

Utilization of Tannins Extract of *Acacia seyal* Bark (Taleh) in Tannage of Leather

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Abstract

Leather is a durable and flexible material created by the tanning of animal raw hide and skin, primarily cattle hide and natural grain, variation in the grains, good breathability and other natural features are all signs that the material is genuine. The most commonly used tanning methods are chrome and vegetable tanning. The vegetable tannins are extracted by using a suitable solvent, usually water followed by concentration and spray drying to get powder or solid. The tanneries in the Sudan imported mimosa and synthetic (syntan) tannins material for the process of retanning and pretanning. This study was undertaken to utilize Taleh bark (*Acacia seyal* Bark) as a retanning material for production of upper and garment leathers. The tannins content of Taleh bark was found to be 28.9% and therefore it was promising and would successfully be used as retaining and tanning materials. In this study; the factors that affect leaching which are mainly time, solvent to solid ratio, temperature, agitator speed and time of extraction. A two - level factorial experiments were designed and the level of the above factors was determined according to the statistical analysis. It was found that a solvent solid ratio of 6:1, speed of agitation of 250 rpm, temperature of 30°C and time 2 hours were the optimum conditions. A complete design of a long tube triple-effect evaporator is made for production of 1000 tons per year which is enough for the present level of capacities in the tanneries to date. In conclusion it is clear that Sudan can produce tannins extract from Taleh bark which can be used for pretannage, tannage and retannage. It is recommended that the Taleh bark and similar *Acacia seyal* can be analyzed and leached to give tannins powder extract to replace imported Mimosa extract.

Keywords: Leather; Tannins; *Acacia seyal* Bark (Taleh); Mimosa extract; Tannage; Retannage; Leather; Barkometer

Introduction

Leather

Leather is a durable and flexible material created by the tanning of animal raw hide and skin, primarily cattle hide. It was extensively used from the primitive times and is widely used now-a-days. Natural grain, variation in the grains, good breathability and other natural features are all signs that the material is genuine [1]. The processing of leather upon hide or skin is in different stages such as preparation of skin/hide, tanning and post- tanning.

Among these processing of leather, tanning is an essential phase in one of the civilization's oldest processes about the transformation of hides/ skins into leather [2]. Tanning is a process in which the leather-making protein is completely stimulating against heat, enzymatic biodegradation, and thermo mechanical stress. In commercial practice, vegetable and chrome tanning methods are widely used [3]. The objective is to convert the fibrous protein of raw hide or skin (Figure 1) into a stable material, to prevent hide or skin from putrefaction and making the leather [3] that is suitable for a wide variety of end applications [4]. In tanning processes tanning materials are able to crosslink with reactive site of fibrous protein, shown in Figures 2 and 3 [5]. It also involves conversion of putrefiable skin or hides to a non-putrefiable material [6] by employing various techniques over time to preserve and make conditioning of hides and skins. These included the use of animal fat, brain and other substances which were used purposely for softening and arresting putrefaction [7].

Chrome tanning

Leather making is a lengthy process and consists of many different chemical and mechanical processes. The chrome tanning method is widely used in leather industries which accounts approximately 85% of the world's heavy leather making [8]. Chrome tannage has proven to be

an effective method of tanning and is done in tanneries worldwide. It is used for the production of the great majority of leathers such as upper, garments and other light leathers. Chrome tan gained the leather with better characters such as high thermal stability, light weight and high strength properties [9].

Bio-tanning materials and tannins

Vegetable or plant or animal or microorganism tannins are called bio-tannins that are probably the earliest used reagents [10] for tanning of skin/hide and convert into useful end product called leather. Tannins are polyphenolic secondary metabolites of higher plants water soluble high molecular weight (500 - 20,000) polyphenolic compounds [10] and ability to precipitate the proteins and alkaloids. Tannin is an acid, and occurring naturally in the roots, wood, bark, leaves and fruit of many plants. Tannins bind (Figure 1) to the collagen proteins in the hide and causing them to become less water-soluble, and more resistant to bacterial decomposition [11]. Tannins are used in industries for the production of leather, adhesive, dye stuff and ink. Also, based on their bitter taste properties tannins are used as medicines in pharmaceutical industry, which promote rapid curing and formation of new tissues on wound and inflamed mucosa [10,12].

Tannins are classified as condensed and hydrolysable tannins and

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Received April 17, 2017; Accepted April 28, 2017; Published March 07, 2017

Citation: Hussein SA (2017) Utilization of Tannins Extract of *Acacia seyal* Bark (Taleh) in Tannage of Leather. J Chem Eng Process Technol 8: 334. doi: 10.4172/2157-7048.1000334

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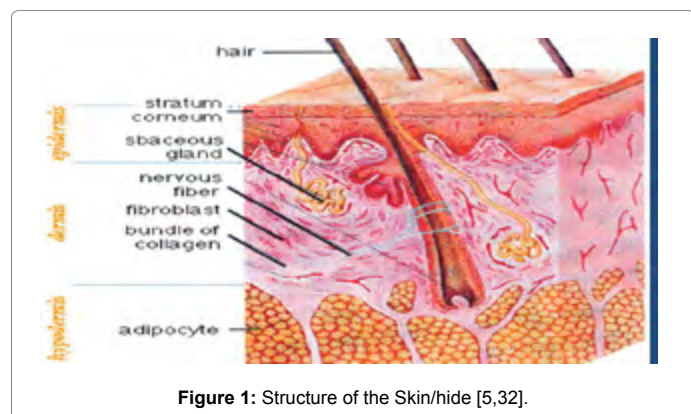


Figure 1: Structure of the Skin/hide [5,32].

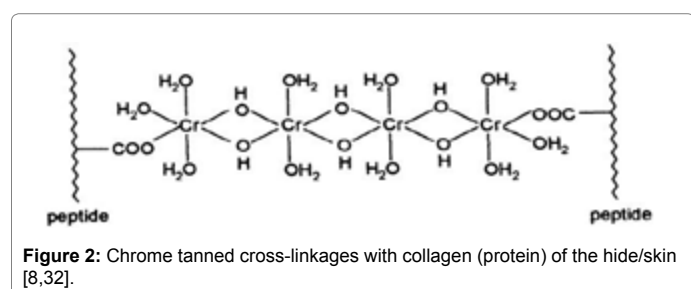


Figure 2: Chrome tanned cross-linkages with collagen (protein) of the hide/skin [8,32].

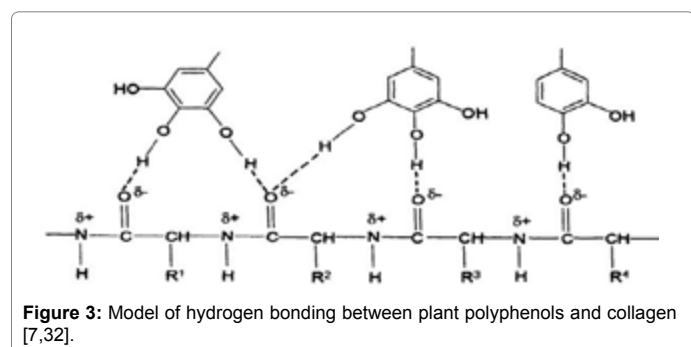


Figure 3: Model of hydrogen bonding between plant polyphenols and collagen [7,32].

they have ability to crosslink with collagen to form a non- putrefiable and hydrothermal stable product called leather inorganic [8,13,14]. According to Matt Richards [14] the bark material that contain hydrolysable tannins are liable to decomposition by hydrolysis. They include gallotannins, derivatives of gallic acid and ellagitannins are derivatives of ellagic acid. The phenolics of these compounds are formed by interaction of their oxygen atom with glucose molecule by ester bonds. They make leathers become pink, red or dark brown shades that are more 'solid'. Further, these tannins also create greenish-black spots on contact with iron. Mimosa, birch, hemlock, quebracho, alder and fir bark contain catechols. Oak bark contains both types of tannins that are used for the tanning of hides/skin [14].

Hydrolysable tannins are categorized in three sub-groups are depsides, gallotannins and ellagitannins. Myrobalan, chestnut, valonia, sumac, tara and divi-divi are examples of hydrolysable tannins containing plants [14]. Condensed tannins are not decomposed by hydrolysis but liable to oxidation and polymerization to form insoluble products. Condensed (catechols) tannins have more stable composition than hydrolysable tannins, which cause phenolic aromatic compounds to combine with carbon atoms. Mimosa, quebracho, hemlock, willow

and gambir are few examples of condensed tannins containing plants. These are preferable for leathers intended for book binding, upholstery and other purposes where longevity is essential. The resultant leather is of pale color varying from creamy or yellowish to light brown. Pyrogallols make bluish-black spots on contact with iron and resist changes in pH value. Sumac, chestnut, oak galls and oak-wood contain pyrogallols [14]. This type of tannin produces "tannin reds" while boiling with acid [13,14].

Brain tissue contains a fairly high fat and oil content that helps explain why it softens leather, keeps it flexible and protects it from water. Another of the active ingredients relevant to brain tanning is a compound called "lecithin," which probably helps the fats and oils in the thick gravy derived from cooking and mashing brain tissue interact with the non-oily components of the leather [13].

Vegetable tanning materials: Vegetable tanning, which is also referred as bark tanning and it is the time-tested method of using vegetable materials to process animal hides and skins into water resistant, non- putrefiable, soft, flexible, heat resistant material [15]. Bark tanning is an ancient method of creating durable, water repellent leather with a lot of body. It can be done to virtually any skin, but it is generally reserved for tanning grain on leathers from large thick hides such as cattle, horse, buffalo and pig. It has been commonly used for saddles, canteens, stiff shoes, belts, wallets, holsters, harnesses, helmets, pouches, trunks, shields and gun cases. Vegetable tanning involve treating the hides/skins with leaves, root and barks containing tannins [5] and it is considered as the "green tanning agent" because of its biodegradation and environmental friendly than that of inorganic tanning. Vegetable tanned leather has excellent fullness, moldering properties, wear resistance, air permeability and solidness; hence, it is of greater significance to reduce chrome pollution in leather making process. Vegetable tanned leather is used in making heavy leather such as furniture leather, garment leather and shoe upper leather [15]. The vegetable tanning method does not require the prior preparation of pickling and therefore the contributions to pollution load from sulfate salts are lower. In addition with vegetable tannins have several advantages such as it make leather to be hard to biodegrade, and hence wastes bearing vegetable tannins degrade slowly [16,17], ingredients (no harmful chemicals) are used when dyeing the hides are lighter in color and can be converted into pastel shade leathers, high softness, good lightness, natural sensation, pleasant touch, beauty over the time environmental friendly and can be recycled, each leather product that is dyed using vegetable tanning is completely unique, rich, warm-tone colors which look completely natural and high performance leather can be obtained, often better than chrome tanning [18].

Vegetable tannins are natural products of relatively high molecular weight which have the ability to complex strongly with carbohydrates and proteins. In this context, they are the most important natural products used industrially, specifically in leather tanning processes and the extracted commercial pod of tara (extracted at 1 hour with water (1:40 w/v) at 65°C) was spray-dried to obtain tara tannins then the quantity of the components are analyzed after and before hydrolysis and these result in obtaining the concentration of gallotannins (gallic acid) in the extract reached 53% reported in literature [19-23] studied the use of power ultrasound in solid- liquid extraction of biotanning materials. This vegetable tanning extracts is essentially based on the extraction of tannins from the tannin-bearing material using a suitable solvent, usually water, followed by concentration and spray drying to get powder or vacuum dried material of solid [23]. Tannins are defined as phenolic compounds of high molecular weight ranging 500 - 3000

Da, which they found in plants leaves, bark, fruit, wood and roots located basically in the tissues of vacuoles [24,25]. Vegetable tannins from four indigenous and exotic woody plant species were studied by different methods such as gelatin salt.

Different methods are conducted for extraction of tannin from vegetables. According to the literature [26] the influence of particle size, temperature, methanol content and time on the extraction of tannins from caesapiniacoriaria (divi-divi pods) determined by pressure autoclave method and tannins are determined by NMR spectroscopy, resulted in degradation of the compound is less at low temperature (40°C), the effect of time and substrate concentration on the extraction and evaluation of tannins were studied. The process of stabilizing the skin collagen against denaturation under heat, enzymes, stress etc., popularly described as tanning [27] is carried out by vegetable tannins derived from plant sources rich in polyphenols extracted with ethanol as the green solvent and highlights [28] the significance of the developed method, in not only enhancing tannin to non-tannin ratio (T/NT), but also improving thermal stability of the tanned collagen [29]. Extracts of tannin-rich plants is an important unit during leather manufacturing, there are several companies providing industrially produced tannin extracts of plants such as, extracts of *Schinopsis lorentzii* (Quebracho), *Acacia mearnsii* (Mimosa), *Uncaria gambir* (Gambier) and *Caesalpinia spinosa* (Tara) has 164.3, 108.2, and 169.3 g kg⁻¹ of tannin respectively and Tare reached 647.5 g/kg of tannins, which is extracted as based on photometrical methods as well as HPLC-ESI-MS [21].

Extraction of tannins from vegetables/plants: Plant tannins are polyphenols that are distributed as condensed and hydrolysable tannins with an immense structural variability and reaches high degree of polymerization. Extracts of tannin-rich plants are analyzed and being an important part of leather manufacturing. The manufacturing of vegetable tannin extract is essentially based on the extraction of tannins by using a suitable solvent usually water followed by concentration and spray drying to get powder or solidification to get solid (block) extract [7]. The extraction procedure of tannins from plants is well established [7].

Acacia seyal (Taleh)

Family: Leguminosae *Mimosoideae*, syn. Mimosaceae. Latin name: *Acacia seyal* Del. Common Synonym(s): *Acacia stenocarpa* Hochst. English: Whistling thorn.

The park of this tree is recognizable even at distance, for example, var. *seyal* has thin red-brown bark, and var. *fistula* has smooth white bark. The thorns of both varieties occur in pairs and are long, slender, and white; in var. *fistula*, the thorns may be swollen at the base by ant galls. In fact, its English name “Whistling thorn” arose because of the whistling noise which can be heard as the wind blows over these swollen thorns. The inflorescence is a bright yellow, axillary pedunculate, globose head. Pods are slightly curved, thin, and long (7-20 cm) [28].

Distribution: Occurs throughout the drier parts of Africa, from Senegal across to the Red Sea and down to Mozambique and Namibia. Many varieties exist [28].

The objectives of this study are:

- Analysis and identification of (*Acacia seyal* Bark).
- Investigation of leaching of aqueous (*Acacia seyal* Bark) extract.
- Application of (*Acacia seyal* Bark) spray dried powder for tanning and retannage of the leather.

- Analysis of physical and chemical properties of leather produced.

Materials and Methods

The tannage and retannage were carried out during the period of March 2012 - May 2015 at Sudan University of Science and Technology (Leather Industrial Incubator). The chemical analysis and physical testing of leathers were carried out at the National Center of Leather Technology Khartoum- Sudan [30].

Determination of moisture content

A sample of 2.5 g were accurately weighed, dried in an air oven at 102-105°C for a period of 2 hours, cooled in the desicator for 30 minutes and weighed. The processes of drying, cooling and weighting were repeated until the constant weight was obtained. The moisture was then expressed as percentage of the weight of the sample taken [31].

Calculations: Moisture=loss in weight (Kg) × 100/Weight (Kg) of sample

Determination of ash content

Two and half grams or more, of the prepared sample were put into a crucible. It was heated gently at first so that the (*Acacia seyal* bark) was not burnt. When the sample was completely decomposed the process of heating was continued in a muffed furnace at temperature 500°C until all carbon was consumed. The crucible was removed from the furnace, cooled in a desicator and weighed. The process of cooling and weighing was repeated until constant weight was obtained.

Calculations: Ash%=Weight of Ash × 100 / Wt. of sample used

Determination of total soluble

Apparatus and reagents:

- Whatman filter paper No. 1.
- 25 ml of (*Acacia seyal* bark) infusion.
- Water bath.

Procedure: The (*Acacia seyal* bark) infusion was filtered through Whatman Paper No. 1 until the filtrate optically was clear 0.25 ml of the filtrate was evaporated to dryness and then the residue was dried to a constant weight.

Calculations:

$$\text{Total soluble \%} = \frac{\text{residue} \times \text{volume distilled water} \times 100}{\text{weight taken} \times \text{volume taken}}$$

Determination of total solid

Apparatus and reagents:

- 50 ml of (*Acacia seyal* bark) infusion.
- Water bath.
- Vacuum oven.

Procedure: 50 ml of (*Acacia seyal* bark) infusion was evaporated to dryness on a water bath. The residue was dried at 98.5-105°C in a vacuum oven to a constant weight.

Calculations:

$$\text{Total soluble \%} = \frac{\text{residue} \times \text{volume distillate water} \times 100}{\text{weight taken} \times \text{volume taken}}$$

Preparation of chromed hide powder

Apparatus and reagents:

- Kaolin.
- filter cloth
- 6.25 dried hide powder.
- Distilled water

Procedure: 6.25 g of dry hide powder was shook slowly in 100 ml of distilled water for one hour 1 g of kaolin was added, filtered through linen and then filter paper, evaporated to 50 ml. Then it was dried to constant weight. This weight was multiplied by two gave the water-soluble matter in 6.26 g of dry hide powder.

Determination of tannins and Non-tannins

Apparatus and reagents:

- 100 ml of unfiltered tannin infusion.
- Chromed hide powder.
- 1 g kaolin.
- Whatman filter paper No. 1.

Procedure: 100 ml of the infiltrated tannin infusion was added to the chromed hide powder taken in a shaker bottle and shaken in a mechanical shaker running at 50 to 60 rpm for exactly 10 minutes. Then the contents were poured into a dry filter cloth and the filtrate was collected in a dry beaker containing about 1 g of kaolin. The contents of the beaker were mixed thoroughly and then filtered through whatman filter paper NO.1 until the filtrate obtained was clear. The filtrate was checked with gelatin – salt solution for the presence of tannins. 25 ml of this filtrate is pipette out into a dry previously weighted porcelain basin and evaporated to dryness in a water bath. It was once again dried in an air oven for 3 hours until a constant weight.

Calculations:

Weight of residue="a" g.

$$\% \text{ non - tannins} = \frac{a \times 120}{25} \times \frac{1000}{100} \times \frac{100}{\text{wt. of extract}}$$

Tannin content=total soluble-non tannin.

Experimental work

Leaching experiment: The crushed (*Acacia seyal* bark) was fed into a large wooden vat, coarser material, false bottom. The vat was filled with warm water and left until no more than was leached out. To produce stronger liquors economically a battery of several leach vats was used as shows in Figure 3. The liquors were run on a counter current basis; so that strong liquor which had been previously extracted was run on to the largely extracted (*Acacia seyal* bark) in order to remove the last traces of tan. (A battery of six vats or more may be used, all interconnected). When the (*Acacia seyal* bark) was fully extracted or (spent) as in (C) the vat was emptied and recharged and then became the head leach, with (B) the bottom leach and the next to be discharged. The process was carried-out under the following setup.

The factorial experiments: A series of single- contact batch experiments were carried out to determine the effect of the various factors on leachability of tannins from (*Acacia seyal* bark). Factors which normally influence the rate of extraction of soluble from a solid

are:

- Time of leaching
- Mixing conditions.
- Leaching temperature.
- Solvent – solid ratio.

Two-level factorial experiments were carried out to investigate the effects of the above factors and their significance.

Statistic analysis

Complete randomized design (factorial arrangement $2 \times 2 \times 2 \times 2$) was used in the experiments. The data were subjected to statistical analysis according to (Gomez and Gomez, (1984). Using the statistical package for (SPSS) program.

Physical analysis

Sampling: Sample for physical testing should be cut from the square HGJK as shown in Figure 4.

Conditioning: During the 48 hrs immediately preceding its use in a test, keep each specimen for physical testing in standard atmosphere of temp $20 \pm 2^\circ\text{C}$ And relative humidity $65 \pm 2\%$.

Measurement of thickness: The leather was placed in the gauge with the grain side up and the load was applied gently, reading had been taken 5 minutes after the full load was reached.

Measurement of tensile strength and percentage elongation: The specimen was cut due to the required shape and size from both at parallel and perpendicular directions to the backbone of leather. Measured of width was taken for test piece to the nearest 0.1 mm at three places on the grain side and three places on the flesh side. And also thickness was measured in three places (Figure 5). The specimen was placed in the machine and the machine was running until the specimen breaks. Then calculations were taken as follows:

- Tensile strength=breaking load/area
- Area=Width \times Thickness
- Elongation=Initial length-length at breaking/initial length.

Grain crack load and distention (lastometer test)

Procedure: Specimen was cut of 44.5 mm diameter from the sampling location of shoe upper leather. Specimen was clamped tightly in the lastometer and forced the plunger at rate of 20 ± 0.05 mm/ sec. this is done by turning the hand wheel clockwise at one revolution per second. When the crack spears the force and detention were noted down.

Results and Discussion

Acacia seyal bark analyses

The *Acacia seyal* Bark were collected and estimated for tannins by official method of analysis and the results are given in Table 1. Qualitative analysis of *Acacia seyal* Bark had been performed to investigate the type of tannin. It is seen from the iron alum solution test that the *Acacia seyal* Bark extract gave a green color, which clearly indicates of the presence of condensed tannin. Also formaldehyde – hydrochloric acid test gave precipitate with *Acacia seyal* Bark extract, which clearly indicates the presence of condensed tannin. Table 1 shows the percentages of tannin, non-tannin, total soluble, total solids, insoluble and the moisture of

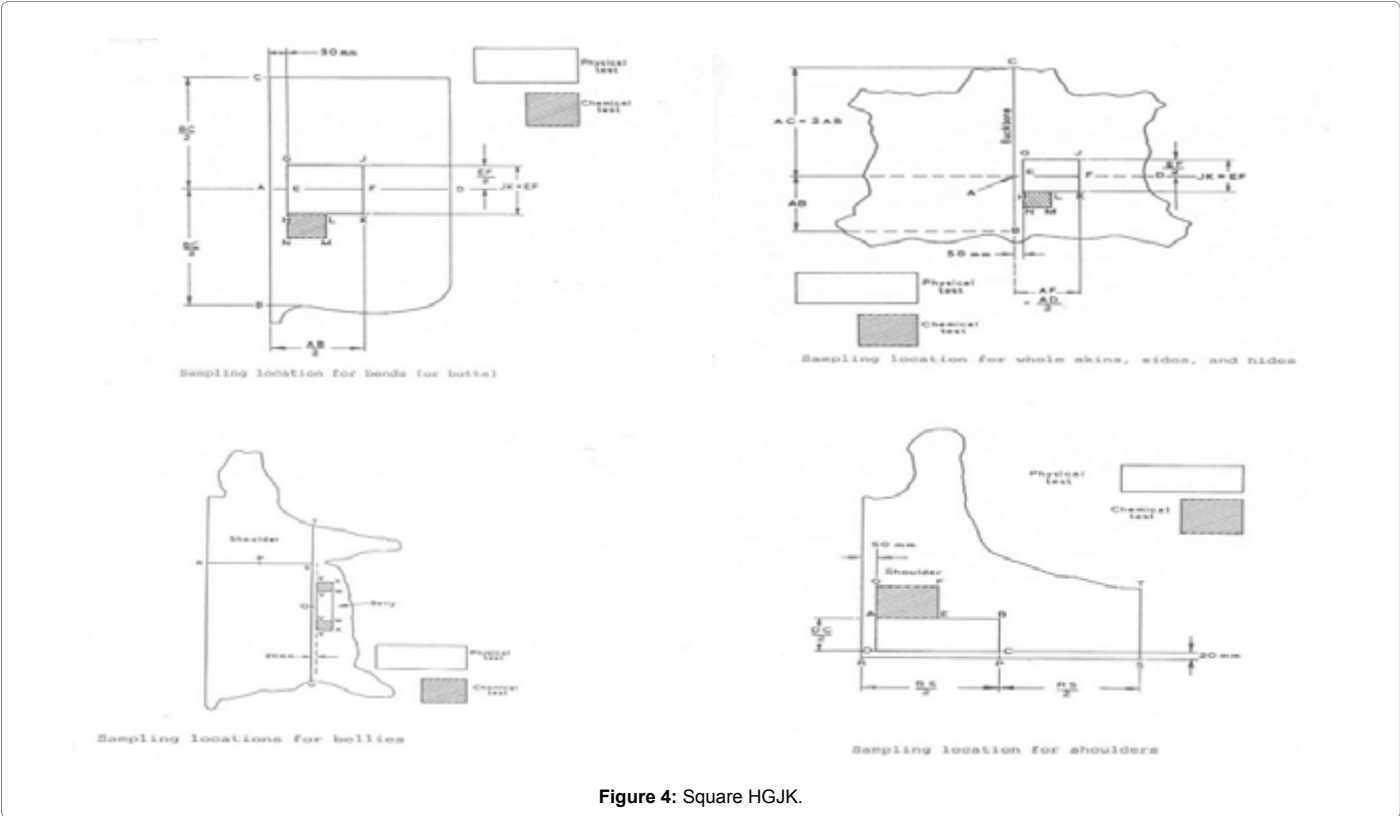


Figure 4: Square HGJK.

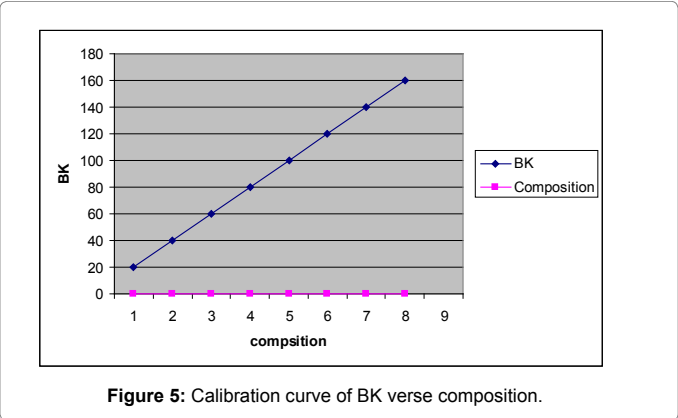


Figure 5: Calibration curve of BK verse composition.

S No	Item	%
1	Total solids	10.2
2	Total soluble	41.38
3	Tannin content	28.9
4	Non-tannin	12.48
5	Ash	1.2
6	Moisture	0.9
7	Other substances	5.02

Table 1: Tannin analysis of *Acacia Seyal* Bark.

Acacia seyal Bark. The *Acacia seyal* Bark gave pH 5.2.

Specific gravity verse Barkometer

Table 2 shows calibration curve of BK vs. composition. The degree to which it sinks is measured by reference to the calibrations on the

stem, in term of degrees Barkometer, SG etc. It is important that the hydrometer is quite clean and floats freely. The Barkometers is most common in tanneries using vegetable tan liquors.

The tannin content was found to been 28.9% which is quite adequate for both tannage and retannage. Hence it was decided to design factorial experiments in order to specify the levels of the most important factors affect the rate of leaching as it shows in Table 3. These factors are temperature, degree of mixing, solvent solid ratio, and time.

Tables 4 and Table 4.1 show the statistical analysis of the factors at low and high levels (Figure 1). From the statistical analysis, it is observed that the solvent – solid ratio is highly significant, indicating that the quantity of solvent increases the mass transfer rate. The solvent first penetrates into the particles, dissolves the solute will be directed from high concentration within the particle to the bulk of the solvent, this process will continue until equilibrium, therefore a solvent – solid ratio of 6:1 is recommended.

It is also observed that the time of leaching is no significant, as the process of diffusion didn't needs time to attain equilibrium, so the optimum time is 60 minutes. As the temperature increases the potential activity of the solute also increases (Figure 3) and it is found that the operating temperature is no significant and therefore the operating temperature of 60°C is recommended (F). More over statistical analysis obtained the speed of agitation insignificant due to the fact that the mixer throws the fine particles into the filter and thus impedes the rate of percolation. This fact when interacts with the factors of solvent – solid ratio becomes very significant indicating that at a high level of the solvent solid ratio the percolation is rapid with efficient leachability.

From Tables 5-5.2 it is seen the simplest method of leaching is the “single contact batch operation” where the solid to be leached and the

BK	Composition
20	0.02
40	0.038
60	0.064
80	0.075
100	0.089
120	0.116
140	0.138
160	0.15

Table 2: Calibration curve of BK verse composition.

Mean g/L	Comp g/L	Ratio	Mix	Temp	Time	No
58.5	52	1	1	1	1	1
	65	1	1	1	1	2
78.5	76	2	1	1	1	3
	81	2	1	1	1	4
58	50	1	2	1	1	5
	66	1	2	1	1	6
68.5	58	2	2	1	1	7
	79	2	2	1	1	8
58.5	53	1	1	2	1	9
	64	1	1	2	1	10
72.5	61	2	1	2	1	11
	84	2	1	2	1	12
58.5	54	1	2	2	1	13
	63	1	2	2	1	14
65	65	2	2	2	1	15
	65	2	2	2	1	16
73.5	82	1	1	1	2	17
	65	1	1	1	2	18
76.5	74	2	1	1	2	19
	79	2	1	1	2	20
73.5	87	1	2	1	2	21
	60	1	2	1	2	22
78	77	2	2	1	2	23
	79	2	2	1	2	24
76	84	1	1	2	2	25
	68	1	1	2	2	26
79	75	2	1	2	2	27
	83	2	1	2	2	28
72	80	1	2	2	2	29
	64	1	2	2	2	30
75.5	75	2	2	2	2	31
	76	2	2	2	2	32

Table 3: Design of experiments and compositions after each treatment.

solvent are contacted once and the extract solution and raffinate solid phases are separated.

Cross-current of thickeners contact is an extension of the single contact operation. Here the solvent is divided into a number of portions and the solid raffinate from the first stage is extracted with fresh solvent in successive stages. Ideally the solid are mixed for a sufficient length of time that equilibrium is attained. M equilibrium stage can be defined as one where the liquid adhering to the solid leaving has the same concentration as the extract withdraw. No separation of solute greater than that in equilibrium is possible in one stage. It is, however, possible to increase the recovery of the solute by cross-current multiple contact [32].

However, this method of extracting with fresh solvent in each stage

does not make the most efficient use of a given quantity of solvent and the resultant extract is dilute.

To utilize the solvent more efficiently and to produce a more concentrated extract, “counter-current multi-stage contacting” is employed. This operation, each stage contains solids at various stages of extraction. Fresh solvent is fed to the stage containing the solid that is nearly exhausted of its soluble content, then passed through the successive stages, and is finally withdrawn from the stage that has been freshly charged.

Table 6 shows physical properties of leathers it is concluded that the leather produced using *Acacia seyal* Bark was quite successful. It is found to be full, soft with good tensile strength and physical properties is. Table 7 shows the chemical analysis of crust leather from experimental

Time	Temperature	Degree of mix	Ratio	Total soluble	
				Mean	Standard deviation
30min	30°C	Without	01:04	28.5	1.9
			01:06	70	1.9
		With	01:04	21.5	2.02
			1:6	55	1.85
	60°C	Without	01:04	57.5	2
			01:06	69.5	1.96
		With	01:04	42.5	2.34
			01:06	69	2.46
60 min	30°C	Without	01:04	37.5	2.29
			01:06	68	2.32
		With	01:04	44.5	2.38
			01:06	66	2.32
	60°C	Without	01:04	52	1.94
			01:06	69	1.9
		With	01:04	45	2.48
			01:06	70	2.34

Table 4: Statistical analysis.

Main effect		Total soluble		Significant
		Mean	Stander deviation	
Temperature	30°C	48.88	1.5	Ns
	60°C	57.5	1.5	
Ratio	1:4	41.13	1.49	**
	1:6	67	1.54	
Degree of mixing	Without	56.5	1.45	Ns
	With	54.69	1.64	
Time	30 min	51.68	1.6	Ns
	60 min	56.4	2.03	

Table 4.1: Statistical analysis.

		Inerts (Kg)	Solute (Kg)
Feed to plant	71	29	-
Wash liquor	-	-	0.4954
Washed solids	71	2.9	0.17734
Liquid product	-	26.1	0.318

Table 5: The overall balance.

Concn (v/v):	0.03	0.045	0.058	0.06	0.077	0.081	0.087	0.092
Height for H1 (cm)	45	40.4	36.6	30	28	21	19	17
Velocity (m s ⁻¹)	3.3×10^{-5}	2.5×10^{-5}	1.9×10^{-5}	8.9×10^{-6}	7.4×10^{-6}	5.8×10^{-6}	4.5×10^{-6}	2.2×10^{-6}
Batch flux (m s ⁻¹)	0.99×10^{-6}	1.1×10^{-6}	1.1×10^{-6}	0.5×10^{-6}	0.57×10^{-6}	0.47×10^{-6}	0.39×10^{-6}	0.2×10^{-6}

Table 5.1: Experimental height, velocity and batch flux.

Parameter	a	b	c	d
Critical flux (m s ⁻¹)	1×10^{-6}	1.2×10^{-6}	4×10^{-6}	6×10^{-6}
Minimum area (m ²)	32.6	26.5	8.15	5.44
Minimum Diameter (m)	3.2	2.9	1.6	1.3

Table 5.2: Design parameter of thickeners.

tanning trials are given in Table 6; the chemical analysis data was quite successful (Tables 8 and 9).

Conclusion

In conclusion the following must be observed:

1. The tannin content of Taleh bark was found to be 28.9.
2. It was found that the leather produced is soft, with a good tensile

strength and physical properties. From these results Taleh bark (*Acacia seyal* bark) can be used in tannage and retannage.

3. Temperature of 50°C is recommended for leaching.
4. Solvent – solid ratio of 6:1 gives the highest leaching.
5. The leaching time is found to be 1 hour, after this time the infusion is solvent – solid ratio.

Description	Thickness (mm)	Tensile strength (N/mm ²)	Elongation %	Load at crack (Kgs)	Load at Grain Burst (Kgs)
Sample no 1 // to backbone crust	1.1	21.5	42	15	23
Sample no 1 ⊥ to backbone crust	0.7	31	53	21	24
Sample no 2 // to backbone crust	0.6	25.8	44.2	13	21
Sample no 2 ⊥ to backbone crust	0.8	28.9	43.1	24	33
Sample no 3 // to backbone crust	1.04	26.1	50	29	33
Sample no 3 ⊥ to backbone crust	0.9	24.5	52	19	19
Sample no 1// to backbone (finishing)	0.82	26.2	53	18	32
Sample no 1 ⊥ backbone (finishing)	0.85	23.8	42	19	32
Sample no 2 // backbone (finishing)	0.93	24.9	60.5	19	31
Sample no 2 ⊥ to backbone (finishing)	0.95	22	63.5	18	29
Sample no 3 // to backbone	0.83	25	50	18	26
Sample no 3 ⊥ to backbone	0.85	24	62	18	31

Table 6: Physical strength characteristic of crust leather.

Parameter	
Moisture %	15
Total ash content %	3.4
Fats and oils %	3
Water soluble matter %	6.1
Hide substance %	55
Insoluble ash %	0.9
Degree of tannage %	30.18

Table 7: Chemical analysis of the crust leather.

Factor	Treatment I	Treatment II
	Low	High
Temperature	30°C	60°C
Solvent solid ratio	01:04	01:06
Degree of mixing	Without	With
Time	2 hours	4 hours

Table 8: Factors and their levels.

Process	%	Duration (min)	Remarks
Adjustment of pH	100 0.75	3 × 15	pH 4.5-4.7
Tanning	2	30	
	8	120	
	1	120	
Fixing	0.25	60	
Washing	200	20	Check the pH to be 3.5. Drain the bath and pile overnight. Next day sammed and shaved to 1.4 mm. The shaved weight noted.

Table 9: Tanning process for pickled ship skin.

Acknowledgments

The author wish likes to thank Allah for enabling me to finish my research work. I would like to thank Dr. Grashi Abdelaa Gasmelssed. For his valuable guidance, scholarly suggestions, and constant encouragement throughout this research work. I take this opportunity to thank the Center of Leather and Industrial Research which sponsored this research. I am grateful to my husband for his patience and endurance while working in this research. And lastly, my sincere thanks to my

family for support and encouragement. Without their blessings and good wishes, I would not be to finish this work.

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