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UTILIZATION OF SOME NON-EDIBLE OILS AS FATLIQUORING PRODUCTS IN LEATHER TANNING

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Key Words: castor, fatliquor, jatropha, non-edible oils, plant oil, sulphation, deep frying oil.

ABSTRACT

Fatliquor affects the physical properties of the leather and makes it more flexible and softer. This study was carried out to utilize some non-edible oils, Castor, Jatropha and Deep Frying Oil (DFO), to prepare sulphated fatliquor, can be used in leather tanning. The used oils in this study were obtained by automatic hydraulic press. The sulphated fatliquors emulsions were prepared by sulphitation of oils with concentrated sulfuric acid. Chemical characterizations of oils and prepared fatliquor were determined. Prepared fatliquors were compared with commercial fish oil fatliquor (stander) at two concentrations, 6% and 12% based on the pelt weight. All fatliquors were used in fatliquoring calf wet-blues to study the change in leather properties. Results explained that the fat content in Castor seeds and jatropha seeds were 32.04% and 55.74%, respectively. The content of unsaturated fatty acids were 96.86%, 81.28% and 50.10% in extracted oils of Castor, Jatropha and DFO respectively, the iodine value of extracted oils from them which was (89.43 gm. I_2/100 gm. oil), (103.17 gm. I_2/100 gm. oil) and (70.58 gm. I_2/100 gm. oil) respectively. Therefore, oils - which are liquid - are rich in unsaturated fatty acids. Iodine value indicates to a melting point of the extracted oils. So fats and oils are usually classified, on the basis of their iodine value as drying oils, semi-drying oils and non-drying oils. Also existence of the double bond in the acids makes the sulfation reaction easy through breaking that bond and completing the reaction which was suitable for preparing fatliquor for leather tanning. After fatliquoring the calf wet-blues with different studied fatliquors and finishing it, the properties of finished leathers were similar in quality and suitable for different purposes of leather manufacturing. Therefore, the study is recommended to utilize studied fatliquoring in leather tanning to decrease the production cost of leathers, as well as, reducing pollution resulting from unsafe disposal of these oils.

INTRODUCTION

Leather tanning is a general term for the numerous processing steps involved in converting animal hides or skins into finished leather. The process aims to isolate collagen by removing non-collagenous components of skin and then making it resistant to physical, chemical and biological factors, in addition to protecting it from drying. **(Burgess 1994).**

Hence, various chemical and mechanical treatments are applied to produce finished leather. Among leather chemical additives, fatliquoring agents are one of the most effective chemicals to impart softness and flexibility to leather and their use is critical to attaining the required characteristics for leather and its products. Fatliquoring is an oil-addition process by which the leather fibers are lubricated. Thus after drying, fibers will be capable of slipping over one another and produce an adequate compliance and softness **(Akpan *et al.*, 2006).**

Fatliquoring process is considered very important in leather finishing due to maintain the fibers without drying and reduces frictional forces within the fiber weaves, thus allowing the fibers to move laterally over each other (**Kronick, 1998).** Additionally, it improves the leathers quality in mechanical properties, fullness, soft handle, flexibility and pliability, as well as, keeps leather's colors steady and more appealing (**Nashy *et al.*, 2011).**

Fatliquoring step is done by adding biological and/or non-biological fatty substances. Using different non-traditional resources for producing leathers fatliquors is important to produce leathers with various properties, in addition to utilize these resources **(BASF, 2007)**.

Castor plant *(Ricinus communis),* belonging to the family *(Euphorbiaceae)* and it grows naturally over a wide range of geographical and climatic regions **Omari *et al.*, (2015).**

Akpan *et al.*, (2006) reported that Castor oil is a nonedible oil crop, pale amber viscous liquid and non-drying oil with mild or no odor or taste. Chemically, it is a triglyceride which is a glycerol molecule with each of its three hydroxyl group esterified with a long clown fatty acid. Its major fatty acid is the unsaturated, hydroxylated 12-hydroxy, 9-octadecenoic acid, known familiarly as ricinoleic acid. The fatty acid composition of a typical castor oil contains about 87% of ricinoleic acid. In addition, castor seeds contains about 30-35% oil, which can be extracted from castor seeds by either mechanical pressing or solvent extraction or combination of them.

Jatropha plant *(Jatropha curcas)* is a potential anti-feedant candidate, belongs to the family *(Euphorbiaccae).* The seed which is black and oval in shape is rich in fixed oil.

Also **Akintayo (2004)** reported that jatropha oil contains 47.25% of crude oil and 5.54% of moisture content. The high iodine value of it (105.2 gm. I_2/100 gm. oil) is caused by high content of unsaturation fatty acid 78.5% such as oleic acid and linoleic acid.

Adebowale and Adedire (2006) noted that the percentage of oil is high (66.4%) which golden yellow, it much higher than those recorded for most oil-rich seeds and this would therefore be an advantage in terms of the exploitation of the oil in producing.

On the other hand; **El-Shattory *et al.,* (2012)** reported that Jatropha tree has been successfully cultivated in Egypt as it can grow well in the desert as it withstand drought and can be irrigated with treated sewage water since its oil is nonedible. Jatropha seeds contain nonedible viscous oil which can be used for several industrial applications. So, this work explores usage of the non-edible Jatropha fatty acids as a fatliquoring agent in order to save the needed edible fats and oils for food purposes.

In frying oils, which ever type the oil, it is usually heated to about 170^{o} C to 220^{o} C. When the oil is heated to these temperatures in the presence of oxygen (air), the oil undergoes thermal, physical and chemical degradation by reaction **(Moreira *et al.,* 1999)**. Thus, frying is an intense process that induces a multitude of chemical reactions in the frying medium and generates a plethora of chemical compounds **Belitz *et al.,* (2004).**

Also **Romero *et al.,* (2006)** found that the amount of degraded products increases with the duration of heating at high temperature. Therefore, the more the oil is heated, the more degradation takes place and the more toxic compounds are formed in the oil.

Megahed and Nashy (2010) reported that the application of the discarded palm oil as "deep frying oil" in leather industry as fatliquoring agent. Fatliquors helped to prevent the loosening of leather grain and ugly appearance of chrome tanned leather after drying. In addition, fatliquoring process improves leather characteristics such as soft handle, full, flexibility, and pliability as well as enhancement its mechanical properties.

Idun-Acquah *et al.,* (2016) reported that the degradation in the physico-chemical properties of the plant cooking oil after repetitive frying. We conclude that repetitive use of plant oil safe 1-2 times of batch frying after that should be avoided since changes in physico-chemical properties of the oil affect oil quality for human consumption so deep frying oils not suitable for human consumption would be suitable for alternate uses..

Habib and Alshammari (2017) studied recycling and application of the deep frying oil in the leather industry as a fatliquoring agent. The oil was sulfated at optimal conditions and evaluated in order to verify their capacity to be used as a leather fatliquoring agent using different concentrations (4, 6, 8 and 10% of sulfated oil). The analytical data reveal that the aqueous solution of 10 % sulfated oil (fatliquor emulsion) show a high degree of stability against metallic ions and pH as well as great ability to penetrate the chrome tanned leather, adding mass to the leather.

Therefore, this study aimed to using Castor, Jatropha and Deep Frying Oil (DFO) as non-traditional resources of biological oils to produced leather fatliquors and comparing it with fish oil fatliquor (stander), which commercially used in tanneries.

MATERIALS AND METHODS

This study was divided into two main parts, preparing fatliquor emulsion from plant oils, and then testing prepared fatliquor emulsions in leather fatliquoring process. The finished leather was tested physically and chemically after completing finishing steps.

1. Preparing fatliquors emulsions from oils:

About 10 Kg Castor and Jatropha seeds were collected from several local farms at Al-Buhaira Governorate, Egypt and several Agricultural companies at Ismailia city, Egypt, respectively. Seeds were packed in polyethylene packages and stored in deep freezer at -18 ± 2 ºC.

The Castor and Jatropha oils were prepared from collected seeds by automatic hydraulic press in National Research Center, Dokki, Giza according to **Allawzi *et al.* (1998)**, while DFO was collected from several restaurants at Cairo, Egypt.

Sufficient amounts of oils were used in producing fatliquor emulsions as follows:

- **Castor fatliquor:**

According to **Tawfig *et al.*, (2017)** 15% of concentrated sulfuric acid 98% was added based on oil weight as drops on the castor oil. During addition, the oil was stirred at 18-20°C. The sulfation process was carried out slowly for about 3 hrs. A saturated sodium chloride solution was added to the resultant products and mixed with them. The mixture was then kept in a separating funnel overnight to separate the layers. The upper layer was neutralized to pH 5.0 by adding sodium hydroxide solution 30% to produce the fatliquor.

- **Jatropha and DFO fatliquors:**

According to **Habib and Alshammari (2017)**, 15% of concentrated sulfuric acid 98% was added based on oil weight as drops on Jatropha or DFO oil. The overall reaction time was 2 hrs. During the addition of acid, the reaction temperature was controlled below 30°C by low stirring and slowly adding sulfuric acid. The sulfated oil was washed with 10% sodium chloride solution at room temperature and neutralized to pH 6.7-7.2 using 30% aqueous solution of sodium bicarbonate with agitation for 30 min.

After preparing different fatliquors, chemical properties were determined in seeds, extracted oils and prepared fatliquor emulsions. NIR analysis, moisture and fat contents were determined in plant seeds, while identification of fatty acids, iodine value, and saponification value and acid value were determined in extracted oils. On the other hand, moisture content, ash content, pH, density, fatliquor stability in different solutions and fatliquor substance were determined in fatliquor emulsions prepared.

2. Testing prepared fatliquor emulsions in leather tanning:

Prepared fatliquor emulsions were used in fatliquoring leathers at El-Shafei son’s tannery in El-Max region, Alexandria, Egypt. Eight wet-blues from calves were divided into 8 groups (4 fatliquors X 2 concentrations) as show in Table (1). All leathers were close in thickness and size, which graded as grade I.

Table (1): Different experiments of fatliquoring leathers.

Groups	Concentrations of fatliquoring materials			
	Castor oil	Jatropha oil	Deep frying oil	Fish oil
1	6%	-	-	-
2	12%	-	-	-
3	-	6%	-	-
4	-	12%	-	-
5	-	-	6%	-
6	-	-	12%	-
7	-	-	-	6%
8	-	-	-	12%

Firstly, wet blues were shaved by shaving machine to decrease the thickness from the flesh side into approximately 0.9 mm. After then, wet blues were ready for the next steps as follows in table (2).

After finishing, chemical, physico-mechanical and organoleptic properties of the finished leather were determined on finished leathers according to standard procedures **(ASTM, 2010).** The properties were leather thickness, tensile strength, elongation, split tear strength; fat, moisture, ash and pH.

Table (2): Finishing steps recipe for studied calf wet-blues.

Process	*%*	*Chemical*	*TIME*	*˚C*	*pH*	*OPERATION*
Degreasing	200	H2O				*Check grease Drain + Wash*
	1	OXALIC				
	0.2	SOAP	60			
Retanning	150	H2O		35		*Drum speed 5 cycle/min.*
	1	BLACK HH200	10			
	2	F G L AMX	30			
	2	SINTICROMO				
	2	CROME 33	60			
Fixation	1.5	SOD. FORMATE	90	*Over Night & Drain + Wash*		
Neutralization	150	H2O		30		*Check pH=5.5-6 Drain + Wash*
	2	LECOSIN CDD				
	0.8	SOD. FORMATE	20			
	0.5	NAHCO3	40		5.5	
	4	LECOREN 200	40			
Dyeing	80	H2O		30		*Check penetration*
	3	F G L R7S				
	3	SMITH SF156				
	2.5	F G L CN - NEW				
	4	BLACK AF 135	60			
	5	MIMOSA				
	5	QUBRARCHO	60			
Fatliquoring	100	H2O		70		*Same path*
	2.5	F G L F88	20			
	X	X				
	2	ECOSOFT 1001	60			
Fixation	2	FORMIC	2X10+50			*overnight Check pH = 3.5-4 next day Drain + Wash*

RESULTS AND DISCUSSION

The chemical composition of plant seeds:

Results in table (3) show the chemical composition of plant seeds by Near Infrared analyzer. The moisture content in Castor and Jatropha seeds was considered low 5.79% and 7.81% respectively, where fat content was very high 32.04% and 55.74% respectively. The highest oil yield or content probably might be due to the type of plant or the type of soil and the climate.

Table (3): The chemical composition of seeds by Near Infrared analyzer.

Seeds	The chemical composition %						
	Moisture	Fat	Protein	Ash	Fiber	Carbohydrates	Total
Castor	5.79	32.04	23.87	5.43	23.65	9.22	100%
Jatropha	7.81	55.74	7.64	4.89	19.91	4.01	100%

Identification of fatty acids of extracted oils by (GLC) analyzer:

Results in table (4) show the identification of fatty acids of extracted oils by gas liquid chromatography analyzer which can be divided into two main groups as illustrated in the table. The saturated fatty acids content in castor, Jatropha and deep frying oil were 3.11%, 16.70% and 47.80% respectively, where unsaturated fatty acids content were 96.86%, 81.28% and 50.10% respectively. The ratios of total saturated fatty acids to the total unsaturated fatty acids were 1:31.14, 1:4.87 and 1:1.05 respectively.

Table (4): Fatty acid composition of extracted oils by (GLC) analyzer.

Fatty acids			Percentage of fatty acids %		
			Castor	Jatropha	Deep frying oil
Saturated	C14:0	Myristic acid	0.00	0.00	0.34
	C16:0	Palmitic acid	1.52	9.55	30.20
	C17:0	Margaric acid	0.03	0.14	0.11
	C18:0	Stearic acid	1.49	6.76	16.45
	C20:0	Arachidic acid	0.07	0.22	0.32
	C22:0	Behenic acid	0.00	0.03	0.38
	Total		3.11%	16.70%	47.80%
Unsaturated	C16:1	Palmitolic acid	0.01	0.72	0.10
	C17:1	Margoleic acid	0.01	0.06	0.05
	C18:1	Oleic acid	5.50	47.41	27.67
	C18:2	Linolic acid	5.38	32.14	15.65
	C18:3	Linolenic acid	0.50	0.85	6.40
	C20:1	Gadoleic acid	0.48	0.10	0.23
	C18:1 - 12 OH	Ricinoleic acid	84.98	0.00	0.00
	Total		96.86	81.28	50.10
Unknown			0.03%	2.02%	2.10%
Total			100%	100%	100%

From these results, major fatty acid is higher content of the unsaturated fatty acids which suitable for using in leather fatliquoring (**Covington, 2009).**

Characterization of Extracted oils:

From data in table (5), extracted oils shows that the oils can be used in leather fatliquroing according to scales range introduced by **BASF (2007).** The iodine, saponification and acid values for extracted oils were near similar to the corresponding values of palm oil, neatsfoot oil and beef tallow fats, which used already in leather fatliquoring **(Covington, 2009).**

For this chemical composition and characterization of extracted oils; it can be concluded the ability of converting their fats into sulphated fatliquor emulsions.

Table (5): Characterization of Extracted oils.

Oils	Characteristics					
	Extraction yield (%)	Iodine value (gm. I_2/100 gm. oil)	Saponification value (mg KOH/gm. oil)	Acid value (mg KOH/gm. oil)	Density (gm./cm^3)	Colour
Castor	25	89.43	189.69	2.12	0.95	Pale yellow mild
Jatropha	40	103.17	197.04	3.48	0.93	Dark greenish yellow
Deep frying oil	-	70.58	200.69	1.51	0.79	Dark brown

Characterization of prepared fatliquoring emulsions:

Fish oil fatliquor is considered from the most commercial sulphated fatliquor used in leather tanning **(BASF 2007).** For that samples from prepared sulphated fatliquors and commercial fish oil fatliquor were taken to compare their chemical characterizations. The results were tabled in Table (6).

Table (6): Characterization of prepared fatliquoring emulsions.

Characteristics	Prepared Fatliquors			Fish oil
	Castor	Jatropha	Deep frying oil	
Preparation Yield (%)	151.00	178.00	143.00	-
Moisture (%)	37.00	41.00	38.00	54.60
Ash (%)	2.91	2.65	2.47	0.80
Fatliquor Substances (%)	60.09	56.35	59.53	44.60
Density (gm./cm^3)	0.93	0.90	0.89	0.85
pH (10% aqueous solution)	7.16	7.00	7.33	8.00

The moisture was lower in prepared fatliquors than commercial fish oil fatliquor that might be due to the efficiency of washing step, which was done after sulphitation reaction for fats. While the ash values were higher in prepared fatliquors. The density values were similar approximately, while pH (10% aqueous solution) was lower in prepared fatliquors than commercial fish oil fatliquor.

Testing prepared fatliquor emulsions in leather tanning:

The results were showed in Table (7). Regarding to physical properties of finished calf leathers, both prepared and fish oil fatliquors exhibited similar effect on all physical properties of corresponding finished leathers. With respect to the concentration effect of adding fatliquor, an increase of concentration caused an increase in values of all physical properties almost (Tensile Strength, elongation, tearing and thickness).

Table (7): Physical properties of calf leathers.

Item		N	*Thickness* (mm)	*Tensile Strength* (kg/cm^2)	*Elongation (%)*	*Tearing Strength* (kg/cm)
Fatliquor effect						
Castor		8	1.20 ± 0.015 ^{b}	204.43 ± 16.28 ^{a}	45.93 ± 2.60	18.33 ± 0.97 ^{c}
Jatropha		8	1.15 ± 0.015 ^{c}	214.91 ± 16.28 ^{a}	51.97 ± 2.60	21.96 ± 0.97 ^{b}
Deep frying oil		8	1.26 ± 0.015 ^{a}	200.40 ± 16.28 ^{a}	51.16 ± 2.60	27.50 ± 0.97 ^{a}
Fish oil		8	1.23 ± 0.015 ^{ab}	141.29 ± 16.28 ^{b}	42.78 ± 2.60	20.20 ± 0.97 ^{bc}
Significance			0.000	0.017	0.061	0.000
			**	*	NS	**
Concentration Effect						
6%		16	1.23 ± 0.011 ^{a}	172.08 ± 11.51 ^{b}	45.78 ± 1.84	20.74 ± 0.69 ^{b}
12%		16	1.19 ± 0.011 ^{b}	208.44 ± 11.51 ^{a}	50.14 ± 1.84	23.26 ± 0.69 ^{a}
Significance			0.046	0.035	0.107	0.016
			*	*	NS	*
Interaction effect						
Castor oil	6%	4	1.20 ± 0.02 ^{bc}	184.38 ± 23.02 ^{ab}	46.86 ± 3.68	17.97 ± 1.38 ^{d}
	12%	4	1.20 ± 0.02 ^{bc}	224.48 ± 23.02 ^{a}	44.99 ± 3.68	18.70 ± 1.38 ^{d}
Jatropha oil	6%	4	1.18 ± 0.02 ^{cd}	203.02 ± 23.02 ^{a}	46.27 ± 3.68	19.34 ± 1.38 ^{cb}
	12%	4	1.13 ± 0.02 ^{d}	226.80 ± 23.02 ^{a}	57.67 ± 3.68	24.57 ± 1.38 ^{ab}
Deep frying oil	6%	4	1.28 ± 0.02 ^{a}	181.55 ± 23.02 ^{ab}	47.79 ± 3.68	28.27 ± 1.38 ^{a}
	12%	4	1.25 ± 0.02 ^{ab}	219.26 ± 23.02 ^{a}	54.54 ± 3.68	26.73 ± 1.38 ^{ab}
Fish oil	6%	4	1.25 ± 0.02 ^{ab}	119.37 ± 23.02 ^{b}	42.20 ± 3.68	17.37 ± 1.38 ^{d}
	12%	4	1.20 ± 0.02 ^{bc}	163.21 ± 23.02 ^{ab}	43.36 ± 3.68	23.04 ± 1.38 ^{bc}
Significance			0.001	0.042	0.076	0.000
			**	*	NS	**

*** Significant at P < 0.05**

**** Highly significant at P < 0.01**

NS Not Significant

a, b and c means in the same coulmn with different superscripts were significantly different(P<0.05).

It can be concluded that using prepared fatliquor gave the same behavior and effects on collagen fiber like commercial fish oil fatliquor. Also, all leathers were similar in quality and suitable for leather manufacturing according to quality requirements for the main types of leather which observed by **BASF (2007).**

From the results in Table (8), chemical properties of finished calf leathers; from chemical properties of finished leathers, moisture contents and pH values were comparable among all finished leathers. On the other hand, ash and fat contents increased within each fatliquor group along with increasing fatliquors concentration, which was expected. With the exception of ash and fat content, the significant differences among values for chemical properties were not recorded, which demonstrates the similarity in tanning steps. High significant differences were found in ash content due to the ash content of added fatliquor, which was higher in prepared fatliquors than fish oil fatliquor as explained previously in table (6).

Table (8): Chemical properties of calf leathers.

Item		N	% Fat	% Moisture	% Ash	pH
Fatliquor effect						
Castor		6	7.10 ± 0.34	14.57 ± 0.3	5.90 ± 0.19	3.70 ± 0.03
Jatropha		6	7.14 ± 0.34	14.43 ± 0.3	5.56 ± 0.19	3.77 ± 0.03
Deep frying oil		6	6.64 ± 0.34	14.41 ± 0.3	5.66 ± 0.19	3.73 ± 0.03
Fish oil		6	7.19 ± 0.34	14.47 ± 0.3	5.52 ± 0.19	3.76 ± 0.03
Significance			0.653	0.980	0.571	0.271
			NS	NS	NS	NS
Concentration Effect						
6%		12	4.83 ± 0.24[b]	14.37 ± 0.21	5.20 ± 0.14[b]	3.72 ± 0.02
12%		12	9.21 ± 0.24[a]	14.56 ± 0.21	6.11 ± 0.14[a]	3.76 ± 0.02
Significance			0.000	0.531	0.000	0.127
			**	NS	**	NS
Interaction effect						
Castor oil	6%	3	4.94 ± 0.48 [b]	14.78 ± 0.42	5.25 ± 0.28 [bc]	3.68 ± 0.04
	12%	3	9.25 ± 0.48 [a]	14.36 ± 0.42	6.51 ± 0.28 [a]	3.71 ± 0.04
Jatropha oil	6%	3	4.70 ± 0.48 [b]	14.11 ± 0.42	5.16 ± 0.28 [c]	3.77 ± 0.04
	12%	3	9.57 ± 0.48 [a]	14.75 ± 0.42	5.95 ± 0.28 [abc]	3.77 ± 0.04
Deep frying oil	6%	3	4.73 ± 0.48 [b]	14.08 ± 0.42	5.19 ± 0.28 [c]	3.65 ± 0.04
	12%	3	8.55 ± 0.48 [a]	14.74 ± 0.42	6.13 ± 0.28 [ab]	3.81 ± 0.04
Fish oil	6%	3	4.92 ± 0.48 [b]	14.53 ± 0.42	5.18 ± 0.28 [c]	3.77 ± 0.04
	12%	3	9.45 ± 0.48 [a]	14.40 ± 0.42	5.86 ± 0.28 [abc]	3.75 ± 0.04
Significance			0.000	0.857	0.015	0.119
			**	NS	*	NS

*** Significant at P < 0.05**
**** Highly significant at P < 0.01**
NS Not Significant
a, b and c means in the same coulmn with different superscripts were significantly different(P<0.05).

On the other hand, the high significant differences of fat content were found due to concentration effect of adding fatliquores. Therefore, the increasing in the fatliquor concentration was corresponded with an increase in fat contents in finished leathers.

From chemical properties values, it can be concluded that all finished leathers were in acceptable range for using leathers in manufacturing, which explained by **BASF (2007).**

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إستخدام بعض الزيوت الغير صالحة للأكل كمنتجات تشحيم في دباغة الجلود

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تؤثر مواد التشحيم على الخصائص الفيزيائية للجلد حيث تجعله أكثر ليونة ومرونة وقد أجريت هذه الدراسة لاستخدام بعض الزيوت النباتية الغير الصالحة للأكل مثل زيت الخروع والجاتروفا وزيت القلي المستخدم لتحضير مواد التشحيم التي يمكن استخدامها في دباغة الجلود. تم استخلاص الزيوت المستخدمة في هذه الدراسة بواسطة الكبس الهيدروليكي الأوتوماتيكي. ثم تم تحضير مواد التشحيم عن طريق معاملة الزيوت بحامض الكبريتيك المركز. تم تحديد الخصائص الكيميائية للزيوت ومواد التشحيم المحضرة. تمت مقارنة مواد التشحيم المحضرة مع زيت السمك التجاري باستخدام تركيزين 6٪ و 12٪ من وزن الجلد. وقد تمت علي جلود العجول بعد مرحلة الدباغة بالكروم لدراسة التغير في خصائص الجلد. أوضحت النتائج أن نسبة الدهون في بذور الخروع وبذور الجاتروفا تبلغ 32.04٪ و 55.74٪ على التوالي. كما كان محتوى الأحماض الدهنية غير المشبعة في

الزيوت حوالي 96.86٪ و 81.28٪ و 50.10٪ في زيت الخروع والجاتروفا وزيت القلي المستخدم على التوالي ، وتشير قيمة الرقم اليودى إلى درجة إنصهار الزيوت المستخرجة لذلك تصنف الدهون والزيوت عادة على أساس قيمة الرقم اليودى إلى زيوت جافة وزيوت شبه جافة وزيوت غير جافة ؛ كما أن وجود الرابطة المزدوجة في الأحماض يسهل تفاعل السلفنة من خلال كسر تلك الرابطة واستكمال التفاعل وتحضير مواد تشحيم منها تدخل في صناعة دباغة الجلود. ومن خلال تطبيق ومقارنة مواد التشحيم المحضرة مع زيت السمك التجاري علي جلود العجول كانت الجلود النهائية متشابهة في الجودة ويمكن استخدامها في أغراض مختلفة من صناعة الجلود. لذلك توصى الدراسة باستخدام الزيوت غير الصالحة للأكل في تصنيع مواد تشحيم تستخدم في صناعة الجلود وذلك لتقليل تكاليف الإنتاج وتقليل التلوث الناتج عن التخلص غير الآمن منها.