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Post-Harvest Practices Effect on the Quality Protocol of *Acacia seyal* Gum from Sudan

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ABSTRACT: The paper investigated the effects of post-harvest practices on the physicochemical properties and microbial content of *Acacia seyal* (Talha) gum at various stages. A total of fifteen gum samples were collected from three distinct regions in western Sudan namely; Buram, Hijleij, and Deain. The investigations were carried out on the gum Arabic samples at different stages: extraction from trees, collection in jute sacks, transportation facility, storage in production sites, storage in factories, and during cleaning and processing phases before exporting the product to external markets. The findings indicated a significant increase ($p= 0.05$) in the gum's coloration as it passed from the collection sites through storage facilities to the factory. Subsequently, a notable decrease in color was observed after the cleaning process, ultimately reaching the final export-readiness stage. During the cleaning and processing stages, various impurities were systematically removed. These include bark, residue, sand, and other foreign materials. Furthermore, visual grading performed by laborers during cleaning allowed for the differentiation of gum lots based on color, facilitating a blending process aimed at standardizing the coloration of the final export product. No significant positive correlation was noted among the other physicochemical properties, except for optical rotation ($R= 0.65$), which mirrored the pattern observed in coloration. The microbial analysis revealed a consistent trend across samples from different areas, though the intensity varied. For instance, the total bacterial count was highest in the gum immediately after harvesting and increased during subsequent handling, before experiencing a dramatic decrease in the final stages.

Keywords: *Acacia seyal* (Talha); color; microbial contents, physiochemical properties, post-harvest effect

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INTRODUCTION

Gum Arabic is defined as the dried exudate obtained from the stems and branches of acacia senegal (Hashab) or *acacia seyal* (Talha) trees (Tarig et al., 2017). It is worth noting that the volume of gum talha exports to Sudan has increased significantly over the past ten years. In this context, quantitative data provided by the Gum Arabic Board (GAB) (Figure 1) indicated that gum Talha exports have increased significantly from less than a fifth during the period prior to 2009 to more than three times that during the past ten years (2009-2019). This increase is attributed to the lower export prices of gum talha compared to gum hashab in addition to the enhancement of blending

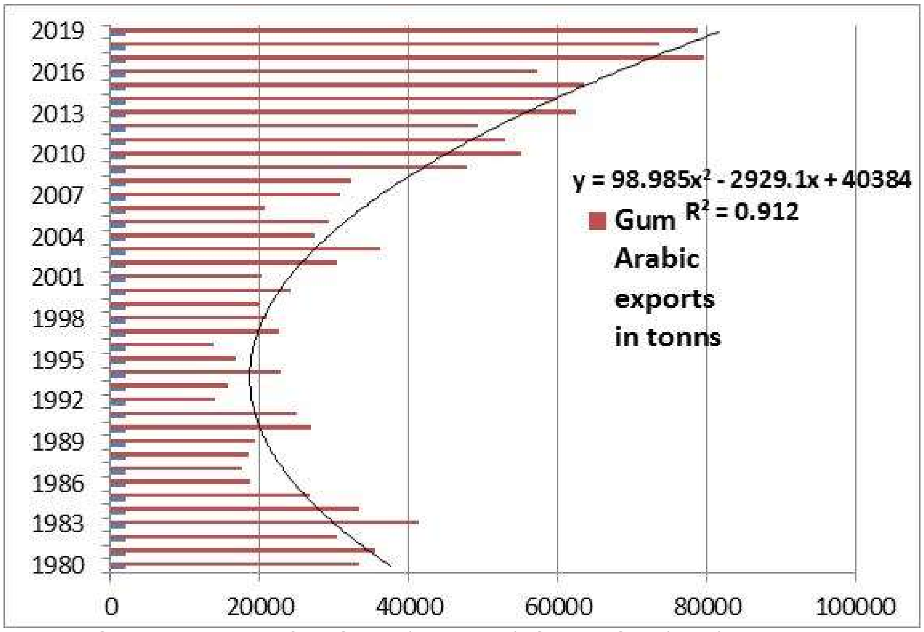

Figure 1: Gum Arabic exports from Sudan (1980-2019), Source: GAB (2020).

technology as shown by the results of the Codex Alimentarius definition (E414) which considers both gums as gum arabic, despite the significant difference in the physiochemical and functional properties of the two types of gum Arabic (FAO, 1999).

Gum Arabic, from both species, is one of the most abundant polysaccharides in nature, and has an excellent water solubility and biocompatibility and low cost (Ernst et al., 2017). However, gum from *Acacia seyal* is usually colored, and the colors varied according to tree variety as the two varieties of *seyal* gum are commercially used.

Generally, the gum obtained from *Acacia seyal* var. *seyal* is characterized by a yellow to dark brown color and the one obtained from *Acacia seyal* var. fistula is characterized by white to light yellow color (FAO, 1999). Despite this the presence of color in the gum Arabic is usually referred to as impurities. Causes of these colors may be attributed to the storage atmosphere, temperature and climatic changes. Therefore, the presence of color and its intensity in the gum arabic reduce the quality of the gum (Ibrahim, 2009), also reported the effect of storage conditions mainly temperature and relative humidity as well as stacking load and light on gum arabic quality concludes to adverse effect to gum quality if those factors not been managed properly. However, the color of the gum is not included in the Joint Expert Committee on Food Additives (JECFA) and FAO/WHO (FAO, 1990) specifications, the gum exuded is a natural product and the color is inherited characteristic and is not an impurity.

Gum exudates from seyal harden very quickly and hence has acquired the name “friable”. Moreover, the exudates from the *seyal* tree form a variety of shapes, namely a clear nodule, seep, spiro and occasionally in the form of a web. Currently, all *Acacia seyal* gums which originate from Sudan are sold as “*seyal*” (locally known as Talha gum) irrespective of its taxonomic variety (Andres-Brull et al., 2015). Nevertheless, seyal obtained from various production areas shows variation in terms of color and shape (Awad, et al., 2018a) but the reasons behind that are unknown. Obied (2012) evaluated the microbiological aspects of *Acacia seyal* gums in Sudan, including: aerobic plate count, molds and yeast for certain authenticated and commercial samples. The mean values for these samples were found to be 1.5 x10^3, 2 x10, and 4.8 x10 cfu/g, respectively. The most dominant molds found are *Aspergillus niger, Aspergillus fumigatouus, Aspergillus terrus* and *Pencillum* sp. All gum samples under evaluation were found to be free from either coliform /*E. coli* sp or *Salmonella* sp. Only 21 of lactose fermented bacteria (dominant), were identified as *Citrobacter* sp., *Enterobacter* sp. and *Klebsella* sp. This investigation clearly showed the possible contamination of gums by such microbes during any stages of handling and storage conditions.

Previous studies indicated that as gum collected from various trees with different ages and, however, there is more tannin in the older trees for *Acacia seyal var. seyal* compared to var. fistula as observed by (Andres-Brull et al., 2015) and is consistent with the observation that bark in var. seyal tree gets darker with age. The amount of tannin increases with age in both species and is higher in older trees compared to young trees for both nodules and seep. The Maillard reaction which is a non-enzymatic browning reaction is a complex network of reactions involving carbonyl and amino compounds, such as reducing sugars and amino acids. It is the main reaction responsible for the transformation of precursors into colorants and flavor compounds during food processing (Echavarría et al., 2012). Maillard-type reactions between the amino groups and carbonyl groups are responsible for the graft reaction between the protein and polysaccharide. This phenomenon can be explained by the linkage of the terminal and interstitial amines of the protein to the reducing sugar through the Amadori rearrangement. As reported by previously, protein-polysaccharide conjugates showed better functional properties than the polysaccharides alone (Amid et al., 2013). Color formation is the primary characteristic of the Maillard reaction, yet even now the knowledge of the colored moieties responsible for the coloration is only rudimentary.A clear protocol for *Acacia seyal* gums is crucially needed (Awad et al., 2016, 2018b) to maintain the quality of different parameters and specifications in each production stages, i.e. gum collected from trees, product entrance to store, after cleaning, after storage period and final stage product ready for export. In line with these conclusions and ongoing arguments this study aiming at investigating the effect of postharvest practices on color intensity, other physiochemical properties and microbial content of *Acacia seyal* (Talha) at different handling stages from three different locations in Sudan.

MATERIALS AND METHODS

Materials

The samples of *Acacia seyal* gum were collected in the season 2017/18. A total of fifteen gum samples were collected from three distinct regions in western Sudan namely; Buram, Hijleij, and Deain Areas. The investigations were carried out on the gum Arabic samples at different stages: extraction from trees, collection in jute sacks, transportation facility, storage in production sites, storage in factories, and during cleaning and processing phases before exporting the product to external markets.

Method

The dried samples were then ground into fine powder (to pass 0.4 mm mesh screen). The prepared samples were kept in tight containers and stored at room temperature until required for subsequent analysis. The samples were used unfractionated. Each analysis was done in triplicate, and the values were averaged and reported. Samples at different postharvest practices were collected randomly and samples at export market outlets were also collected using the procedure method developed by Elrayah (2011) and adopted in this study. The sample are analyzed for physicochemical properties namely moisture content, color, Specific Optical Rotation (S.O.R.), pH, ash, nitrogen, protein contents, total bacterial counts, yeast and mold.

Moisture content

The moisture content of the samples was determined by drying 5 g of the ground gum sample to constant mass at 105 °C using a hot air oven (Memmert Oven). Dried samples were cooled in a desiccator before weighing. Moisture content was expressed as % of mass loss from the original mass according to method of Association of Official Analytical Chemists (AOAC, 1990).

Color intensity

Subsequently, the physicochemical analysis was conducted to identify the color within the samples taken from different postharvest practices across the three locations using Lovibond Tintometer Model F. Measurements were carried out using 1-inch path length cell on 25 wt% gum solutions prepared in distilled water and filtered through 100 mm mesh filter.

Ash content

The ash content was also determined by using 5 g of gum sample, which was first heated on a burner in air to remove its smoke. Then it was burned in a furnace at 550 °C using Nabertherm furnace. The ash content was expressed as a % ratio of the mass of the ash to the oven dry mass (Yebeyen et al., 2009).

Specific optical rotation

The specific rotation was determined on 1% w/v solution, according to (FAO, 1990) using ATAGO POLAX-2 L Polarimeter.

pH

pH of 25% aqueous gum solution (w/v) was measured using a glass electrode pH meter (HANNA, 209 209 R).

Protein content

The protein content of the samples was determined by micro-kjelhahl technique according to the method of Association of Official Analytical Chemists (AOAC, 1990).

Total bacterial count and yeast and molds

The total bacterial count as well as yeast and molds were

Table 1: Physiochemical and microbiology properties of commercial *Acacia seyal* Talha gum from Buram production area.

Postharvest practices	Moisture content (%)	Color (Lovibond unit)	S.O.R. (º)	pH	Ash content (%)	Nitrogen content (%)	Protein content (%)	Total bacteria Counts×10³ (cfu/gm)	Yeast and molds (cfu/gm)
1	14.43	24.8	+45	4.3	3.10	0.19	1.25	5.233	4000
2	10.83	31.5	+45	4.51	3.52	0.17	1.12	56.333	700
3	11.70	37.1	+50	4.46	3.46	0.17	1.12	7.400	400
4	9.89	35.9	+47	3.60	3.45	0.14	0.92	0.360	233.3
5	9.3	31.4	+47	4.28	2.48	0.11	0.73	0.500	0

1: Directly collected from trees, 2: Store entrance in Buram using jute sacks, 3: Store entrance in factory (Khartoum) using jute sacks, 4: After cleaning in factory (Khartoum Stores), 5: Ready to export (*Subra* sample).

Table 2: Physiochemical and microbiology properties of commercial *Acacia seyal* Talha gum from Deain production area.

Postharvest practices	Moisture content (%)	Color (Lovibond unit)	S.O.R. (º)	pH	Ash content (%)	Nitrogen content (%)	Protein Content (%)	Total bacteria Counts×10³ (cfu/gm)	Yeast and Mold ×10³ (cfu/gm)
1	10.44	18.9	+32	4.22	2.26	0.08	0.53	5.0	4. 0
2	9.13	35.5	+42	4.29	2.71	0.11	0.73	55.0	0.7
3	10.65	36.7	+55	4.47	3.41	0.11	0.73	5.033	0.233
4	10.14	33.1	+53	3.73	3.40	0.11	0.70	0.683	433.3
5	9.8	28.7	+55	4.56	2.60	0.11	0.73	0.50	0.0

1: Directly from tree, 2: Store entrance in Deain using jute sacks, 3: Store entrance in factory (Khartoum) using jute sacks, 4: After cleaning in factory (Khartoum Stores), 5: Ready to export (*Subra* sample).

Table 3: Physiochemical and microbiology properties of commercial *Acacia seyal* Talha gum from Hijleij production area.

Postharvest practices	Moisture content (%)	Color (Lovibond unit)	S.O.R. (º)	pH	Ash content (%)	Nitrogen content (%)	Protein content (%)	Total bacteria Counts ×10³ (cfu/gm)	Yeast and Mold ×10³ (cfu/gm)
1	7.56	29.5	+40	4.69	2.62	0.17	1.11	58.666?	0.566
2	7.87	31.9	+52	4.78	5.61	0.06	0.37	74.333	0.700
3	10.42	37.1	+60	3.67	3.03	0.20	1.29	0.450	0.0
4	9.75	35.5	+50	4.29	2.16	0.11	0.73	0.600	0.0
5	10.30	29.9	+50	4.60	2.26	0.11	0.73	0.500	0.0

Directly collected from trees, 2: Store entrance in Hijleij using jute sacks, 3: Store entrance in factory (Khartoum) using jute sacks, 4: After cleaning in factory (Khartoum Stores), 5: Ready to export (*Subra* sample).

determined by the method described by Harrigan and McCance (1976).

RESULTS AND DISCUSSION

Tables 1, 2 and 3 showed the results of the analysis for the gum samples from the three different locations. The results revealed that the color increased significantly (p=0.05) for the gum collected directly from trees to the stores at the production sites as well as the processing warehouses for the exporting companies. Contrary to that, the color decreased after the cleaning process made at the warehouses including other preparatory practices needed for gum exports. Impurities such as barks, *kadap*, sand dust, and other foreign materials are always removed during cleaning and processing stages. Additional to the visual grading that is often done by workers during the cleaning process to differentiate the gum lots based on color of the mixture to minimize the color of final product as one of the export requirements worldwide. Under this context, the requirements of most importing companies emphasize that the degree of color for *Acacia seyal* gum (cleaned grade) should not exceed a certain level (less than 40) (Awad et al*,* 2018a).

Furthermore, the results of other physicochemical properties demonstrated no significant differences between the three samples, except for specific optical rotation (S.O.R.) that follows the same trend of color and showed a significant positive correlation (R= 0.65) between S.O.R and color. The same result was obtained by (Awad et al 2018a) as indicated in (Fig. 1). Accordingly, this confirms that whenever color increased in a gum Talha sample the optical rotation obtained from that sample follows the same pattern and vice versa.

The results show an inverse relationship between moisture content and color intensity. However, there is a proportional relationship between moisture content and total bacterial counts and yeast and molds, while the specific optical rotation, pH, ash content, nitrogen and protein contents are almost constant and are falling within limits specified by JECFA (1990).

The microbial content of samples obtained from the three production areas behaved at equal trend, however, the intensity is different from one area to another. For instant the bacterial total count observed in gums immediately after harvesting from the trees increased drastically when the gum is transported from forests to local storage in jute sacks which probably were contaminated. Then it decreased dramatically as the product moves to the processing warehouses or during the final preparation to the export outlets (Tables 1, 2, and 3). Despite these observations there was no clear correlation between the total bacterial count, yeast and mold, the color and moisture content.

Conclusion

The study shows an inverse relationship between moisture content and color intensity in the analyzed samples of gum Arabic. However, there is a direct proportional relationship between moisture content and total bacterial counts, yeast and mold, while the specific light cycle, pH, ash content, nitrogen, and protein content are almost constant and within the limits specified by JECFA. The total bacterial count increased significantly when the gum was transported from forests to local storage in jute bags, which were possibly contaminated. The present study has emphasized the importance of technical protocol for all stakeholders handling *Acacia seyal* in all pre-harvest and post-harvest practices. This can play a vital role in improving the quality aspects and handling procedures that should be adopted by stakeholders in the upstream and downstream value chain as the commodity moves from production sites to rural markets and from there to urban centers, processing depots, and export outlets. Further investigations are urgently needed regarding the trends in color despite the current results that showed the importance of the cleaning process in reducing the color intensity in *Acacia seyal* gum, along with the same observations regarding the total number of bacteria, yeast, and molds, which may be related to the sanitary procedure and/or a rapid decrease in moisture content in the transported samples. Therefore, food safety management, including the application of Hazard Analysis and Critical Control Points (HACCP), is crucial to maintaining the quality of the gum.

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