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SPRAY DRYER FOR GUM ARABIC

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Abstract

The aim of this research is investigation the production of spray dried gum Arabic at concentrations10, 20 and 30 (w/w %) with inlet temperatures of160Cº for all experiments. The spray dried powder was obtained with efficiency of (55.97), (52.95) and (65.85) percent respectively with feed rates (8.48), (5.78) and (6.27) m L/min respectively, PH is4.3, 4.2and 4.1 respectively, the total solid was 87.78, 89.75 and 91.6 percent for every run. The powder was obtained using pilot spray dryer model FD20 laboratory Solteq. The results are in agreement with Sudanese Standards and Metrology Organization (SSMO) **(NO3454)**

Key Words: Spray drying, Gum Arabic, efficiency, PH, total solid.

Objectives:

1. Investigate the possibility production of spray dried gum Arabic with optimum concentration and efficiency.
2. Study of some properties and effect of spray dryer on moisture in final powder.

I. Introduction

Acacia Gum or Gum Arabic is a natural agricultural resource from the Gum Belt region of Africa, i.e. countries geographically ranging from East to West -from Sudan, Somalia, Eritrea and Ethiopia to Chad, Central African Republic, Mali, Niger and further west up to Nigeria, Senegal and even Mauritania. Economically Speaking, Acacia Gum mainly comes from Sudan, Chad and Nigeria [32].

In Sudan, the term Gum Arabic is used in a wider context to include two types of gum which are produced and marketed, but which are, nevertheless, clearly separated in both national statistics and trade: "hashab "(from A. Senegal) and "talha"(from A. Seyal). In a still wider sense, Gum Arabic taken to mean the gum from any Acacia species (and is sometimes referred to as acacia gum) [33].

The JECFA defined Gum Arabic as dried exudates from the trunk and branches of acacia Senegal or acacia seyal of the family Leguminous [34].

II. Chemical structure of Gum Arabic:

Gum Arabic consists mainly of high –molecular weight polysaccharides and their calcium, magnesium and potassium salts, which on hydrolysis yield Arab nose, Galactose, Rhamnose and Glucuronic acid.

Acacia seyal gum has lower Rhamnose and Glucuronic acid contents, higher Arab nose, and 4-O-methyl Glucuronic acid contents than gum from acacia Senegal.

Acacia seyal gum contains a lower proportion of nitrogen and the specific rotations are very different. The amino acid compositions are similar with hydroxyl proline and serine the major constituents [35].

III. Grade of gum

Hand Picked Selected, Cleaned, Siftings, Dust and Red gum

IV. Gum Arabic Quality

Quality is generally defined as a measure of excellence. It is a widely used concept that, however, remains abstract and complex. In production, quality is a state of being free from defects and significant variations, brought about by a strict and consistent adherence to measurable and verifiable standards with the purpose of achieving uniformity of output that satisfies specific user requirements (DALE et al., 1997)[8]. In business, quality of goods and services refers to the creation of customer satisfaction and is one of the elements that contribute to profitability (EVAN Sand LINDSAY, 2005)[9].

The quality of Gum Arabic as received by the importer depended on the source. Gum Arabic hashab from Sudan is the highest quality and sets the standard by which other Gum Arabic judged. Not only does Sudanese gum come from a species acacia Senegal which intrinsically produces high quality exudates with superior technical performance, but also the collection, cleaning, sorting and handling of it up to the point of export is well organized and highly efficient.

Sudan has dominated world production and trade of Gum Arabic and during the period

(1925-1985) exported from Sudan accounted for around 80% of the world exports. This domination however, has become less marked in recent years. The Gum Arabic Company (28.2 % owned by the government) is the monopoly holder for the export of crude Gum Arabic from the Sudan [34]

The declines of world demand for gum Arabic is due to several reasons such as world market requirements for high quality product to many industrial, for this gum spray dried is good

Process to product high quality gum Arabic and reduced the cost.

Spray drying is a unit operation in which a liquid mixture is fed to the dryer and then dehydrated via contact with dry air in order to produce a final solid product (23)

It has been widely utilized for commercial production of fruit and vegetable juice powders. Spray drying involves the conversion of feed material in liquid or slurry form to dry powder.

The basic idea of spray drying is the production of highly dispersed powders from a fluid feed by evaporating the solvent. This is achieved by mixing a heated gas with an atomized (sprayed) fluid of high surface –to-mass ratio droplets, ideally of equal size, within a vessel (drying chamber), causing the solvent to evaporate uniformly and quickly through direct contact, Spray drying on the other hand, offers a very flexible control over powder particle properties such as density, size, flow characteristics and moisture content [13].

product depends on spray drying conditions including inlet air temperature, feed flow rate, concentration of drying aid used, feed characteristics etc. The spray drying process can be described by four stages: Atomization, spray and air Contact, evaporation of the moisture from the droplets and product discharge.

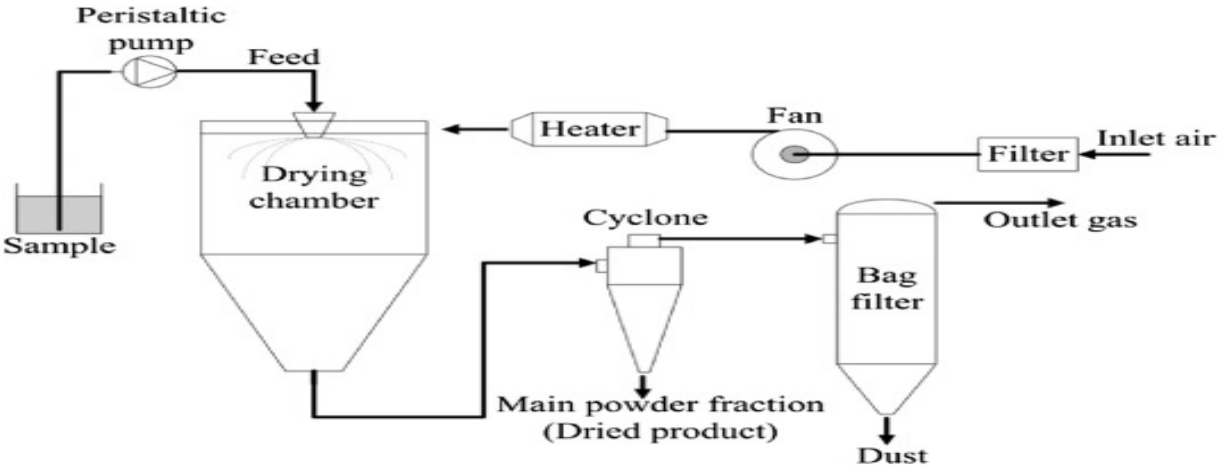

FIG (1) Physical diagram of the process

V. Previous study

Optical rotation

Specific rotation is considered as the most important criterion of purity and identity of gum Arabic In the revised specifications FAO (1990) A. Senegal gum specific rotation falls within the range between 26 to –34 . Anderson et al. (1966a) reported the specific rotation as –31.5 .

Vavdevelde (1985) reported specific rotation to be ranging between –29 to – 34.4.

Jurasek et al. (1993) in a chemo metric studies concluded that the specific rotation of gum Arabic ranged between –20 to –32. Siddig (1996) analyzed about 807 A. Senegal gum samples and she reported the mean value of –31.3. The values of optical rotation for A. polyacantha, and A. mellifera were reported as –30 to - 12, -35 to –42, and –45 to –56 respectively, (Anderson, 1968 and Karamalla, 1965).

Mahasin Elamin Mohammed Kheir (July 2005) reported optical rotation for Spray- dried was (-31.63º).

Viscosity

Viscosity is a factor involving the size and the shape of the macro-molecule. It can be presented in many terms such as relative viscosity, specific viscosity, reduced viscosity, inherent viscosity, kinematic or dynamic viscosity and intrinsic viscosity .

Absolute viscosity was measured using Brookefieldviscometer.60rpm spindle 62 at 25Cº Naima Elnour Siddig Ali (2003) reported range (89.3 – 109 cp) .

Anderson (1966a) in an early investigation for electro-dialyzed fractions of Acacia. Senegal gum showed that the intrinsic viscosity for this gum was $20cm^{-3}g^{-1}$. Anderson (1983) reported $13.4cm^{-3}g^{-1}$ intrinsic viscosity for 26 authenticated specimens and $17cm^{-3}g^{-1}$ for commercial samples of A. Senegal gums. Vandevelde et al. (1985) found that the intrinsic viscosity for A. Senegal gum originated from Sudan was in the range of 15.5 to $40ml^{-3}g^{-1}$.

Anderson et al. (1991b) reported 16 $cm^{-3}g^{-1}$ for Sudanese samples Jurasek et al. (1993) surveyed the analysis of 18 specimens of A.senegal and found their values to range from 13.4 to 23 $ml^{-3}g^{-1}$.

Mahasin Elamin Mohammed Kheir (July 2005) reported (1.44)Relative viscosity.18.36Intrinsic Viscosity (η) ml/g) for Spray- dried that found in Table (3) Comparative physicochemical properties of eight Gum Arabic (Acacia Senegal) formulations Senegal) formulations.

Mohamed alhasan algaeb the values of the viscosity was in the range (94.5 - 137.4 cp) and (40.5 - 59.5 cps) in the samples of ELnohud and aldamazin areas, respectively(2014) .Jurasek et al. (1993) surveyed the analysis of 18 specimens of A. Senegal and found their values to range from 13.4 to 23 $ml^{-3}g^{-1}$.

Moisture contents:

The mean value of the moisture content for A. Senegal gum samples is 10.75% and the range is 8.1-14.05%. These data are in agreement with Anderson, Brown Douglas, Morrison, and Weiping (1990) and Anderson, Dea, Karamalla, and Smith (1968)

data from the quality control records of The Khartoum Gum Arabic Processing Company and The Gum Arabic Company Ltd for seasons (1992-1996) also shows that the mean value for moisture of 100 commercial gum samples (9.15 to 14.30) is in close agreement with those reported by Osman, Williams, Menzies, and Phillips (1993)

The moisture content of A. Senegal was found to fall within a range of 10.0-16.15% , 9.0 -12.77 , Analytical data for Acacia Senegal var. Senegal gum samples collected between 1993 and 1995 from Sudan , K.A. Karamalla, N.E. Siddig h, M.E. Osman 1997.

The moisture content value of A. Senegal in(Table (1) and (table (3) are within the range (10-14%) presented by Karamalla (1965) and Ishag (1977)

PH

The mean p_H value for A. Senegal gum samples) is in agreement with Ishag (1977) and Karamalla (1965). a mean value of pH for 40 A. Senegal commercial gum samples (season 1993/1994) and 100 commercial gum samples (season 1994/1995), which agree with Anderson et al. (1998) and Ishag (1977) (4.3 -5.1) .

Mahasin Elam in Mohammed Kheir (July 2005) reported PH for Spray- dried was (4.25)

Dextrin

Not found according to Sudanese Standards and Metrology Organization (SSMO) **(NO3454)**

Microbiological test

Not found according to Sudanese Standards and Metrology Organization (SSMO) **(NO3454)**

VI. METHODLOGY

Sample collection

Samples of GA were collected from ELnohud town, gum grade Senegal Hashab, year of production 2017-2018, to Kerry ingredients and flavours /krt

Solution preparation

Ten grams of gum Arabic was weighted using sensitive balance type adventure / OHAUS – item No AR2140, and then dissolved in distilled water (10% w/w) at room temperature until homogenous. The solution was then stirred using Hot plate stirrer J lab tech and stirrer until a homogeneous solution was obtained which gives a sample solution labelled "A".

The above procedure was repeated to obtain two more solutions labelled B (20%w/w), and C (30%w/w).

VII. Procedure

In this process the gum is firstly dissolved in water and then filtered or centrifuged to remove impurities of the solution (Coppen 1999). To remove the microbial contamination, the solution is pasteurized, and then sprayed into fine droplets by atomization stream of hot air to promote evaporation of the water (Osman 1993). The gum Arabic powder, which is produced by spray drying techniques, can be adapted to a wide range of scales (from feed rates of a few kilograms per hour to over 100 tonnes per hour). This is considered as one of its advantages, but the disadvantage of the process is that it is an energy-intensive process that increases the cost and the requirement for large quantities of pure water (Salim 2000).

Efficiency = final weight / initial weight x (percentage of solid in initial weight (run weight)) x100%

Total solid% = 100- moisture.

More details

Ten grams of gum Arabic was weighted then dissolved in distilled water (10% w/w) at room temperature. The solution was stirred until a homogeneous, then filtrated for remove impurities used vacuum pressure, weighted solution before and after filtration , weighted filter paper before and after filtration solution , uses offend (offen memert , din 12880K, F-N , 220) in 105cº for remove humidity , weighted again and calculated variation , then put in water path to concentration solution at 100 Cº , lastly go to run in spray dried with :

Specifications

1. Designed for rapid spray drying process, downward co- current operation (affine jet of liquid is brought into contact with hot air stream).

2. Product flow rate from 0 -1500 ml /hr.

3. Inlet air temperature max 200C0

4. Heat capacity 3KW

5. Drying air through flow 70m3 / h (fixed)

Overall dimension

Height 1.1 m

Width 0 .5m

Depth 0.5m

Jet size 0.5mm

VIII. Spray drying condition

The powder was obtain using pilot spray dryer model FD 20 laboratory solteq, the spray dryer operates co-current and has spray nozzle with an orifice of 100 to 200 micron diameter range . the inlet air temperature was 160 Cº for all investigation . and inlet air pressure was 3.5 k_{Pa} ,the out air temperature was 47 Cº, liquid feed temperature 73 Cº and full pump speed the experiment ware performed at constant Conditions .

Table 1 : The experimental design and analysis of spray drying (Result)

Concentration (10%)	
Parameters	
Feed flow rate	8.48 ml/min
Inlet air temperature	160 Cº
out air temperature	47 Cº
density at 30.3 cº	1.0377g/cm^3
viscosity	16.50 cp
B.B solution	102.00 Cº
Feed temperature	73Cº
Moisture content	12.22 %
PH	4.3
Inlet air pressure	3.5 k_{Pa}
Specific volume	0.964 $cm^3 g^{-1}$
Loss of water before run to spray	14.3 gram
weight of sample run	88.893 gram
Weight of powder	4.975 gram
Total solid%	87.78 %
efficiency	55.97 %
Optical rotation	-30º
brix	9.8
dextrin	Not found
Microbial test	absent

Table 2 : The experimental design and analysis of spray drying (Result)

Concentration (20%)	
Parameters	
Feed flow rate	5. 87 ml/min
Inlet air temperature	160 Cº
out air temperature	47 Cº
density at 30.3 cº	1.071g/cm3
Viscosity	48.26cp
B.B solution	102.2 Cº
Feed temperature	73Cº
Moisture content	10.33%
PH	4.19
Inlet air pressure	3.5 k_{Pa}
Specific volume	0.934 cm3 g-1
Loss of water before run to spray	14.8662 gram
weight of sample run	88.042 gram
Weight of powder	9.324 gram
Total solid%	89.67 %
Efficiency	52.95 %
Optical rotation	-30 .5º
Brix	20
dextrin	Not found
Microbial test	absent

Table 3 : The experimental design and analysis of spray drying (Result)

Concentration (30%)	
Parameters	
Feed flow rate	6.267 ml/min
Inlet air temperature	160 Cº
out air temperature	47 Cº
density at 30.3 cº	1.091g/cm^3
Viscosity	150.48cp
B.B solution	102.4 Cº
Feed temperature	73Cº
Moisture content	8.4%
PH	4.12
Inlet air pressure	3.5 k_{Pa}
Specific volume	0.917 cm^3 g^{-1}
Loss of water before run to spray	14.117 gram
weight of sample run	63.363 gram
Weight of powder	12.518 gram
Total solid%	91.6 %
Efficiency	65.85 %
Optical rotation	-31º
Brix	31.3
dextrin	Not found
Microbial test	absent

IX. Discussion

The specific rotation for A.senegal in this study agree with the values reported previously in the literature and the values reported by Anderson (1991, 1978 and FAO, 1990).

The specific rotation for A.senegal value in (table 3) agree with value obtained by Mahasin Elamin Mohammed Kheir (July 2005) reported the specific rotation as –31.63 .

Anderson et al. (1966a) reported the specific rotation as –31.5 . Vavdevelde (1985), Jurasek et al. (1993) Siddig (1996) A.polyacantha, A.laeta and A.mellifera were, (Anderson, 1968 and Karamalla, 1965 and agree with Sudanese Standards and Metrology Organization (SSMO) **(NO3454)**

(–22.00 to –34.00) analytical data in table (1) and table (3) is **similar** to Anderson et al. (l968) and JECF A (l 990).

Anderson (1968) in an early investigation of Acacia. but **different** from Vandevelde, and Fenyo (1985). Furthermore (1983) Vandevelde et al. (1985) is similar data in table (2). Anderson et al. (1991b) for Sudanese samples Jurasek et al. (1993) .

Analytical data in table (3) and table (2) similar to Mohamed alhasan algaeb (2014) .Jurasek et al. (1993)

the range given by our data is very much than the range reported by Jurasek et al. (1993a, 1993b).

The wide variation in **the viscosity** of A. Senegal gum not only with anticipated factors such as gum concentration, Temperature, pH, cationic composition, etc., but also with less obvious factors such as mesh size, storage period and even the method of preparation of gum solution.

Naima Elnour Siddig Ali (2003) reported range (89.3 – 109 cp), the value obtained in the table (1) and table (2) is lower, but value was obtained in table (3) is higher than this range.

Mohamed alhasan algaeb the values of the viscosity was in the range (94.5 - 137.4 cp) the value was obtained in the table (1) , table (2) and table (3) is different from this range .

The pH-value of A. Senegal was reported to be 4.4 (Anderson 1990; Karamalla 1965; Ishag 1977). A range of 3.19 to 5.64 was given by Siddig (1996) is **similar** to value obtained in the three table

The pH-value in table (1) is **similar** to value obtained by (Nazik Mukhtar Obied Mukhtar 2003) , and K.A. Karamalla , N.E. Siddig , M.E. Osman (1997)

The pH-value in table (2) and table (3)is similar to value obtained by Mahasin Elamin Mohammed Kheir (July 2005) reported (4.25) but differ from table (1)

Moisture content Table (l) demonstrates that the value of the moisture content for A. Senegal gum powder is 12.22% These data are in agreement with Anderson, Brown Douglas, Morrison, and Weiping (1990) and Anderson, Dea, Karamalla, and Smith (1968).

the value in table in table (1) and (2) agreement with data obtain in K.A. Karamalla, N.E. Siddig h, M.E. Osman (1997), with range (9 to 12.77).

In table (3) value agree with Sudanese Standards and Metrology Organization (SSMO) **(NO3454)** for spray dryer powder (8%) but different from Nazik Mukhtar Obied Mukhtar (2003), (9.98%).

Values of the moisture contents obtained by this study similar with value obtained by Mahasin Elam in Mohammed Kheir (July 2005) reported the moisture contents for spray powder (8.32) and agree with international sander (Not more than 10) ,but was different in table (1) and table (2) .

The moisture level of the spray dried in table (3) (8.4%) was significantly lower than the International standard (10%)

However, the values of the moisture contents obtained by this study conform to the requirements and parameters set by JECFA (1986, 1990) be applied.

Microbiological test (absent) Ali, E. M. O.(1998). And similar to Mahasin Elamin Mohammed Kheir (July 2005) reported (-ve) .

The moisture content in this study is decrease by increasing the concentration, the efficiency

And total solid also increasing by increasing concentration, from this study the optimum parameter obtain by concentration 30%.

This study shows that decreasing the optical rotation by increasing concentration.

May be operating system in full speed give large humidity that show in table (1) and table (2), because the particles of feed does not expose to enough hot air to evaporate.

This work operated in open system and in august month (autumn season, rainy month) gives another reason to increase the humidity.

I think that the velocity of pump and some fixed classification for operation of pilot spray dryer Led to the emergence of thickness problem in chamber.

X. CONCLUSIONS

Economic cost

Purchase price per ton of crude hashab is (2300) dollars

Cost of process (spray powder) is (1000) dollars

Global Selling Price is (15000) dollars (Source: Ministry of Foreign Trade January 2018)

Nowadays Sudan has the ability to export gums in processed (spray powder) The expected gain will be increase for this Government policies about Gum Arabic should be clear, stable and not to change yearly

XII. Recommendations

- For industrial application gum Arabic is recommended to be used preferably as spray-dried form
- In the near future gum Arabic is going to be use as a part of a meal; beside its current uses as food additive so more researches is needed.
- The government must give especial attention to the Gum Arabic process through reduction of the taxes to encourage others investors to invest in this sector.
- Spray-dried of gum is better process for gum Arabic to give high income to country after petroleum incoming back.
- Thickness problem in chamber needed more research and measure to improve amount and quality of powder.
- More research is needed to study the properties of gum and use spray dryer in the combination (blend) of talha and hashab gum to modify the properties of talha.

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