Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research

ISSN No: 0975-7384
CODEN(USA): JCPRC5

J. Chem. Pharm. Res., 2011, 3(6):918-924

The physico-chemical and organoleptic properties of milk fabricated from *Glycine max*, *Vigna subterranean* and *Sphenostylis stenocarpa*

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ABSTRACT

This experimental study was carried out to examine the physico-chemical and organoleptic properties of milk produced from Soybean (Glycine max), Bambara Groundnut (Vigna subterranean) and Yam bean (Sphenostylis stenocarpa). Following extraction, the three milk products were analysed for their chemical composition, mineral composition and organoleptic properties. Results show that conversion of plant beans to milk led to high losses of crude protein, fat, fibre, ash. There was high mean mineral retention of between 63-73% in the milk samples. The pH levels of the plant milk products of between 6.10 and 6. 40 were similar to cow milk pH of 6.40 - 6.60. Organoleptic measurements of each of the three milk products showed them to be highly acceptable for human consumption and could serve as good weaning foods. These novel foods could serve to keep malnutrition in check, a condition which is common among rural dwellers.

Keywords: Bambara groundnut, soybean, yam bean, milk and weaning food.

INTRODUCTION

Legumes are a unique plant family with seeds in double seamed pods and they include peas, soybean, yam bean and other types of beans. Legumes are generally grouped into two main categories, namely pulse and oil legumes. The African yam bean and Bambara groundnut belong to the class of less consumed pulse legumes of the humid tropical regions. The soybean on the other hand is an oil legume with high proportion of exploitable vegetable oil. Pulse legumes are therefore the ones with low levels of oil. In the tropical areas, the pulse legumes constitute the main source of protein to supplement protein-deficient staples. Soybean is a food crop that is being planted in many geographical regions of the world and has been involved in different industrial utilization world-wide. The other two grains, the African yam bean and Bambara groundnut have limited popularity compared to soybean. These three types of beans are however, not conventionally consumed as Cowpeas. These legumes have all been found to be good sources of minerals.

Improved research has led to remarkable uses of the legumes either as staples or fortifiers e.g. *Soy-moinmoin, Soy-ogi, akara and gari* [1]; [2]; [3]; [4]. Animal milk has dominated the market as a good source of protein, minerals and vitamins. Alternatives to animal milk are now fast growing. These three non-conventional legumes are currently good sources for the extraction of milk. They share certain characteristics such as the glassy appearance of their grains and are hard to cook.

In this present work milk was extracted from the legumes with a view to estimating the quality and the effects of processing on the nutritive and mineral compositions of the plant seed flours from which the three types of milk were fabricated.

EXPERIMENTAL SECTION

Sample collection

Soybean and Bambara groundnut were purchased locally from Bodija Market in Ibadan, while yam bean was purchased at Esa-Oke Market, Osun State, Nigeria.

Processing

Extraneous materials were removed from the raw samples and the samples were then analysed tor moisture, ash, crude protein, crude fat, crude fibre and nitrogen free extract [5].

The legumes were soaked overnight, dehulled and ground in a grinding machine. The slurry obtained was diluted so that 100g of beans could produce 500ml of milk [6]. The homogenized milk from each type of bean was pasteurized at 80^{o}C for 15 minutes and then cooled to room temperature (27^{o}C – 30^{o}C).

Sensory evaluation of plant milk

They were all evaluated sensorily by judges for taste, colour, odour and mouth feel on 5-point hedonic scale [7].

Chemical analysis

Plant milk from each specimen was analysed for proximate composition, mineral composition, pH and acidity [5].

Specific gravity was determined by the method of Pearson [8], Chemical Analysis of Foods.

Statistical analysis
The data obtained were analysed using ANOVA and treatment. Means were compared by using Duncan's Multiple Range (DMR 0.05) test to determine the effect of treatment when F – test was statistically significant at $P < 0.05$ [9].

RESULTS

Table 1 shows the proximate composition of the flour and milk samples of soy bean, Bambara groundnut and yam bean. The moisture content of the three types of plant flour varied from 9.60 – 11.4% and in contrast, their milk moisture varied from 70 – 73%. Yam bean flour (YBF), Bambara groundnut flour (BGF) and Soybean flour (SBF) crude protein values varied from 22 – 36% contrasting their milk crude protein varying from 1.07 – 2.02%. This result showed a marked crude protein loss during conversion process from flour to milk. Fat reduction/loss was remarkably high, from SBF to SBM (91.8%), from YBF to YBM (60%) and BGF to BGM (30%). The fibre of SBF (2.55%), BGF (6.0%) and YBF (5.40%) were all removed in their corresponding milk samples. The plants' flour ash varying from 3.40 – 5.32% were drastically reduced to levels varying from 0.76 – 0.82%. The plant flour carbohydrate contents varied from 25% in SBF to 54% and 58.76% in YBF and BGF respectively. Their respective derived milk samples varied from 24 – 26% in carbohydrate content.

The reference cow (Three Crowns) milk recorded higher moisture (88%), higher protein content, higher fat content but remarkably lower carbohydrate content than plant milk samples, their ash contents were similar and none of the milk samples was fibrous.

Table 1: Proximate Composition of the flour and milk samples of Bambara groundnut, Soybean and Yam bean

			Composition in %			
Sample	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
SBF	8.60 ± 0.25	36.25 ± 2.10	20.30 ± 1.20	5.55 ± 0.61	4.52 ± 0.50	24.78
0.85						
SBM	70.00 ±1.25	2.02 ± 0.02	1.66 ± 0.03	nil	0.82 ± 0.01	25.50
1.25						
BGF	10.80 ±1.00	24.44 ± 1.45	2.00 ± 0.10	6.0 ±	4.00 ± 0.20	58.76
2.04						
BGM	71.59 ± 1.4	01.07 ± 0.01	1.40 ± 0.04	nil	0.78 ± 0.02	25.16
1.20						
YBF	11.40 ±0.54	22.36 ± 1.45	3.10 ± 0.20	5.40 ±	3.40 ± 0.02	54.34
1.85						
YBM	73.07 ±1.0	1.37 ± 0.03	1.25 ± 0.02	nil	0.76 ± 0.01	13.55
1.14						
COWM*	87.70	3.29	3.61	nil	0.76 ± 0.01	7.93

Values are duplicate means ± SD (Standard Deviation)
**Source, David Pearson, 1976; Hamad and Baiomy, 2010.*
SBF - Soy bean flour; SBM - Soy bean milk
YBF - Yam bean flour; YBM - Yam bean milk
BGF - Bambara groundnut flour; BGM - Bambara groundnut milk
COWM - Cow milk (Ref. Milk)

Table 2 shows the mineral composition of each plant flour and their milk samples. Mineral losses due to conversion of plant flour to milk were noticeable. The overall mineral retention in milk samples were 73.10%, 64.63% and 67.30% in SBM, YBN and BGM respectively. Barring all other incidental losses, these mineral contents of plant milk may be available for physiological functions of the human body.

Mineral composition of each plant flour and their milk samples.

Table 2

Sample	Ca	Mg	K	Na	P	Fe	Cu	Zn	Mn	Mean Retention/Milk %
	Mineral Composition in mg/100g									
SBF	77.25	23.00	23.10	8.22	37.92	15.43	9.42	9.46	35.40	
SBM	72.40	18.20	11.40	5.90	27.20	9.20	5.20	5.10	28.74	
% retained	93.72	78.27	92.64	71.78	71.70	59.62	55.20	53.76	81.19	73.10
YBF	30.00	1.60	12.00	0.80	2.2	0.91	0.17	0.27	0.27	
YBM	27.75	1.04	9.43	0.34	0.43	0.53	0.16	0.25	0.16	
% retained	72.50	64.30	78.58	42.50	19.55	58.30	94.12	92.59	59.26	64.63
BGF	63.94	43.86	42.00	10.14	35.43	20.05	6.26	8.93	8.04	
BGM	38.68	34.40	33.00	9.72	22.00	13.23	3.76	3.16	5.52	
% retained	60.49	78.44	78.57	95.86	62.09	65.98	60.09	35.39	68.66	67.30

Values are duplicate means ± SD (Standard Deviation)
**Source, David Pearson, 1976; Hamad and Baiomy, 2010.*
SBF - Soy bean flour
SBM - Soy bean milk
YBF - Yam bean flour
YBM - Yam bean milk
BGF - Bambara groundnut flour
BGM - Bambara groundnut milk
COWM - Cow milk (Ref. Milk)

Observation in Table 3 reveals that the pH values of plant derived milk (YBM and BGM), and cow milk were uniform (6.40) except for SBM which varied within a narrow limit (6.10). The acidity of SBM was almost twice as large as those of BGM & YBM each of which was 0.45g/kg lactic acid. The reference cow (Three crown) milk acidity is much higher than those of the three plant derived milk. The specific gravity of YBM (0.92) was identical to that of cow milk (0.93). Those of BGM & SBM were similar and are also identical.

Table 3: Physico-chemical properties of bean milk samples

Parameter	SBM	BGM	YBM	COWM*
PH	6.10	6.40	6.4	6.4 – 6.6
Acidity as g/kg lactic acid	0.85 + 0.15^{b}	0.45 + 0.03^{c}	0.45 + 0.03^{c}	1.40^{a}
Specific gravity	0.98 + 0.06	0.99 + 0.07	0.92 + 0.10	0.93

Values are duplicate means ± SD (Standard Deviation)
**Source, David Pearson, 1976; Hamad and Baiomy, 2010.*
SBF - Soy bean flour
SBM - Soy bean milk
YBF - Yam bean flour
YBM - Yam bean milk
BGF - Bambara groundnut flour
BGM - Bambara groundnut milk
COWM - Cow milk (Ref. Milk)

Table 4 displays the organoleptic properties of plant derived milk compared with cow (Three Crowns) milk solution prepared in ratio 1:5 with water. In all sensory properties the standard milk was significantly better ($P<0.05$) than plant milk samples except only in texture of SBM. All plant milk samples, however, displayed, very good sensory scores.

Table 4: Sensory Evaluation of Milk Samples Compared with Three Crown Milk

Parameter	Standard	SBM	YBM	BGM
Taste	5.00 + 0.00^{a}	4.40 + 0.52^{b}	4.00 + 0.63^{b}	4.10 + 0.57^{b}
Colour/Appearance	5.00 + 0.00^{a}	4.50 + 0.53^{b}	4.50 + 0.53^{b}	4.30 + 0.48^{b}
Odour	5.00 + 0.00^{a}	4.20 + 0.42^{b}	4.20 + 0.42^{b}	4.40 + 0.42^{b}
Texture/Mouth feel	5.00 + 0.00^{a}	4.60 + 0.52^{ab}	4.60 + 0.50^{b}	4.40 + 0.51^{b}

Values are means ±Standard deviation of measurements.
Values significantly different ($P < 0.05$) are denoted by superscripts
Abbreviations are as found under table 1
Three crown Milk of 1:5 water dilutions as standard
Values are duplicate means ± SD (Standard Deviation)
**Source, David Pearson, 1976; Hamad and Baiomy, 2010.*
SBF - Soy bean flour
SBM - Soy bean milk
YBF - Yam bean flour
YBM - Yam bean milk
BGF - Bambara groundnut flour
BGM - Bambara groundnut milk
COWM - Cow milk (Ref. Milk)

DISCUSSION

Generally in this study, there were remarkable losses in both proximate and mineral composition in the three specimens. This is not unexpected bearing in mind that raw material treatments involved soaking, dehulling and cooking. Virtually all highly soluble minerals can be widely leached into the soaking or cooking water, potassium and sodium (K & Na) being the most vulnerable. Vigorous cooking further lent to the removal of minerals which are not easily leachable. Mineral losses may be caused by relative rapid movement of ions from seed cell into cooking water in response to diffusion gradient [1]. The vigorous cooking may also release minerals such as phosphorous from disruption of protein-phytate complex. Loss of mineral may also be due to removal of hulls, an integral part of processing that culminate in milk production. What accounts for low retention level of Na and P in yam bean milk and Zn in BGM is unknown. The extent of solubility of the component part of plant flour would determine the composition of flour milk. Protein and fat being very bulky do not have tendency for appreciable water solubility. The portions of proximate compounds in the seed flour would be so discrete to form part of colloidal solution in the milk. Carbohydrate constitutes the most predominant portion (24-26%) of the plant flour that goes into milk colloidal solution. The crude protein values obtained in this study correspond to values of 1.47-2.06 reported by a previous researcher [8].

In conformity with the composition of cow milk reported in one study [10], moisture constitutes the major component of plant milk, other components being present in small proportions.

The pH values reported in this study are similar to previous reports [4]; [10], for soymilk. The acidity of the milk samples in this study is comparatively higher than a previously reported value [4]. The characteristic low pH of milk, whether of animal or plant origin, is indicative of low acidity in which bacterial growth may be limited. While some foods are characterized by inherent acidity, others owe their acidity or low pH to the actions of certain microorganisms. Therefore, the natural acidity of foods may be thought of as nature's way of protecting products from destruction or spoilage by microorganisms [11].

When milk from soybean, yam bean and Bambara groundnut was compared with cow (Three Crowns) milk (which was diluted in the ratio of 1:5 with water), in terms of taste, colour, odour and mouth feel, the judges considered plant milk to be very good.
This study has therefore shown that plant milk is quite acceptable on the basis of organoleptic scores compared with the standard milk.

CONCLUSION

These plant seeds have been subjected to extraction procedures which require no specialized and sophisticated equipment. This process is adaptable at the village level. The processing retained a high degree of mineral nutrients needed in the body. If adopted, they could be used as weaning foods to alleviate malnutrition among rural dwellers.

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