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Characteristics Study of Some Sudanese Origin Natural Gums Prepared for Food Processing

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***Abstract*—** *Tow species from Acacia gums namely Arabic Gum (Acacia senegal) Sunt gum (Acacia nilotica var .nilotica) and karaya gum (Sterculia setigera) from Sudanese origin were investigated for physical, chemical and microbiological characteristics. The moisture, nitrogen and protein content, ash and pH were found to be ranging from 9.83% to12.39%, 0.34% to 0.37%, 2.19% to 2.24%, 2.50% to 3.90% and 4.33% to 5.35%, respectively. The results of refractive index revealed similarity between the three gums which were reported1.334, 1.363 and1.333, respectively. Clear differences in specific optical rotation and viscosity results were observed which were reported-28.50°, +106.41°and+2.0°, respectively and 50 Cps, 60 Cps, and 110 Cps, respectively. The results recorded an absence of tannin content in Arabic Gum and Karaya gum, where Sunt gum appears negligible amounts (0.05).Microbiological load of the investigated gums proved it is free of yeasts and moulds, total Coliform, Escherichia coli and Salmonella.*

***Keywords*—** *Characterization; Natural gums; Sudanese origin.*

I. INTRODUCTION

Gum is a polysaccharide of hydrocolloids [1]. Exudate gums are used in an overwhelming number of applications, mainly situated in the food area. The gums have two major properties gelling and thickening, all gums by definition have a thickening effect. This property is the basis for their use as bodying, stabling and emulsifying agents in many foods. Arabic Gum is a dried exudation obtained from the stems of *Acacia senegal* L. Arabic Gum has been used as a stabilizer in frozen products such as ice-cream, ice milk, ice pop, and water-ice, because of its water-absorbing properties, it has also been used in chocolate, milk drink, pudding, cottage cheeses, cream cheese, cheese spread and yoghurt [2]. Other gum types may be used as a substituent of Arabic Gum after the study of their physicochemical properties and functionalities [3]. Karaya gum has a more recent history and has only been used commercially for about 100 years. It is obtained from *Sterculia* tree which is a native of dry deciduous forests in tropical climates [4]. In Sudan, *Sterculia setigera* is known as *Tartar* and *Fidir* [5]. It is used in meat and dairy products (yoghurts, cheese, ice-cream, dairy desserts, sausage).The Species *Acacia nilotica* belong to the Genus *Acacia* and its gum called (*Sunt*) in Sudan. It is edible and used to relieve throat and chest complaints [6]. In predated study [7] revealed that *Acacia nilotica* var. *nilotica* gum produced emulsions having an excellent emulsifying stability compared to *Acacia senegal*.

Recognition of differences in the species, varieties and environment is important in producing gums for a desired end use [8]. [2] Mentioned the five most important parameters that can be used to identify raw gums mostly used as food additives are Specific optical rotation, Nitrogen content, Ash content, Moisture content and Absence of tannins. Due to the hard competitiveness of natural gums prices in the local and foreign markets, Sudanese natural gums facing many attempts of adulteration, for instance the mixing between different species. Thus, characterization is considered one of the most important approaches that used for authentication of gums. Wherefore, this research aims at study some physicochemical and microbiological properties of the under utilized natural gums namely *Sunt* gum (*Acacia nilotica var. nilotica*) and Karaya gum (*Sterculia setigera*) compared with Arabic Gum (*Acacia senegal*) so as to ensure it is conformity with the specifications, as well as to expand its applications base particularly in the field of food processing.

II. MATERIALS AND METHODS

2.1 Gum Samples Collection and Preparation

Adequate authentic samples of Arabic Gum (*Acacia senegal*) was obtained from *Alhumeraa* forest, North of Kordofan State, Sudan. *Sunt* gum (*Acacia nilotica var .nilotica*) was collected from *Alsunt* forest, Khartoum State. Karaya gum (*Tartr* gum) (*Sterculia setigera* L.) was obtained from *Alabasia* area, Eastern Mountains, South of Kordofan State, Sudan. Gum samples were dried under the shade and cleaned to remove any impurities; the cleanest nodules were selected and made into fine powder using an electric mill and kept in sealed polyethylene labeled bags for analysis.

2.2 Methods of Analysis

Moisture content, pH, ash content, protein and nitrogen content of each sample was determined according to the [9]. Sugars content were determined via hydrolysis by the methods described by [10] using High Performance Liquid Chromatography (HPLC). Tannins content was measured quantitatively according to the method of Sudanese Standards and Metrology Organization [11]. Specific optical rotation was determined at room temperature for 1.0% solution on dry weight basis according to [12]. The viscosity test was determined using Brookfield viscometer V1-V2 with concentration of (10%) for Acacia gum samples (Acacia senegal and Acacia nilotica) and (2.5%) for Karaya gum sample (Sterculia setigera) at ambient temperature and the

viscosity of gum solution was read directly in centipoises (Cps). Microbiological analysis (Total viable bacterial count (TVBC), total yeasts and moulds, Coliform bacteria, E. coli and Salmonella Spp.) were carried out using the methods described by [13].

III. Results and Discussion

3.1 Moisture Content

According to Table 1 the moisture content was found to be (11.30%) for Arabic Gum (*Acacia senegal*) which is consistent with [14] who reported that the mean value of moisture content for 803 *A. senegal* gum samples collected in season 1994/1995 was 10.75% and the range was 8.1% – 14.05%. [15] Reported the mean value of moisture content for (*A. senegal*) gum as 11.01% and the range was 9.91% – 14.72%. On the other hand the moisture content of *Sunt* gum (*Acacia nilotica* var *nilotica*) was found to be (9.83%).This result is in agreement with those reported by [7] who found that the moisture content of *Sunt* gum (*Acacia nilotica*) samples collected from Khartoum State in season 2010 was in the range of 9.85-11.69% with an average value of 10.81%. For Karaya gum (*Sterculia setigera*) moisture content was found to be (12.39%).This result is in close agreement with the values of Karaya gum (*Sterculia setigera*) from Blue Nile (12.5%), and higher than those samples from Kordofan (13.2)% which were reported by [16], but agrees with the value of 12.8 % given by [17]. These results are in line with the Sudanese Standards which stated not more than 20% moisture content for *Sterculia setigera* gum in Sudan [18]. [7] Pointed out that the moisture content of the gum is usually affected by the season of collection, the prevailing climate conditions and the storage conditions.

3.2 Nitrogen and Protein Content

As illustrated in Table 1 nitrogen and protein content of (*A. senegal*) gum was found to be (0.37%) and (2.42%), respectively. These results were exactly conformable to those obtained by [19] who reported the average value of nitrogen content as (0.37%), whereas, protein content as (2.4%).The nitrogen and protein content of *Sunt* gum (*A. nilotica* var. *nilotica*) was found to be (0.34 %) and (2.19%), respectively**.** Apparently, these results were far less than those indicated by [7], who stated that the mean percentages of nitrogen and protein content for the seasons 2008, 2009 and 2010 were found to be ranged between 0.02% and 0.16%, respectively for all seasons. According to [20] there is a strong correlation between the proportion of protein in the gum and emulsifying stability. The results revealed that nitrogen and protein content for Karaya gum (*Stercula setigera*) were found to be (0.35%) and (2.32%), respectively. These results are comparatively near to the values of 0.15% and 0.19% nitrogen and 0.95% and 1.20% protein which reported by [21] for Blue Nile and Kordfan Karaya gums, respectively. Nitrogen and protein components play a very important role in the structure, physicochemical properties and functionality of gums.

3.3 Ash Content

As shown in Table 1 ash content of Arabic Gum *(Acacia senegal)* was found to be (3.22 %).This result somewhat less than the average of (3.32%) that reported by [19].The result is also in accordance with the range of ash content of Sudanese specifications, which stated range of (Not more than 4%) for Arabic Gum [22]. Furthermore, the ash content for *Sunt* gum (*Acacia nilotica*) was found to be (2.50%).This result is almost similar to those results obtained earlier by [23] which fell in the range of 1.98- 2.48%, but less higher than the results reported by [7] in the study of *Sunt* gum collected on seasons 2008, 2009 and 2010, respectively from different locations of Sudan, which were reported as 1.82%, 1.84% and 1.91%.

TABLE 1. Some Chemical Characteristics of Acacia Gum (*Acacia senegal, Acacia nilotica*) and Karaya Gum (*Sterculia setigera*)

Gum Type	Moisture Content%	Crude Protein%	Nitrogen%	Ash Content %	pH
Arabic Gum	11.30±0.10	*2.42±0.10	0.37±0.01	3.22±0.10	4.77±0.10
***Sunt* Gum**	09.83±0.10	**2.19±0.40	0.34±0.04	2.50±0.10	5.35±0.05
Karaya Gum	12.39±0.20	*2.32±0.10	0.35±0.01	3.90±0.05	4.33±0.10

Data are mean values of triplicate determinations ± standard deviation
*Nitrogen Conversion Factor (NCF) 6.6 [30]
**Nitrogen Conversion Factor (NCF) 6.51[7]

On the other hand, ash content for Karaya gum (*Sterculia setigera*) was found to be (3.90%) .This result approach to the values reported by [21] who gave values of (6.1%) and (4.4%) for Blue Nile and Kordofan gums, respectively. These results are matches with the Sudanese Specification for karaya gum [18] which stated a standard of not more than (8%) as ash content.[2] stated that the type of soil (clay or sand) significantly affected the ash content of the gum.

3.4 pH

The pH value for Arabic Gum (*Acacia senegal*) was found to be (4.77).This result is close to those determined by [15] who reported a value of (4.78) for (*A. senegal*) and (5.16) for (*A. seyal*) gum. [14] Reported the pH mean value of 4.66 for the 755 authentic (*A. senegal*) gum samples, collected in season 1994/1995. Regarding *Sunt* gum (*Acacia nilotica*) pH value was found to be (5.35).This result is in agreement with the findings obtained by [7] who studied (66) samples of (*A. nilotica* var. *nilotica*) gum collected from six different states of Sudan at season 2008, 2009 and 2010. As shown in Table 1 the pH value for Karaya gum (*Sterculia setigera*) was found to be (4.33).This result agrees with the findings reported in the literature ([17] -[21]). Compared with Arabic Gum and *Sunt* gum, the results obtained shows that the pH of Karaya gum is lower than the values (4.77, 5.35) which reported in this study for (*Acacia senegal*) and (*Acacia nilotica*) gums, respectively.

3.5 Refractive Index

According to data obtained in Table 2, the refractive index of Arabic Gum (*Acacia senegal*) was found to be (1.334) which is very close to that (1.34) obtained by [24] for Kordofan gum and higher than (0.146) which reported earlier

by[25]. Similarly, the refractive index of *Sunt* gum (*Acacia nilotica*) was found to be (1.334). Like wise, the refractive index of Karaya gum (*Sterculia setigera*) was found to be (1.333).

3.6 Specific Optical Rotation

The specific optical rotation is considered as one of the analytical parameters by means of which an *Acacia* species gums can be distinguished from other *Acacia* species gums. The specific optical rotation for Arabic Gum (*Acacia senegal*) was found to be (-28.50^o) . This result close to the findings reported earlier by [26] who specified the specific optical rotation of (*Acacia senegal*) to be ranging between (-29^o) to (-34.4^o) and [27] who reported specific optical rotation of (*Acacia senegal*) to be ranging between (-29^o) to (-31^o). This result fell in the range specified by Sudanese Specifications [22] (-22^o to -34^o). Further, the specific optical rotation for *Sunt* gum (*Acacia nilotica*) was found to be (+106.41^o) .This result compatible with the findings obtained by [7] who pointed out that the highest value of specific optical rotation of (*Acacia nilotica* var. *nilotica*) was (+107.5 ^{o}), whereas the lowest was (+72.5^o). On the other hand, the specific optical rotation for Karaya gum (*Sterculia setigera*) was found to be (+2.0^o) .This result is in close agreement with value of (+3.0^o) which reported by [16] for both Blue Nile and Kordofan regions. As well, this result are comparable to the value of (+1.5^o) given by [17] and disagree with the values of (+57^o) and (+ 47^o) reported by [4].This might be attributed to the climatic and environmental differences between the Sudanese regions.

3.7 Viscosity

The viscosity result for Arabic Gum (*Acacia senegal*) was found to be (50Cps) which is lower than (60Cps) that recorded for *Sunt* gum (*Acacia nilotica*).These results disagree with those given by [7] who stated both *A. senegal* and *A. seyal* have higher value of intrinsic viscosity compared to *A. nilotica*. The majority of gums dissolve in water at different concentrations. Gum Arabic readily dissolves in cold and hot water in concentrations up to (50%). Regarding Karaya gum sample (*Sterculia setigera*) the viscosity was found to be (110Cps).This result was compatible with the result in the literature. According to [4] Karaya gum possesses high viscosity at extremely low gum concentration and it has a low solubility in water, so it tends to swell rather than dissolve in water [28]. [14] Observed in an earlier study with 94 authenticated Arabic Gum samples that viscosity have very wide variation among the different samples studied and added that, it varies with factors such as gum concentration, temperature difference, storage period and preparation method of the gum solution. [24] Concluded that the differences in the values of viscosity reflect the influence of the environmental conditions on some physicochemical properties of the gum produced.

3.8 Tannins Content

Data presented in Table 2 reflects tannin content. As tannin content considered one of the most important tests that can be used to identify (*A. senegal*) and distinguish it from other *Acacia* gums. The only gum that did not show presence of tannin was the gum from (*A. senegal*), thus distinguishing itself distinctly and distantly from other *Acacia* gums. However, this result matches with the Sudanese specifications for Arabic Gum (*Acacia senegal*), which stated gums should be free of tannins [22].Tannins content of *Sunt* gum (*Acacia nilotica*) was found to be (0.05). A similar finding was reported earlier by [2]. The finding obtained in this work slightly less than the mean values reported by [7] which were found to be 0.08%, 0.08% and 0.1% for seasons 2008, 2009 and 2010, respectively. [2] Concluded that the large group of *Acacia* showed presence of tannins in their gums. This finding was of significant importance when considering gums as food additives. Although the percentage of tannins content seem to be fewer amounts, it is so important to mention that the higher percentage of tannins content concentrated in leaves, bark, and heartwood. It is clear, as explained in Table 2 there is an absence of tannin content in Karaya gum (*Sterculia setigera*).This result support the incorporation of Karaya gum into food processing.

TABLE 2. Some Physical Characteristics of Acacia Gum (*Acacia senegal, Acacia nilotica*) and Karaya Gum (*Sterculia setigera*)

Gum Type	Refractive Index	Specific Optical Rotation (Degree)	Viscosity (Cps)	Tannins Content
Arabic Gum	1.334±0.06	- 28.50°±0.05	50±10.00	*ND
***Sunt* Gum**	1.363±0.04	+106.41°±0.02	60±10.00	0.05±0.20
Karaya Gum	1.333±0.03	+2.0°±1.00	110±5.00	*ND

Data are mean values of triplicate determinations ± standard deviation
* ND = Not Detected.

3.9 Sugars Content

As shown in Table 3 sugars content of Arabic Gum (*A. senegal*) was 23.03% galactose, 24.07% arabinose and 13.92% rhamnose. [29] reported sugar composition as 34-46% galactose, 23-35% arabinose and 9-16% rhamnose for (*A. senegal*). Comparatively, similar results were obtained by [30] who reported the value of 35% galactose, 27% arabinose, 14% rhamnose. As well, these findings were fell in the range of values obtained by [2] who reported comparative analytical data for (*A. senegal*) and (*A. seyal*) gums collected between 1960 and 1999 in Sudan, he reported that sugar content had a value of 36-42% galactose, 24-29% arabinose, 12-14% rhamnose and for *A. senegal*, whereas had a value of 37-38% galactose, 41-45% arabinose and 3-4% rhamnose for *A. seyal*. Similarly, the average values of sugar content determined by [19] of (*A. senegal*) were 29.7% galactose, 21% arabinose and 10.1% rhamnose. According to Table 3 sugars content of *Sunt* gum (*Acacia nilotica*) were found to be11.87% galactose, 43.76% arabinose and 12.00% rhamnose.The results agrees with that obtained by [7] who reported that the mean values of sugars content were found to be17.43% galactose, 41.20% arabinose, and 10.68% rhamnose in season 2008. [2] Reported a value of 42% and 1.8% for arabinose and rhamnose, respectively. For Karaya gum (*Sterculia setigera*) sugars content were found to be 17.13% galactose, 1.69% arabinose and 11.77% rhamnose.

TABLE 3. Sugars Content of Acacia Gum (*Acacia senegal, Acacia nilotica*) and Karaya Gum (*Stercula setigera*) Using HPLC Technique

Gum Type	Arabinose%	Galactose%	Rhamnose%
Arabic Gum	24.07±0.20	23.03±0.02	13.93±0.03
***Sunt* Gum**	43.76±02.23	11.87±1.81	12.00±0.50
Karaya Gum	1.65±0.17	17.13±0.03	11.77±0.20

Data are mean values of triplicate determinations ± standard deviation

3.10 Microbiological Analysis

Data presented in Table 4 reflects the microbiological investigation of studied gums. Total Viable Count of Bacteria (TVCB) of Arabic Gum (*Acacia senegal*), *Sunt* gum (*Acacia nilotica*) and Karaya gum (*Stercula setigera*) were found to be 2.44, 2.22 and 2.29 $\log_{10}$ cfu/g, respectively. These results of far low reading of total viable count of bacteria which reflecting good hygienic conditions of gum collection, handling and processing. On the other hand, yeast and mould test for Arabic Gum, *Sunt* gum and Karaya gum shows that there are no yeast and mould detected. This result complies with the findings reported by [31].

TABLE 4. Microbiological Load of Acacia Gum (*Acacia senegal, Acacia nilotica*) and Karaya Gum (*Sterculia setigera*)

Gum Type	TVBC $\log_{10}$ (cfu/g)	Yeasts and Moulds $\log_{10}$ (cfu/g)	Total Coliform (MPN/g)	*Escherichia Coli* $\log_{10}$ (cfu/g)	*Salmonella* Spp $\log_{10}$ (cfu/g)
Arabic Gum	2.44±0.07	*ND	*ND	*ND	*ND
***Sunt* Gum**	2.22±0.03	*ND	*ND	*ND	*ND
Karaya Gum	2.29±0.04	*ND	*ND	*ND	*ND

Data are mean values of triplicate determinations ± standard deviation
* ND = Not Detected

Regarding the results of Total *Coliform*, *Escherichia coli* and *Salmonella* Spp. Table 4 reflects the absence of these bacteria. These results are in well agreement with Sudanese specifications in terms of the microbiological criteria for natural gums of Sudanese origin, whereby stated that gum samples should be free of *Salmonella* Spp and *Escherichia coli* ([22] - [18]). Generally, the microbiological results obtained for studied gum samples are confirming its validity for incorporation as food additives.

IV. CONCLUSION

The characterization findings of this study mirrored the compatibility of these gums to the local and international specifications. *Sunt* gum (*Acacia nilotica*) has characteristics close to that obtained for Arabic Gum (*Acacia Senegal*). As Karaya gum (*Sterculia setigera*) has been used in food applications, the results also reflects similarity with Arabic Gum in some of the physicochemical and microbiological properties. It is recommended that further research need to be carrying out to investigate other functional properties and safety aspects for both *Sunt* gum and Karaya gum, the thing that can open the road and maximize its utilization in food industry as an alternative of Arabic Gum or combined with it.

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REFERENCES

[1] Williams, P.A., Phillips, G.O. Gum arabic. In: Phillips, G.O., Williams, P.A. (Eds.), Handbook of Hydrocolloids. Woodhead, Cambridge. 2000.
[2] Karamalla, K. A. Gum stabilizers for food industry. *Food Hydrocolloids*, 10 , 40. 1999.
[3] Taha, K.K., Elmahi, R.H., Hassan, E.A., Ahmed, S.E., Shyoub, M.H. Analytical study on three types of gum from Sudan. *J. For. Prod. Ind.* 1 (1), 11–16. 2012.
[4] Anderson, D. M. W.; McNab, C. G. A.; Anderson, C. G.; Brown, P. M. and Pringuer, M. A. Studies of uronic acid materials, part 58; Gum exudates from the genus *Sterculia* (Karaya gum). *International Tree Crop Journal*, 2:147-154. 1982.
[5] Andrews, F. W. The flowering plants of Anglo-Egyptian Sudan. 1. T. Buncle and Co. LTD Arbroath, Scotland. 1952.
[6] El Hadiyah, T.M., Abdulhadi, N.H., Badico, E. E. M., and Mohammed, E.Y.G. Toxic Potential of Ethanolic Extract of *Acacia nilotica* (*Garad*) in rats. *Sudan J.M.S.*, 6: 1. 2011.
[7] Elhassan, A .A. Characterization and toxicological study of *Acacia nilotica var nilotica* gum from Sudan .Ph.D. Thesis. Collage of Graduates Studies and Scientific Research, Sudan University of Sciences and Technology, Sudan. 2011.
[8] Yebeyen, D., Lemenih, M., Feleke, S. Characteristics and quality of gum arabic from naturally grown *Acacia senegal* (Linne) willd. Trees in the Central Rift Valley of Ethiopia. *Food Hydrocolloids* 23 (1), 175–180. 2009.
[9] A.O.A.C. Association of Official Analytical Chemists. Official methods of analysis of the Association Official Analytical Chemists. 18th ed. Arlington, Virgin. USA. 2008.
[10] Randal, R. C; Phillips, G.O. and Williams, P.A. *Food hydrocolloids* , 2(131) pp. 740.1989.
[11] SSMO. Sudanese Standards and Metrology Organization, Method of tannins content determination (SDS.158). Ministry of Cabinet of Ministers, Sudan Government. 2011.
[12] Noble O., Perez D., Rochas C. and Travel F. Optical rotation of branched polysaccharides, Polymer Bulletin,16, 175 -180.1989.
[13] Harrigan, W.F. Laboratory methods in food microbiology. Academic Press, London. 1998.
[14] Karamalla, K. A., Siddig, N. E., and Osman, M.E. Analytical data for *Acacia senegal var. senegal* gums samples collected between 1993 and 1995 from Sudan. *Food Hydrocolloids*, 12, 373-378.1998.
[15] Younes, A. A. O. Physicochemical studies on some acacia gums and their fractions. Ph. D. Thesis. Chemistry Department. Faculty of Science, Sudan University of Science and Technology. Sudan. 2009.
[16] Elkhalifa, A.A, and Hassan, A. E. Characterization of *Sterculia setigera* gum (Karaya gum) in Sudan. International University of Africa. *Journal of Science*, 1(1): 18 -26. 2010.
[17] Taher, A. A. Analytical and structural studies on some plant gum exudates. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum. Sudan. 1998.
[18] SSMO. Sudanese Standards and Metrology Organization, Karaya Gum (*Sterculia setigera* L) specification (SDS 2874). Ministry of Cabinet of Ministers, Sudan Government. 2017.
[19] Abdelrahman, M. A. Preparation and characterization of physicochemical and functional properties of potassium glucuronate from *Acacia seyal var. seyal* gum. M.Sc. Thesis. Chemistry Department, Faculty of Science, Sudan University of Science and Technology. 2008.
[20] Dickinson, E., V. Galazka and D.M.W. Anderson. Emulsifying behaviour of gum Arabic. Part 2: Effect of gum molecular weight on the emulsion droplet-size distribution. *Carbohydr. Polym*., 14(4): 385-392. 1991.
[21] Hussein, M. S. Comparative study on some Sudanese gums: Hashab (*Acacia senegal*), Talha (*Acacia seyal*) and karaya (*Sterculia setigera*).

M.Sc. Thesis, Faculty of Science, University of Kordofan. Sudan. 2006.
[22] SSMO. Sudanese Standards and Metrology Organization, Gum Arabic (*Acacia senegal*) specification (SDS 121).Ministry of Cabinet of Ministers, Sudan Government. 2017.
[23] Kapoor, V. P. and Farooqi, M. I. H. (1991). *Carbohydrate Re*search, 222- 289.
[24] Karamalla, K. A. Gum's stabilizers for food industry. *Food Hydrocolloids*, 10, 40. 1999.
[25] Sabah El-Kheir, M.K., Yagoub, A. A., and Abu Baker, A.A. Emulsion-stabilizing effect of gum from *Acacia Senegal* (L) Willd. The role of quality and grade of gum, oil type, temperature, stirring time and concentration. *Pakistan Journal of Nutrition*, 7 (3): 395-399. 2008.
[26] Anderson, D. M. W, and Dea, I.C. M (1968). *Carbohydrates. Res.*, 6:104- 110.
[27] Vandevelde, M. C. and Fenyo, J. C. Carbohydrate Polymer, 5: 251.1985.
[28] Osman, M. E. Fractionation and characterization of gum from acacia Senegal. Ph. D Thesis , University of Salford. England. 1993.
[29] Meer, W. In hand book of water soluble gums and resins, ed .R. L. Davidson, McGraw- Hill, New York P. 8.1- 8.24. 1980.
[30] Jurasek, P., Kosik, M., and Phillips, G.O. Achemometric study of the *Acacia* (gum Arabic) and related natural gums. *Food Hydrocolloid*, (7):73. 1993.
[31] Osman, M. E., Williams, P.A., Menzies, A.R. and Phillips, G.O. Characterization of commercial samples of Gum Arabic. *Journal of Agricultural and Food Chemistry*, 41(1): 71-77.1993.
[32] Idris, O.H.M., P.A. Williams and G.O. Phillips. Characterization of gum from *Acacia senegal* trees of different age and location using multidetection gel permeation chromatography. *Food Hydrocolloids*, 12(4): 379-388. 1998.