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Assessing the suitability of locally produced gum exudates in the food industry

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Abstract

The over-reliance of the food industry in Ghana on imported gums ultimately increases the final cost of processed food. Gums produced by some trees in Ghana have not been exploited commercially, probably due to lack of data on the properties which influence their application in the food industry. This study was therefore undertaken to assess the suitability of gums obtained from Cashew, Albizia, and Khaya trees in Ghana in food applications, using Acacia gum as a control. The properties studied include organoleptic, pH, solubility, viscosity, swelling power, and water binding capacity. The physicochemical properties were determined through experimentation and observation. The pH, viscosity, swelling power and water binding capacity of the gums were 3.80-5.00, 93.0-11195.0 mPas (at 3% concentration), 1.64-20.56% and 4.0-428.8%, respectively. Cashew gum showed similar properties as Acacia gum, and can be used as a substitute for Acacia gum. Albizia gum was found to have the highest viscosity and water binding capacity, followed by Khaya gum, and thus has the potential to be used as a thickener in jams, sauces, etc., and also prevent stalling in baked goods and crystallization in confectioneries. The acid stabilities of Cashew and Albizia gums were comparable with that of Acacia gum.

Keywords: Acacia gum, food industry, water binding capacity, swelling power, viscosity, organoleptic properties

1. Introduction

A gum or hydrocolloid is any polymer which is soluble or dispersible in water to form a viscous solution or dispersion (Glicksman, 1969). Many industries such as pharmaceutical, toothpaste, food, cosmetics, adhesive and paper make use of gums. Gums have wide applications in the food industry. They are used as binding agents in sausages, clarifying agents in wine and beer, emulsifiers in confectionery, stabilizer in mayonnaise, suspending agent in chocolate milk, and as thickening agent in jams, sauces, gravies and pie fillings (Glicksman, 1969; Maroziene and de Kruif, 2000). The factors which influence the utilization of gum in the food industry include its colour, odour, taste and texture, pH, solubility, swelling power, water binding capacity, viscosity and its stability in food.

Gums may be obtained from different sources, including terrestrial plants, marine plants, and microorganisms. The terrestrial plants which produce gums include *Acacia senegal, Sterculia urens,* and *Anogeissus latifolia*; the marine plants include *Gelidium amansii, Chondrus crispus,* and *Macrocystis pyrifera;* the microorganisms include *Xanthomonas campestris,* and *Leuconostoc mesenteroides* (Smith and Montgomery, 1959). The terrestrial plants produce gums as a result of injury or removal of the bark of the tree (Glicksman, 1969).

The current price of Arabic gum is $1,500 per ton, gum karaya is $2,250 – $6,000, and gum tragacanth is $3,000 - $4,000 (Nussinovitch, 2010). A survey conducted in Ghana revealed that not only is about 10,000kg of gum used by various food and pharmaceutical industries annually, but also are mostly imported (Anaman, 1998). This means a huge market exists for gum utilization in Ghana, and this has to be utilized for the benefits of the citizenry. Against the backdrop of the continuous depreciation of the Ghanaian currency, the Ghana Cedi, over-reliance of the food industry on the external supply of gums is likely to increase their cost and hence the cost of the final food product. However, the potential to exploit gum resources exists in Ghana.

Many trees in Ghana are reported to be gum producers, including *Acacia campylacantha*, *Albizia zygia*, *Albizia adanthifolia*, *Khaya senegalensis*, *Khaya grandifoliola*, *Sterculia setigera*, *Sterculia tragacantha* (Irvine, 1961), and *Anarcadium occidentale* (Smith and Montgomery, 1959). So far these sources have not been tapped for their gum resources in Ghana, perhaps due to limited or lack of data on the properties that influence their uses in various industries. Viscosity properties of cashew gum were reported (Owusu et al., 2005). Rheological properties of cashew gum were also the subject of a previous study (Gyedu-Akoto et al., 2007). Physicochemical properties of gums from cashew were studied (Gyedu-Akoto et al., 2008a). The application of cashew gum in chocolate pebble production was studied (Gyedu-Akoto et al., 2008b). In the same study, the authors found out that cashew gum is non-toxic. The nutritional importance of *Albizia zygia* gum in wild chimpanzee was reported (Ushida et al., 2006). Emulsifying properties of gum odina (Samanta et al., 2010), and effect of gums on bread quality were reported (Keskin et al., 2007). Based on the above background, the study was conducted to assess the organoleptic and physicochemical properties of some gums produced from trees in Ghana, and to determine their suitability in the food industry.

2. Materials and methods

2.1 Source and preparation of gums

Exudate gums from the tree species Acacia (*Acacia species*), Cashew (*Anarcardium occidentale*), Mahogany (*Khaya senegalensis*), and Okore (*Albizia zygia*) were used for the study (Plate 1-3). *A. occidentale* gum was collected from the Ejura Farms Ltd., Ejura in the Ashanti Region, Ghana. *K. senegalensis*, and *A. zygia* gums were collected from the Bobiri forest Reserve in the Juaso Forest District, Ghana, while the *A. species* gum was obtained from the Forest Research Institute of Ghana, Fumesua. The gums were handpicked to remove pieces of bark, dirt and other woody materials. They were then dried in the sun for about two weeks, and milled. The Acacia gum was used as the control.

Plate 1: Albizia gum

Plate 2: Acashew gum

Plate 3: Khaya gum

2.2 Determination of organoleptic properties of gums

The colour, odour, taste and texture of the gums were assessed through personal observation.

2.3 Moisture content of powdered gum

Two grams powdered sample from each gum exudates were weighed into a previously weighed porcelain crucible and dried to a constant weight in a hot air oven at 105^0C. The moisture loss on drying was then expressed as a percentage of the powdered sample (British Pharmacopoeia, 1993).

2.4 Total ash content of gums

Two grams powdered sample from each gum exudates were weighed into a prepared silica crucible. The gums were then incinerated in a muffle furnace at a temperature not exceeding 450^0C until carbon-free ash was obtained. The weight of the ash was expressed as a percentage of the air-dried gum in triplicates (British Pharmacopoeia, 1993). The percentage ash was calculated using the formula:

$$Total\ ash = \left(\frac{W_b - W_a}{W_b}\right) \times 100\% \quad (1)$$

Where, W_b = weight of the sample before ashing and W_a = weight of sample after ashing.

2.5 Acid insoluble ash

Twenty-five milliliters of 2M HCl were added to the ash obtained from the ash determination and boiled for 5 min. The insoluble ash component was then collected in a sintered glass crucible No. 4, washed with hot water and ignited in a furnace. The weight of the acid insoluble ash was determined in triplicates and expressed as a percentage of the air-dried gum (British Pharmacopoeia, 1993). The percentage acid insoluble ash was determined in triplicates with the formula:

$$Acid\ insoluble\ ash = \left(\frac{W_{ta} - W_{sa}}{W_{sd}}\right) \times 100\% \qquad (2)$$

W_{ta} = weight of total ash, W_{sa} = weight of soluble ash and W_{sd} the = weight of the sample before drying.

2.6 pH of gums

Two grams of each gum were dispersed in 100mL of distilled water at room temperature (28^0C). A pH meter was standardized (HI 9024 Microcomputer) using the pH 4 and 7. The pH of the gum solutions was then determined in triplicates.

2.7 Solubility and swelling power of gums

One gram of each gum exudates was weighed into clean, dried, and previously weighed centrifuge tube and 40mL of distilled water added. The solution was stirred constantly at room temperature (28^0C). It was then centrifuged for 15 min at 2200 rpm (Damodoran, 1996). The supernatant solution was then transferred into a previously weighed glass crucible and evaporated to dryness. The solubility and swelling power were then determined in triplicates using the formulae:

$$\text{Solubility} = \frac{W_{sge}}{W_{sdb}} \times 100\% \qquad (3)$$

$$\text{Swelling power} = \frac{W_{sp}}{W_{sdb} \times (100 - \%\text{Solubility})} \times 100\% \qquad (4)$$

Where, W_{sge} = weight of soluble gum exudate, W_{sdb} = weight of sample (dry basis) and W_{sp} = Weight of sedimented paste.

2.8 Water binding capacity

Water binding capacity (WBC) of the gums was determined using the method of Yamazaki (1953) and which was modified by Medcalf and Gilles (1965). Two grams of each gum were dispersed in 40ml of distilled water at room temperature (28oC) to form a suspension. The suspension was agitated with Griffin Flask Shaker (Griffin and George Ltd., Great Britain) for 1 h. It was then centrifuged at 2200 rpm for 10 min using a centrifuge (Gallenkamp Centrifuge). After

decanting the free water, the remaining wet sample was drained for 10 min. The drained sample was weighed with an analytical balance (Mettler H 10) and the WBC was calculated using the formula:

$$WBC = \frac{Bound\ water \times 100}{Weight\ of\ dried\ sample}\% \qquad (5)$$

2.9 Viscosity of gum exudates

Three percent (w/v) solution of each of the four gum exudates was at 28^0C, and left to stand for 30 min. The Brookfield Viscometer (Model DV-II+ Version 3.0) was then used to determine the viscosity (mPas) at 100 rpm in triplicates.

2.10 Effect of pH on viscosity

Two percent (w/v) solutions of Khaya and Albizia gum exudates, and 10.0% (w/v) solutions of Cashew and Acacia gum exudates were prepared and made to stand at room temperature (28^0C) for 30 min. The pH of the solutions was adjusted to values ranging from 1.0 to 5.5 with drops of hydrochloric acid and sodium hydroxide. The Brookfield viscometer was used to measure the viscosity at 100 rpm after every pH adjustment (Model DV-II+ Version 3.0). The experiment was triplicated.

2.11 Statistical analysis

The data obtained from the study were analyzed using SPSS, Version 17, and means were considered significant at $P<0.05$.

3. Results and discussion

3.1 Organoleptic properties of gums

The organoleptic properties such as colour, odour and taste, influence the commercial value and application of gums in the food industry (Nussinovitch, 2010). The organoleptic properties of the gums studied are shown in Table 1. Albizia gum exudate had a colour ranging from cream to yellow. The colour of Cashew and Acacia (Control) gums was cream to white. Khaya gum exudate showed a white colour. Colour is a very important parameter in terms of the commercial value of gum, and gums with light colours are more preferred (Nussinovitch, 2010).

Table 1
Organoleptic properties of gum exudates

Gum exudates	Colour	Odour	Taste
Acacia (Control)	Cream to white	Odourless	Tasteless
Albizia	Cream to yellow	Odourless	Tasteless
Cashew	Cream to white	Odourless	Tasteless
Khaya	White	Odourless	Tasteless

Gundidza et al. (2011) found that *Dichrostachys cinerea* (*L.*) gum was colourless. The colour of the gums studied was comparable to those prescribed by British Pharmacopoeia (1993) for food products. All the gums were odourless and tasteless. According to Glicksman (1969) water-soluble gums are usually odourless and tasteless. The present results agree with those reported previously (Gundidza et al., 2011).

3.2 Physicochemical properties of the gums

The physicochemical properties of the gums are shown in Figs. 1-5. The ash content of gums could be used as a crude indicator of their mineral content (Herbers, 1994). The total ash (TA) (Fig. 1) content of the gums studied ranged from 1.77-3.75%, and fell within the acceptable level of less than 4% of gum arabic (United States Pharmacopoeia XVII, 1965; Belitz et al., 2004). The TA content for Cashew gum was slightly higher than 0.5-1.2% found by Gyedu-Akoto et al. (2008a) and 1.5% reported by Okoye et al. (2012). In addition the TA values were comparable to the 2.59±0.01% reported for *Dichrostachys cinerea* (*L.*) gum (Gundidza et al., 2011). The acid insoluble ash (AIA) (Fig. 1) values for the gums were in the range 0.09-0.31%, and compares favourably with 0.3% reported earlier for Cashew gum (Okoye et al. 2012). The values are within the acceptable range for gum arabic (≤0.5%), gum tragacanth (≤0.5%), and gum karaya (≤1.0%) (United States Pharmacopoeia XVII, 1965). The pH of the gums ranged from 3.80 to 5.00 (Fig. 2), with Khaya recording the lowest and Acacia the highest. The pH for cashew gum in the present study agrees with 3.8-4.2 found by Gyedu-Akoto et al. (2008). The most widely used exudate gums in the food industry, gum arabic, gum tragacanth and gum karaya have the respective pH ranges 4.5-5.5, 5-6, and 4.4-4.7 (Glicksman, 1969). It has also been found out that acidic and neutral gums have useful commercial value in the food industry (Tyler et al., 1981). The solubility values of the gums in water ranged from 43.85-81.87% (Fig. 3). The Acacia gum (Control) was the most soluble ($P<0.05$) while the Khaya gum was the least soluble. The differences in the solubility values may be due to differences in the nature of their acetyl groups (Imeson, 1992). The viscosity values of the gums at 3% concentration are shown in Fig. 4. Albizia and Acacia (Control) gums recorded the highest ($P<0.05$) and the lowest viscosity values respectively. Lal et al. (2006) found out that gums which have high viscosities could be used as thickening agents. The results indicate that Albizia gum could be used as a thickening agent in jams, sauces, gravies and pie fillings better than the rest of the gums. In addition, Albizia gum could serve as a better binding agent in a product such as sausage. Also Albizia gum gave the highest, while Acacia (Control) gum recorded the lowest swelling power (SP) value (Fig. 5). The water binding capacity (WBC) was higher for Albizia gum than the rest (Fig. 6). Thus the Albizia gum may be a good agent for prevention of staling in pastries, and prevention of crystallization in confectioneries. According to Glicksman (1969), gums which trap large amount of water are used to retard staling of baked products and to inhibit ice crystallization in confectioneries. The correlation between SP and WBC of the gums is shown in Table 2. The correlation between the two parameters was significant at $P\leq0.01$ and positive. The results indicate that gums which exhibited stronger swelling ability were able to hold much water and vice versa. Differences in botanical sources may account for the differences in the physicochemical properties of the gum exudates.

Table 2
Correlation between swelling power and water binding capacity

		%SP	%WBC
% SP	Pearson Correlation	1	.842**
	Sig. (2-tailed)		.001
	N	12	12
%WBC	Pearson Correlation	.842**	1
	Sig. (2-tailed)	.001	
	N	12	12

**Correlation is significant at 0.01 level (2-tailed), SP – Swelling power, WBC – Water binding capacity

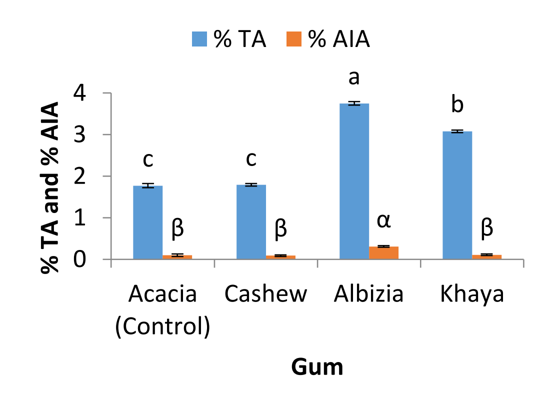

Fig.1: Total ash (TA) and acid insoluble ash (AIA) contents of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

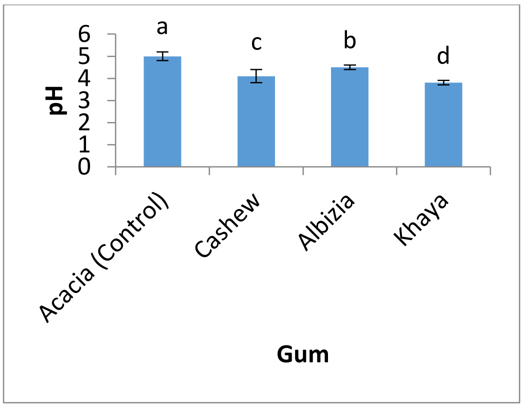

Fig.2: pH of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

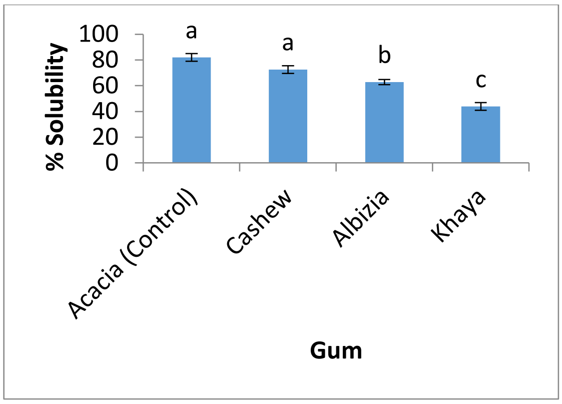

Fig. 3: Solubility of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

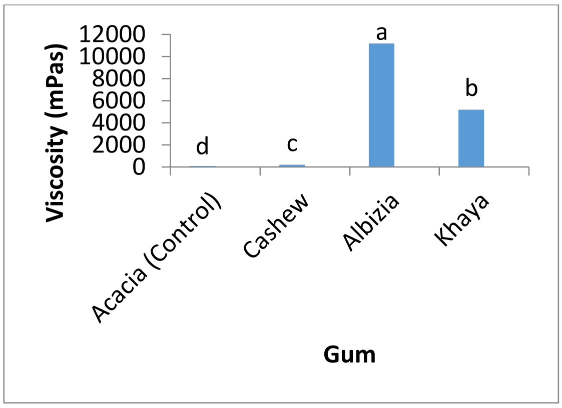

Fig.4: Viscosity of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

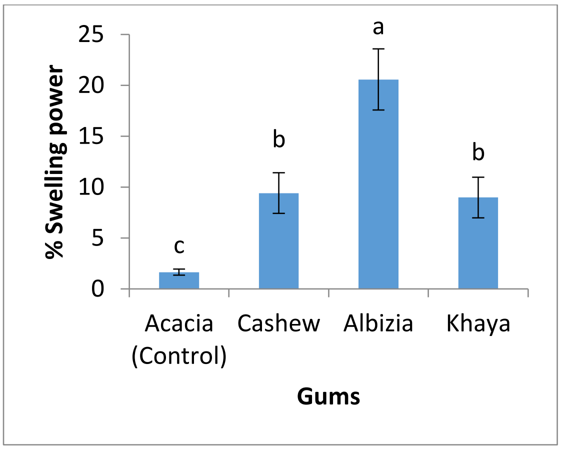

Fig.5: Swelling power of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

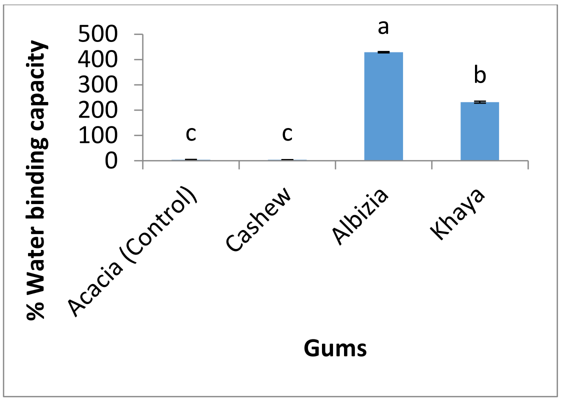

Fig.6: Water binding capacity of gum exudates. Different alphabets and Greek letters show that means are significant at $P < 0.05$.

3.3 Acid stability of the gum exudates

The viscosity of the gum solutions was determined at different pH values, and the results are shown in Fig. 7.

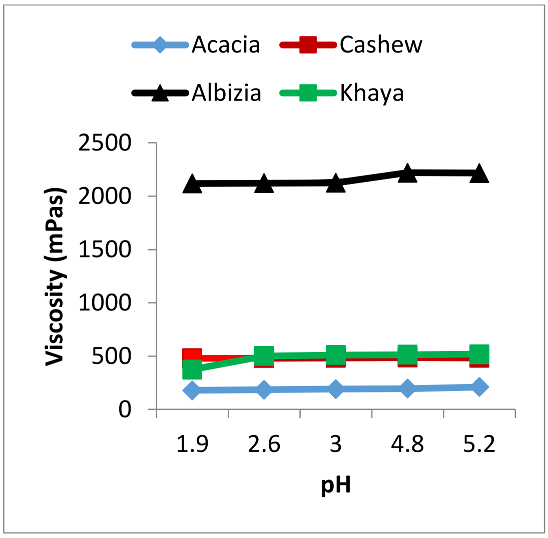

Fig.7: Change in viscosity with pH

The results show that the viscosity of the Cashew and Albizia gums was more stable over a wider pH range and compared favourably with that of Acacia gum (Control). A gum's stability in an acid solution is useful for the stabilization of citrus oil emulsion (Nussinovitch, 2010). The Cashew and Albizia gums may therefore be more suitably applied in acidic foods than Khaya gum.

4. Conclusions

The study has revealed that the organoleptic properties of the gum exudates are comparable with the commercial gums which are already applied in food. Most of the physicochemical properties of the Cashew gum compared favourably with those of Acacia gum, and thus the latter can be used as a good substitute for the former in food applications. Among the gum exudates studied, Albizia gum is the best thickener, binding agent, and can prevent staling and crystallization better than the rest.

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References

Anaman, A. (1998). Utilization of gum exudates from Acacia spp. Unp. MSc. Thesis. Department of Wood Science. Institute of Renewable Natural Resources, KNUST, Kumasi.

Belitz, H. D., Grosch, W., and Schieberle, P. (2004). Food Chemistry. 3rd ed. Springer, Berlin.

British Pharmacopoeia (1993). Vol. 2. Cambridge University Press, London.

Damodoran, S. (1996). Amino acids, peptides and proteins: *In* R. F. Owen (ed.), Food Chemistry. Marcel Dekker Inc. New York, Basel. pp 377-378.

Glicksman, M. (1969). Gum technology in the food industry. Academic Press, New York.

Gundidza, M., Mmbengwa, V., Sibambo, S. R., Magwa, M. L., Mushisha, O., Gundidza, E., and Samie, A. (2011). Analysis of a gum from the exudates of *Dichrostachys cinerea* (L.) Wight and Am. African Journal of Biotechnology, Vol 10 No 33, pp 6241-6245.

Gyedu-Akoto, E., Oduro, I., Amoah, F. M., Oldham, J. H., Ellis, W. O., Opoku-Ameyaw, K. and Hakeem, R. B. (2008a). Physicochemical properties of cashew tree gum. African Journal of Food Science, Vol 2, pp 060-064.

Gyedu-Akoto, E., Oduro, I., Amoah, F. M., Oldham, J. H., Ellis, W. O., Opoku-Ameyaw, K., Asante, F., and Bediako, S. (2008b). Quality estimation of cashew gum in the production of chocolate pebbles. African Journal of Food Science, Vol 2, pp 016-020.

Gyedu-Akoto, E., Oduro, I., Amoah, F. M., Oldham, J. H., Ellis, W. O., Opoku-Ameyaw, K. (2007). Rheological properties of aqueous cashew tree gum solutions. Scientific Research and Essay, Vol 2 No 10, pp 458-461.

Herbers, L. H. (1994). Ash analysis: *In* S. S. Nielson (ed.), Introduction to the chemical analysis of foods. Jones and Barlett, Boston. pp 113-121.

Imeson, A. (1992). Thickening and gelling agents for food. Chapman and Hall, London.

Irvine, F. R. (1961). Woody plants of Ghana with special reference to their uses. Oxford University Press, London.

Keskin, S. O., Sumnu, G., and Sahin, S. (2007). A study on the effects of different gums on dielectric properties and quality of breads baked in infrared-microwave combination oven. European Food Research Technology, Vol 224, pp 329-334.

Lal, S. N. D., O'Connor, C. J., and Eyres, L. (2006). Application of emulsifiers/stabilizers in dairy products of high rheology. Advanced Colloid Interface Science, Vol 26, pp 123–126.

Maroziene, A., and de Kruif. C. G. (2000). Interaction of pectin and casein micelles. Food Hydrocolloid, Vol 14, pp 391–394.

Medcalf, D. G., and Gilles. K. A. (1965). Wheat starches 1. Composition of physicochemical properties. Cereal Chemistry, Vol 42, pp 558-568.

Nussinovitch, A. (2010). Plant gum exudates of the world: Sources, distribution, properties and applications. CRC Press, Taylor and Francis Group, New York.

Okoye, E. I., Onyekweli, A. O., and Fatoki, O. O. (2012). Evaluation of LD of cashew gum and the comparative study of its functionality in cotrimoxazole granule and tablet formulations. British Journal of Pharmacology and Toxicology, Vol 3 No 4, pp 156-164.

Owusu, J., Oldham, J. H., Oduro, I., Ellis, W. O., Barimah. J. (2005). Viscosity studies of cashew gum. Tropical Science, Vol 45, pp 86-89.

Samanta, A., Ojha, D., and Mukherjee, B. (2010). Stability analysis of primary emulsion using a new emulsifying agent gum odina. Natural Science, Vol 2 No 5, pp 494-505.

Smith, F., and Montgomery, R. (1959). The chemistry of plant gums and mucilages. Reinhold Publishing Corporation, New York.

Tyler, V. E., Brady, L. R., and Robbers. J. E. (1981). Pharmacognosy. 9th ed. Lea and Febiger, Philadelphia.

United States Pharmacopoeia XVII. (1965). XVII Revision. p. 107. *In* M. Glicksman (ed.), Gum Technology in the Food Industry. Academic Press, New York.

Ushida, K., Fujita, S., and Ohashi, G. (2006). Nutritional significance of the selective ingestion of *Albizia zygia* gum exudates by wild chimpanzee in Bossou, Guinea. American Journal of Primatology, Vol 68, pp 143-151.

Yamazaki, W. T. (1953). An alkaline water retention test for the evaluation of cooking, and baking potentialities of soft water wheat flour. Cereal Chemistry, Vol 30, pp 242-246.