fiber plays an important role in carotenoid bioavailability. Vahouny (1982) demonstrated in humans that pectins exert an effect on the  $\beta$ -carotene bioavailability considerably. Spiller (2005) equally demonstrated that several dietary fibers, including pectins, increased the viscosity of reconstituted duodenal medium and effected emulsification and lipolysis of fat, two indispensable steps for carotenoid micellization (Eastwood and Kritchersky, 1996).

Determining the level of dietary fiber in food is important, not only to support clinical programs but also to provide data for legal requirements such as food labeling. The manifestation of such legal requirements has been observed from the recent approval of the regulation on nutrition and health claims made on foods in Europe regarding dietary fiber (WHO, 2003). It establishes that a food can be categorized as a "source of fiber" when it contains at least 3 g of dietary fiber per 100 g or at least 1.5 g of dietary fiber per 100 kcal, and "high fiber" if the food contains at least 6 g of dietary fiber per 100 g or at least 3 g of dietary fiber per 100 kcal. The recommendation for dietary fiber intake therefore is within 25-30 g/person (Osilesi et al., 2005).

Because of the indispensable benefits of dietary fiber intake, and health hazards resulting from their deficiency, nutritional experts have come up with a number of new ideas for food recipes. One of these ideas bear some relation to wood anatomy, i.e. the addition of wood fiber to wheat flour to produce or bake breads of low calorific value and high dietary fiber content (Oladele, 1991). Wood is predominantly cellulosic. Water-insoluble woods are potentially a cheap source of dietary fibers. However, the sources of soluble dietary fibers are not affordable. Perhaps, one of the cheapest means of dietary fiber administration is to add processed fibers to regular foods. While this is practicable to some extent, the addition of the required quantity would alter the appearance, taste, chewiness and feel of human food. The more preferred media of processed fiber consumption

would therefore be in the form of baked foods such as bread, noodles and so on, rather than in cooked food.

In certain diseases, dietary modification is more important than medical treatment, and in others, diet therapy goes hand-in-hand with medical care. The specific elimination or addition of certain nutrients, or alteration in the normal pattern of diet are employed in different approaches to disease management (Begum, 2007).

The objective of this work is to identify a suitable source of insoluble dietary wood fiber in a woody species, *Gliricidia sepium* (Jacq.) Kunth ex Walp. syn. *Robinia sepium* Jacq. *G. sepium* is a species native to Central and Southern America. It has however spread to different parts of the world, including West Africa, the West Indies and South Asia. *G. sepium* is often simply referred to as *Gliricidia* (common names: *Mata Raton*; *Cacao de nance* or *cacahnance* in Honduras; *Kakawate* in the Philippines, *Madre Cacao* in the Philippines and Guatemala; *Madriado* in Honduras; and *Madero negro* in Nicaragua; locally known as "Agunmaniye" in the western part of Nigeria) is a medium size leguminous tree belonging to the family Fabaceae and subfamily *Faboideae*, tribe *Robinieae*. It is considered the second most important multi-purpose legume tree, surpassed only by *Leuceana leucocephala* (Ranibatisch, 2007). *G. sepium* is a tree and can grow to 10-12 m high. The bark is smooth and its color can range from a whitish gray to deep red-brown. It has composite leaves that can be 30 cm long. Each leaf is composed of leaflets that are about 2-7 cm long and 1-3 cm wide. The flower is located at the end of branches that have no leaves. These flowers are bright pink to lilac in color. The pods are about 10 to 15 cm in length. It is green when ripe and becomes yellow-brown when maturity is attained. The pod produces 4 to 10 round brown seed. The tree grows well in acidic soils with pH of 4.5-6.2. *Gliricidia* is used as living fences/hedges, cut and carry feed for ruminants, alley farming, protein banks, green manure, support, shade, honey, rodenticide, medicinal, firewood and the pigmentation of eggs.

## MATERIALS AND METHODS

### *Anatomical structure*

Five different cylinders were cut from the wood of *G. sepium* using a handsaw. These small bits of wood were immediately fixed into a bottle containing formal acetic alcohol (FAA) to stabilize the cell and tissue components for subsequent chemical and physical analysis. The plant materials were fixed for three days, after which they prepared for sectioning. Sectioning was carried out using a sledge microtome. The sections were 20  $\mu\text{m}$  thick. The thin transverse section (TS) and longitudinal sections (LS) were subsequently stained with safranin and mounted using dilute glycerin.

The wood was chemically macerated in concentrated  $\text{HNO}_3$ . Small blocks of *G. sepium* wood were boiled in a boiling tube containing concentrated  $\text{HNO}_3$  for 6 min., after which the macerated tissue was rinsed in several changes of tap water. The fibers were stained with safranin and mounted on slides using diluted glycerin. The slides were viewed using a light microscope to examine the fiber properties such as the fiber type, shape and dimensions. Dimensions such as fiber length (L), lumen width (I), lumen diameter (D) and cell wall thickness (C) were determined with the aid of a calibrated ocular micrometer fitted to the microscope. From these dimensions, coefficient of flexibility (I/D) and relative fiber length or fiber slenderness (L/D) were calculated (Jane, 1970; Wood, 1989; Fuwape, 1991).

### *Preparation of wood dust for feeding trial*

The wood dust was allowed to soak in preboiled water for 24 h in an oven regulated at 100°C, after which it was washed in several changes of tap water. To ensure effective soaking, the wood dust was allowed to stay for another 24 h in preboiled tap water. This was to extract the tannin present in the wood dust. After boiling for 48 h, it was again washed in several changes of tap water and kept in a muslin cloth for several hours in a standing water bowl. The wood dust was drained and sundried for several days. It

was thereafter pulverized using an electric blender. The pulverized wood dust was passed through a fine sieve and stored in a labeled plastic bag.

### *Feeding trial of experimental animals with prepared wood fiber as a dietary fiber supplement/additive*

Sixteen albino rats about eight weeks old were purchased along with their normal compounded feed from an established feed mill industry. The rats were acclimatized for two weeks in cages with access to their normal feed and water. After two weeks, the rats were divided into four feeding groups, each containing two males and two females. The initial live weights of all the rats were determined weekly. The first group (G1) was fed on a normal diet without fibers and served as control. The second group (G2) was fed with 10% wood fibers mixed with 90% normal feed, the third group (G3) on 15% wood fiber mixed with 85% normal feed, and the fourth group (G4) on 20% wood fibers 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.

### *Hematological analyses of animals*

The feeding groups (control and experimental animals) were taken to the Hematological Department of University of Ilorin Teaching Hospital (UITH), Ilorin, Nigeria for hematological analysis. Blood collection was carried out through the tail, using a capillary tube. The capillary tube was instantly spun using a hematocrit centrifuge. This was done to avoid clotting of the blood. Preparation and smearing of the blood film was also performed in order to determine the leukocyte type and number fraction (Barrelet, 2004). The blood packed cell volume (PCV) or erythrocyte volume fraction (EVF) was determined for each experiment animals. The PCV was established at the beginning of the first week and at the end of the fourth week of feeding with diets containing wood fibers.

### *Diet Preference Index*

The feed remnant in each feeding group was collected

and weighed. This was used in calculating the preference index of the diet for each of the four treatment levels. This was determined as a percentage using the formula of Ogunkunle et al. (2003):

$$T_c - T_1/T_c \times 100$$

where  $T_c$  = cumulative weight of rat meal supplied to a group in one week and  $T_1$  = 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 on a weekly basis for a period of four weeks.

#### *Baking of the loaves of bread*

The materials used were wheat flour, butter, salt, yeast, a well-powdered wood dust of *G. sepium*, bread cans, a rolling machine and groundnut oil. About two modules of wheat flour were used. The baking was done in a bakery where different fiber-containing distilled water was added to each of the 50 g measured quantity of flour mixed with 10 g of sugar, 1 g of salt and a quantity of yeast. Four different kinds of dough were prepared, one control and three experimental. The stem of the plant was debarked and the woody stem pulverized. To each of the experimental batches of dough, 0.25 g, 0.5 g and 1.0 g of pulverized wood fibers were 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 45 min. (Ogunkunle et al., 2003).

#### *Assessment of bread*

The breads were assessed through questionnaires administered to selected individuals regarding the acceptability of color, texture and flavor. The selected people commented on the acceptability or/and suitability of the bread. Mean dimensional characteristics such as mean weight (g), mean height (cm), mean area (cm<sup>2</sup>) and mean volume (cm<sup>3</sup>) of breads were

also determined. The 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 measuring on a meter rule. The shelf lives of the four categories of breads were determined by exposing the loaves to laboratory conditions. The number of days before any noticeable fungal infestation was taken as the shelf life of each loaf of bread.

#### *Statistical analysis*

A paired-sample t-test was conducted on the initial and final hematocrit values of all the rats. One-way ANOVA and Duncan's multiple range test were also conducted at three different levels on the data from the albino rat feeding trials (Bailey, 1995).

## RESULTS AND DISCUSSION

#### *Wood structure of G. sepium*

As indicated in Fig. 1, a section across the stem of the wood showed an axial parenchyma that has a paratracheal type of arrangement, i.e. the parenchyma cells occur in association with vessel elements (pores). The paratracheal is a vasicentric parenchymatous form because of the presence of sheaths around vessels. The vessels are solitary or occur in twos. This gives a structural resemblance to those of hard wood. The rays occur in segmented and straight forms. Fig. 2 shows a transverse longitudinal section of the wood. In TLS, the rays appear as short vertical compartments. The fibers in *G. sepium* wood are all of the libriform type. The fiber length of the macerated wood gave a mean of 263.33 µm. The fibers were very flexible because measurement of fiber slenderness gave a mean of 0.72 µm. The Runkel ratio calculated was between 0.672 µm to 0.80 µm.

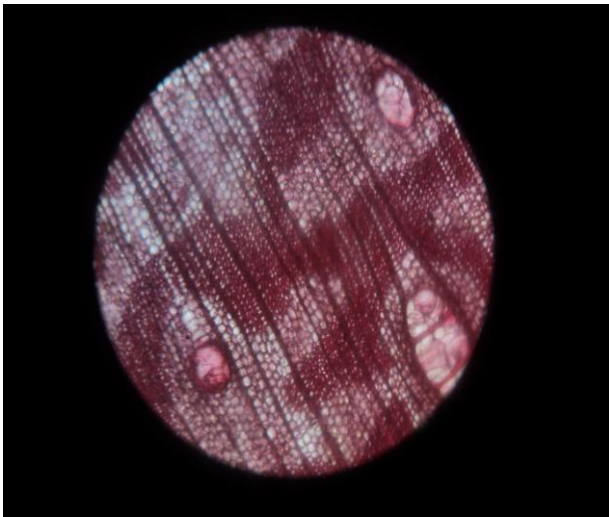
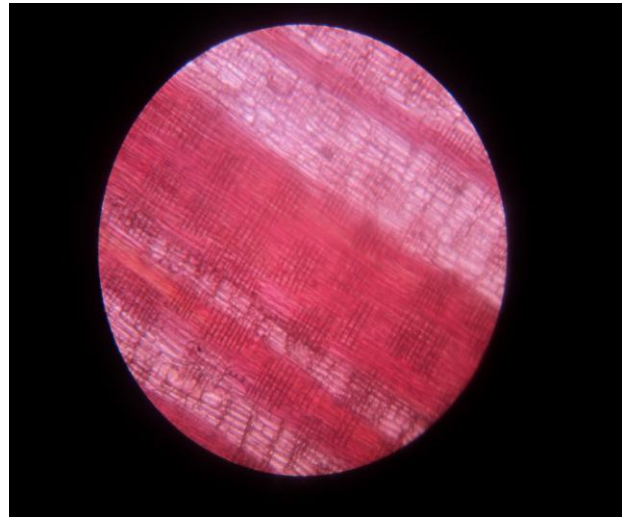
#### *Responses of experimental animals to diet-supplemented feeds*

The p-value was 0.129 (Table 1), We concluded that there was no significant difference in the effects of the four (4) levels of fiber on the blood packed cell volume (PCV) of the experimental animals. Al-

**Table 1:** ANOVA table on effect of fiber on the blood PCV of albino rats

Source of variation	Sum of squares	Degree of freedom	Mean of squares	Fcal	p-value
Treatment	61.567	3	20.522	2.347	.129
Error	96.167	11	8.742		
Total	157.733	14			

$H_0$ : The effects of the four levels of fiber on PCV are significantly different;  $H_1$ : The effects of the four levels of fiber on PCV are not significantly different.  $H_0$  was rejected if  $p\text{-value} < \alpha$ ;  $\alpha$  is the significance level,  $\alpha = 0.05$ . Since  $p\text{-value} (= 0.129)$  was not less than  $\alpha$ , we did not reject  $H_0$ . There is no significant difference in the effects of the four levels of fibers on PCV.

**Fig. 1.** Transverse section of *Gliricidia sepium* wood**Fig. 2.** Longitudinal section of *Gliricidia sepium* wood

though the percentage blood PCV increased in the course of the experiment, no significant difference between PCV was observed. This indicates that the wood fiber-supplemented diet did not have had any adverse effects on the quality and quantity of the rats' blood.

Table 2 shows the effect of the four levels of fibers on the diet preference indices of the albino rats. Statistical analysis revealed a significant difference in the preference indices across the feeding groups, the reason being that the  $p\text{-value} (=0.011)$  calculated was less than  $\alpha$  (0.05). Because of the significant difference, a Duncan Multiple Range Test (DMRT) and a pairwise comparison was conducted among the different feeding groups. The DMRT showed that G2 (10% fiber fed) was different from G3 (15% fiber fed), with G2 having the greatest preference index.

The comparison between G1 (5% fiber fed) and G2 showed a difference in feed intake. All but two out of the comparisons showed a difference among the groups, i.e. G4 (20% fiber fed) and G3; G1 and G3 showed no difference in percentage intake of feed. The DMRT conclusively showed that albino rats fed with 10% fiber content showed a higher preference for feed intake, followed by group four, which consisted of animals fed on food containing 20% fiber. From this, we conclude that the preference for food by the experimental animals did not depend on the amount of fiber.

The mean live weights of all the albino rats decreased through the four weeks of experimentation as indicated by Tables 3 and 4. At the end of the fourth week, we concluded that there was reduction in the live weight of the experimental animals that were fed



**Plate 1.** Bread containing 0g of fiber content (control)



**Plate 2.** Bread containing 0.25g of fiber content



**Plate 3.** Bread containing 0.5g of fiber content



**Plate 4.** Bread containing 1g of fiber content

with different levels of fibers and that the weights of the rats in the control group were significantly different from those of rats in the other groups. From the pairwise comparison, it can also be concluded that the weights of the rats in the other three feeding groups (feeds with wood fibers) were not significantly different from one another. With this, it might be inferred that wood fiber can prevent the occurrence of obesity, as earlier reported by Sungso and Diche (2001).

#### *Analysis of respondents to baked bread*

The color of the loaves of breads ranged from light brown with a creamy tint, chocolate brown, light brown, creamy tint, and pale brown as observed by

the respondents to the questionnaires on the color, flavor and texture of the four laboratory-baked breads (Tables 5 and 6). The four breads (Plates 1-4) were acceptable to all respondents for the above-mentioned characteristics.

The use of soluble fibers in some food recipes has been established. In the United States of America, processed figs of some *Ficus* species are made into pies, puddings, cakes and other bakery products. In addition, fig paste, which is a mixture of the fruits, wheat and cornflour, whey, syrup, oils and other ingredients, is used as a delicacy (Anon., 2001). However, this present study is on how to include insoluble or cellulose fibers in baked foods for human con-

**Table 2:** ANOVA table for the diet preference index

Source of variation	Sum of squares	Degree of freedom	Mean of squares	Fcal	p-value
Treatment	913.959	3	304.653	5.757	.011
Error	635.067	11	52.922		
Total	1549.025	14			

H<sub>0</sub>: The effects of the four levels of fiber on PCV are not significantly different; H<sub>1</sub>: The effects of the four levels of fiber on PCV are significantly different. Ho was rejected if p-value < α; α is the significance level, α= 0.05. Since p-value (= 0.129) was not less than α, we did not reject Ho. α is the significance level, α= 0.05. Since p-value (= 0.011) is not less than α, we did not reject Ho. There is significant difference in the effects of the four levels of fibers on PCV.

**Table 3:** ANOVA table on the weight responses of albino rats to four feeding trial diets over a period of four weeks.

Source of variation	Sum of squares	Degree of freedom	Mean of squares	Fcal	p-value
Treatment	392.433	3	130.811	.191	.900
Error	7543.167	11	685.742		
Total	7935.600	14			

**Table 4:** The weight of control and experimental animals for the four weeks of feeding trials

Feeding groups	1st week (g)	2 <sup>nd</sup> week	3 <sup>rd</sup> week	4 <sup>th</sup> week
1	235	203	120	168
2	206	156	102	160
3	216	141	169	155
4	230	108	-	132
Mean	221.75a	152b	130.33b	153.75b

**Table 5:** Responses of respondents to color of the laboratory-baked breads

Loaf of breads	Creamy tint color (%)	Chocolate brown color (%)	Light brown with cream tint color (%)	Light brown color (%)	Pale light brown color (%)
Control	70	20	10	-	-
0.25g fiber content	-	20	10	60	10
0.5g fiber content	-	50	-	20	30
1.0g fiber content	-	-	20	30	60

**Table 6:** ANOVA table for bread color

Treatments	Control	0.25	0.50	0.10	Total
A	7 <sub>2,25</sub>	1 <sub>2,25</sub>	0 <sub>2,25</sub>	1 <sub>2,25</sub>	9
B	2 <sub>3</sub>	6 <sub>3</sub>	2 <sub>1,25</sub>	1 <sub>3</sub>	12
C	1 <sub>3,5</sub>	2 <sub>3,5</sub>	5 <sub>3,5</sub>	6 <sub>3,5</sub>	14
D	0 <sub>1,25</sub>	1 <sub>1,25</sub>	3 <sub>1,25</sub>	2 <sub>1,25</sub>	2
Total	10	10	10	10	40

H<sub>0</sub>: There is no relationship between color and fiber content; H<sub>1</sub>: There is no relationship between color and fiber content.  $X^2 = 25.39$ ;  $X^2_{(4-1)(4-1), 1-0.05} = X^2_{9,0.95} = 16.92$ . H<sub>0</sub> was rejected if  $X^2 > X^2_{9,0.95}$ . Since  $X^2 (=25.39)$  is greater than  $X^2_{9,0.95}$ , we rejected H<sub>0</sub>.

sumption. Earlier, Ogunkunle et al. (2003) used the wood of *Gmelina arborea* as a preliminary source of dietary fiber in human foods. Meanwhile, the wood

fibers of *G. sepium* have been discovered to be potential insoluble dietary fibers with the prospect for human consumption. This cellulose material incor-

porated into the normal diet of albino rats caused a reduction in live weight of the experimental animals. In addition, the cellulose fibers do not negatively affect the physical, chemical and the baking properties of bread. Bakery products can therefore be looked upon as potential means of wood-fiber consumption for nutritional therapy against excessive body weight and its resultant health hazards such as atherosclerosis, cancer of the colon, hemorrhoids, appendicitis, colitis and diverticulosis. However, empirical data and information on the safety of *G. sepium* wood consumption and metabolism obtained on experimental animal models are need to be undertaken in order to support the results of this study.

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