Journal of Agricultural Chemistry and Biotechnology

Journal homepage & Available online at: www.jacb.journals.ekb.eg

Synthesis of some Sugar Polyesters from Soybean Oil Soap Stock and Evaluation of their Physiochemical Properties

Heba Allah M. E. Shenana ; Enas M. Mekawi and A. E. El-Hadary*

Biochemistry Department, Faculty of Agriculture, Benha University, Benha 13736, Egypt

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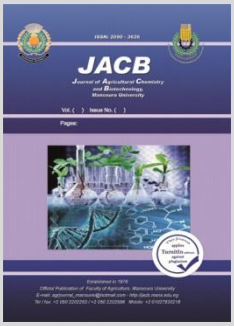

ABSTRACT

Dietary fat substitutes have existed for over a decade, many fat substitutes have been developed over the previous years. carbohydrates, proteins, fats, or a combination of them can all be used as fat substitutes. The current study used varieties of sugar with fatty acid separated from soybean soap stock to synthesize polyesters. The fatty acid of soybean soap stock was extracted, characterized as follows: free fatty acid yield in soybean soap stock was 17.16 %, the acid value was 199.1 mg KOH/g, iodine value was 123.3 mg I_2/100 g, and the saponification value was 191.00 mg KOH/g and identified by gas chromatography (GC). Then, sugar polyester was synthesized by esterifying glucose, sucrose, maltose, and lactose by esterification. The yield of sugar polyesters ranged from 25.94 to 68.5%. The obtained fractionations of fatty acids from the sugar esters samples were identified by GC. The obtained soya sugar polyesters contained high amounts of unsaturated fatty acids ranging from (82.23 - 84.3 %) of the total fatty acid, against only 15.68 - 17.75 % of total saturated fatty acids. Sugar polyesters components were verified using infrared (IR) and H1 nuclear magnetic resonance(H^1–NMR) spectroscopy. The physiochemical properties of polyesters were similar to the fatty acid of soybean soap stock.

Keywords: Sugar polyesters, fatty acids, methyl esters, esterification.

INTRODUCTION

Sugar esters (SE) are an intriguing group of compounds that constitute a substantial class of sugar-based non-ionic surfactants. They are created by joining the hydroxyl group of sugar with a fatty acyl group obtained from oleochemicals (fatty acids present in oils and fats).

Commercial SEs is divided into groups based on the fatty acid composition, and ration of constituting mono- or polys fatty acids. SEs contain a range of hydrophilic-lipophilic properties with hydrophilic-lipophilic balance (HLB) values between 0 and 16. The ratio monoesters in a SEs determine their degree of hydrophilicity. Garti *et al.,* (1999) SEs are considered as non-ionic surfactants because they include the lipophilic component from fatty acid tails and the hydrophilic from the sugar hydroxyl groups. This gives them a special emulsification property, tolerating temperature changes Chansanroj & Betz (2010). SE has also been shown to be non-toxic and biodegradable because of its capacity to be enzymatically hydrolyzed to sucrose and fatty acids prior to intestinal absorption or to be ejected in feces, depending on the degree of esterification. The numerous chemical qualities and benefits of SEs, e.g (tasteless, odorless, non-toxic, and biodegradable) make them extensively utilized in the field of food additives. Barros *et al.,* (2023).

Soap is known as the main byproduct of vegetable oil refinement. It sold for a little portion of the price of the oil despite having little commercial worth. But its analysis reveals the presence of many different kinds of chemicals, which may be very useful if recovered cheaply Dumont and Narine (2007). Significant volumes of this complex lipid combination are created during the refining process of vegetable oil. Characterizing and quantifying these combinations is of interest because they contain components of significant commercial value, like fatty acids, sterols, squalene, and tocopherols Dumont and Narine (2008). Soap stock was extracted from crude soybean oil using alkaline neutralization. It is composed of unsaponifiable materials, phosphatides, neutral oil, soap, and water. Seed quality, oil extraction methods, and refining conditions all affect its composition. Fazli *et al.,* (2013) Used solvent extraction, precipitation, and distillation, this method was predicated on recovering phosphatides, neutral oil, fatty acid, and color pigment from soap stock.

In the US, obesity is a serious and growing public health issue. In accordance with Health and Human Services (HHS) of the United States (2018), 70.7% of American adults were overweight in 2013–2014, and of those, 37.9% were obese. Having a positive energy balance means consuming more calories than one is using up Lowe & Butryn (2007). To reach a healthy weight and maintain good health, two common interventions are diet and exercise Stegenga *et al.,* (2014). As a result, eating low-calorie meals has long been recommended.

The American Heart Association and the American Cancer Society, among other health-related organizations, backed the recommendations because they believed that reducing fat and cholesterol in the diet would lower the prevalence of cancer and coronary heart disease. Przybyla (1990).

According to the patent literature, sucrose fatty acid polyesters (SPE) are the hexa-, hepta-, and octa-esters of polyols like methyl glucose, sucrose, raffinose, mannitol, or sorbitol with saturated or unsaturated fatty acids. This term is more accurately called sugar, polyol, carbohydrate, or saccharide fatty acid esters. Akoh (2008). The component known as carbohydrate or polyol

* **Corresponding author.**
E-mail address: Elhadary.a@fagr.bu.edu.eg
DOI: 10.21608/jacb.2023.250704.1071

is not a chain of sugars, nor is it a chain of fatty acids or esterified fatty acids that resembles fiber, plastics, or cloth-that is, polyester. Polyesters are artificial compounds that contain one, four, eight, eleven, or more fatty acids esterified to the hydroxyl groups of polyol carbohydrates such as maltodextrin, methyl glucose, or raffinose. Its fat-like, lipophilic, non-digestible, and non-absorbable molecules have the same physical and chemical characteristics as traditional fats and oils. Akoh (1994). The physical properties of polyester (PE) can be adjusted by varying the degree of unsaturation and chain length of the fatty acids used in the synthesis to produce polyester with functional properties appropriate for food use, Akoh and Swanson (1990). soybean polyester (SPE) has physical properties similar to triacylglycerols except for its resistance to lipolysis, and thus proposed as a zero-calorie fat substitute Fouad *et al.,* (2001)

Therefore, the aim of the present study is to Synthesis some lipid substitute fat from soybean soap stock with different sugar as a carbohydrate base such as sucrose polyesters (SPE), Glucose polyesters (GPE), lactose polyesters (LPE) and Maltose polyesters (MPE) The synthetic yield and the synthetic conditions for preparing these sugar polyesters (SPE) The physiochemical properties of the prepared SPEs were compared with the commercial soybean oil, to evaluate their commercial values.

MATERIALS AND METHODS

Material

Soybean soap stock was obtained from Royal Cosmetic com., Port Said, Egypt, all chemicals used in these papers were provided by Sigma and Al-Gomhoria chemical company of high quality and purity. Silica gel sheet for TLC Silica gel 60 F254 was purchased from Merck KGaA,64271 Darmstadt Germany EP Engineered clay corporation bleaching clay was obtained as a gift from Arma Food Industries Com, the 10th of Ramadan City, Egypt.

Analytical methods:

Extraction, and purification, of fatty acid from soybean soap stock.

The fatty acids were extracted from soybean soap stock after saponification and acidification according to the method described by the AOAC (2015)

Chemical properties:

Analysis of fatty acids: acids value, iodine numbers, and saponification value were determined by the methods of AOCA (2015).

Methylation process, identification, and determination of fatty acids from soybean soap stock:

The fatty acid methyl esters (FAME). were prepared according to the procedure outlined by Morsi et al., (2008). While, fatty acids were determined by GC according to the method Sabudak (2007).

Synthesis and purification, sucrose, maltose, lactose, and glucose polyesters:

Boutte and Swanson (1994) method was used to synthesize sugar polyesters. The reaction conditions were based on Shieh *et al.,* (1996).

Isolation and purification of sugar polyester PE:

Polyester (PE) was isolated and purified according to the method of Marquez *et al.,* (1994)

Gas Chromatography (GC) analysis of fatty acids methyl esters and sugar esters:

The fatty acid methyl esters were analyzed in an Agilent 6890 N gas chromatography equipped with a flame ionization detector (FID). Fatty acids were identified based on pure fatty acid methyl ester and expressed as a percentage of total fatty acids (area/area), including minor fatty acids Sabudak (2007).

Structure confirmation of sugar polyesters

Infra-red absorption spectra (IR):

Infra-red absorption spectra were verified through FT-IR spectroscopy, and the functional groups found in the reactants and products were recognized. Samples were dissolved, and using a Nicolet iS5 FT-IR spectrometer with an iD5 single bounce ATR attachment fitted with a diamond laminate crystal, IR spectra were obtained (Thermo ScientificTM NicoletTM iSTM5 FT-IR). The infrared spectra were acquired at a resolution of 4.00 cm^{-1} and 10 scans per spectrum, ranging from 4000 to 600 cm^{-1} analyses were described by Gundlach *et al.,* (2019)

Proton-nuclear magnetic resonance (^{1}H-NMR):

Thermo ScientificTM picoSpinTM 45 and 80 NMR spectrometers were used to record the proton-nuclear magnetic resonance (^{1}H-NMR) spectra. The ^{1}H-NMR spectra were obtained by employing NMR spectroscopy to determine the organic framework of the molecules. The analysis was carried out using the same conditions, and the spectrometers were 45/82 MHz pulsed, Fourier transforms ^{1}H-NMR permanent magnet instruments fitted with a capillary cartridge probe. Two to ten milligrams of sugar esters were dissolved in 0.6 to 1 milliliter of solvent-deuterated dimethyl sulfoxide (DMSO) Gundlach *et al.,* (2019) .

Physiochemical properties of sugar esters:

The refractive index (R.I.) and specific gravity of soybean Soap Stock and Polyesters were determined according to the method reported by A.O.A.C. (2015)

Result and Discussion

Extraction and Purification of fatty acids from soybean soap stock:

The fatty acid content extracted from soybean soap stock was determined and the results show the free fatty acid (FFA) yield after extraction was 17.16 %, respectively.

The obtained result is in agreement with Haas *et al.,*(2000) reported that soybean soapstock that saponified at 40°C in the manner indicated contained 51.1% water, 26.6% FFA, and had a pH of 13.5, and Dumont and Narine (2007) who reported that Vegetable oil refining results in substantial volumes of complicated lipid combinations called soap stock and deodorizer distillates. The characterization and measurement of these mixes' constituents, which include major commercially valuable substances including fatty acids, sterols, squalene, and tocopherols, respectively.

Chemical properties of soap stock:

Chemical analysis:

The chemical analysis is important to identify the overall stability and quality of food materials. Some of the important chemical analyses are acid value, iodine value, saponification value, and color. Neagu *et al.,* (2013)

Chemical analysis of soybean soap stock such as acid value, iodine number, and saponification value was determined and the obtained data are presented in Table (1).

Table 1. Chemical analysis of Soybean soap stock:

chemical properties	Soybean soap stock
Acid value (mg KOH/g)	199.1
Iodine value (mg I_2/100 g)	123.3
Saponification value (mg KOH/g)	191.00

The acid value is used to represent the amount of free fatty acids in the oil. It also indicates the quality, age, edibility, and suitability of oil for use in industries Akubugwo *et al.,* (2008). The acid value was 199.1 mg potassium hydroxide (KOH)/g oil. However, the iodine value of Soybean soap stock was 123.3 mg I_2/100 g was high and this indicated the presence of a high percentage of unsaturated fatty acids in the seed oil. The iodine value was above 100 so it could be classified as semi-drying oil Bello *et al.,* (2011). The saponification value of soybean soap stock was 191.00 mg KOH/g.

These results are in line with those reported by Park *et al.*, (2008) who found that hydrolysis of soap stock by KOH and the acidulation of sulfuric acid resulted in high-acid acid oil (HAAO). Acid oil was removed from the soap stock and transformed into HAAO using sodium dodecyl benzene sulfonate (SDBS) to stop the production of potassium sulfate. When the mass ratio of the acid oil, sulfuric acid, and water was 10: 4: 10, at 2% of SDBS, the acid value of the acid oil-HAAO was at its highest, at 194.2 mg KOH/g. Fatty acid methyl ester (FAME) concentrations for soap stock and acid oil, respectively, during the esterification of HAAO with Amberylst-15 were 91.7 and 81.3%. FAME content increased from 96.7% to 98.1% following distillation.

Haas (2005) reported that the iodine value is 129 I_2/100g oil in soybean soap stock methyl ester, and 121 I_2/100g in Soy oil methyl ester. Gopinath *et al.,* (2009) reported that the iodine value of Soybean was 120.52 I_2/100g oil. and the saponification value was 194.61 mg KOH/g oil, Baughman & Jamieson (1992) reported that the iodine value is 128 I_2/100g oil, and the saponification value of soap stock was 189.5 mg KOH/g oil.

Identification of the fatty acid from soybean soap stock:

The total fatty acids obtained from the soap stock samples were methylated by diazomethane and identified by gas chromatography. The fatty acid composition of soybean soap stocks is presented in Table (2) and Fig (1).

The obtained results show that soybean soap stocks contain high amounts of unsaturated fatty acids. The unsaturated fatty acids of Soybean soap stocks are 84.22 % of total fatty acids, respectively.

The major unsaturated fatty acids in soybean soap stock are linoleic 50.08 % and oleic acid 26.39%, while total saturated fatty acids content was 15.76 %, respectively. Among the saturated fatty acids, palmitic acid has the major percentage 10.76% followed by stearic acids 4.25%, respectively.

Table 2. Fatty acids composition of soybean FAME concentration from Soap stock:

fatty acids %	Soybean FAME concentration
Palmitic C16:0	10.76
Margaric C17:0	0.11
Stearic C18:0	4.25
Arachidic C20:0	0.64
Palmitoleic C16:1	0.68
Margaroleic C17:1	0.05
Oleic C18:1	26.21
Linoleic C18:2	50.08
Linolenic C18:3	6.18
Paullinic C20:1	1.02

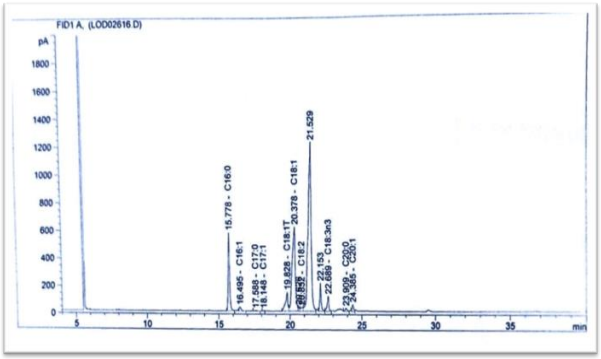

Fig. 1. Gas chromatogram of fatty acid methyl ester composition of soybean Soap stock.

The obtained results are in line with those reported by Akoh and Swanson (1989 and 1990), Sheh *et al.,* (1996), and Shieh and Lai (2001).

Preparation of fatty acid methyl esters from Fatty acids (FAME).

The result of FAME from varieties of soybean soap stocks is presented in Table (3) The yield of FAME was (82.6 to 89.2 %), respectively.

The process only took 5 min at 20°C with a methylation mixture: fatty acids ratio of 13 mL: 1 g, which greatly enhances the findings of Morsi *et al.,* (2008). In comparison to other approaches, this method produces FAME quickly and with a high degree of purity.

The obtained results are in line with Abdelaziz *et al.*, (2023) who found that after a relatively short time (3–3.5 hours), the reaction produced a total sugar ester (SE) yield of over 88% with a typical methyl fatty acid ester conversion of approximately 90%. This was accomplished using a K_2CO_3 catalyst at temperatures that were close to ambient (40–50 ºC) and Haas *et al.,* (2000) stated that the residual water amounts in the saponified soap stock, up to around 10%, did not impede the esterification process, which was mostly finished in less than ten minutes. FAME was a product that contained 0% triglycerides and >99% fatty acid esters..

Synthesis of glucose, sucrose, lactose, and maltose polyesters with free fatty acid from soybean soap stock:

Transesterification of glucose results in the production of long-chain methyl esters of fatty acids with available hydroxyl groups known as glucose polyesters. The result is shown in Table (3). The optimal conditions were determined to be a molar ratio of 6:1, a reaction period of six hours, a synthesis temperature of 115°C, and a catalyst of 2%. In these conditions, the yield was 25.94 % with glucose sugar.

while the structure of sucrose, lactose, and maltose polyesters or Olestra is synthesized by esterification between disaccharide sugar and long-chain fatty acid methyl esters. The number of hydroxyl groups esterified with long-chain fatty acids is known as the degree of substitution (DS).

A purification process employing silica gel column chromatography was conducted and the pure soybean glucose polyester mixture was obtained.

The obtained data in Table (3) show the yield synthesis of glucose, sucrose, maltose, and lactose polyester with different free fatty acids from soybean soap stock, the maximum yield of soybean was 68.5% in SLPE, followed by SMPE was 63.93%, while the minimum range from 25.94 to 38.59% in SGPE and SSPE.

The obtained data are in agreement with Neta *et al.*, (2015) who reported that a variety of sugar esters can be produced, depending on the degree of esterification and the characteristics of the fatty acid and/or sugar. Sugar esters show promise for use in the food sector due to their surface activity and emulsifying ability.

Table 3. Total yield of some sugar polyesters; Soya glucose poly ester (SGPE), Soya Sucrose polyester (SSPE), Soya lactose poly ester (SLPE), Soya maltose polyester (SMPE).

Type of polyester	% Yield
Soya + glucose sugar (SGPE)	25.94
Soya + sucrose sugar (SSPE)	38.59
Soya + lactose sugar (SLPE)	68.50
Soya + maltose sugar (SMPE)	63.93

Gas Chromatography (GC) analysis of sugar esters: -

The total fatty acids obtained from the sugar ester samples were identified by gas chromatography

Fatty acids composition of Soya lactose poly ester (SLPE), Soya maltose polyester (SMPE), Soya Sucrose polyester (SSPE), and Soya glucose poly ester (SGPE) varieties of soya sugar esters are presented in Table (4) and Figs. (2).

The obtained results show that Soya sugar polyesters (SLPE, SMPE, SSPE, and SGPE) contain high amounts of unsaturated fatty acids. The unsaturated fatty acids of polyester varieties were (82.23, 84.3, 83.56 and 83.31%) of total fatty acids, respectively.

The major unsaturated fatty acids in Soya (SLPE, SMPE, SSPE, and SGPE) were linoleic acid (43.91, 49.32, 40.25, and 48.00 %) and oleic acid (23.44, 28.69, 25.96 and 30.32%), while total saturated fatty acids content was (17.75, 15.68, 16.43 and 16.67%), respectively. Among the saturated fatty acids, palmitic acid has the major percentage (7.52, 9.53, 7.11, and 9.79 %) followed by stearic acids (7.24, 5.19, 7.50, and 5.49 %), respectively.

Table 4. Fatty acids composition of different sugar polyesters; , Soya lactose poly ester (SLPE), Soya maltose polyester (SMPE), Soya Sucrose polyester (SSPE), Soya glucose poly ester (SGPE).

Fatty acids %	(SLPE)	(SMPE)	(SSPE)	(SGPE)
Palmitic C16:0	7.52	9.53	7.11	9.79
Margaric Acid C17:0	0.26	0.81	1.61	0.55
Stearic C18:0	7.24	5.19	7.50	5.49
Arachidic acid C20:0	2.73	0.15	0.21	0.84
Palmitoleic C16:1	0.46	0.21	0.87	0.11
Margaroleic acid C17:1	0.52	0.58	3.65	0.45
Oleic C18:1	23.44	28.69	25.96	30.32
Linoleic C18:2	43.91	49.32	40.25	48.00
Linolenic C18:3	11.17	4.30	10.43	3.44
Paullinic acid C20:1	2.73	1.20	2.40	0.99

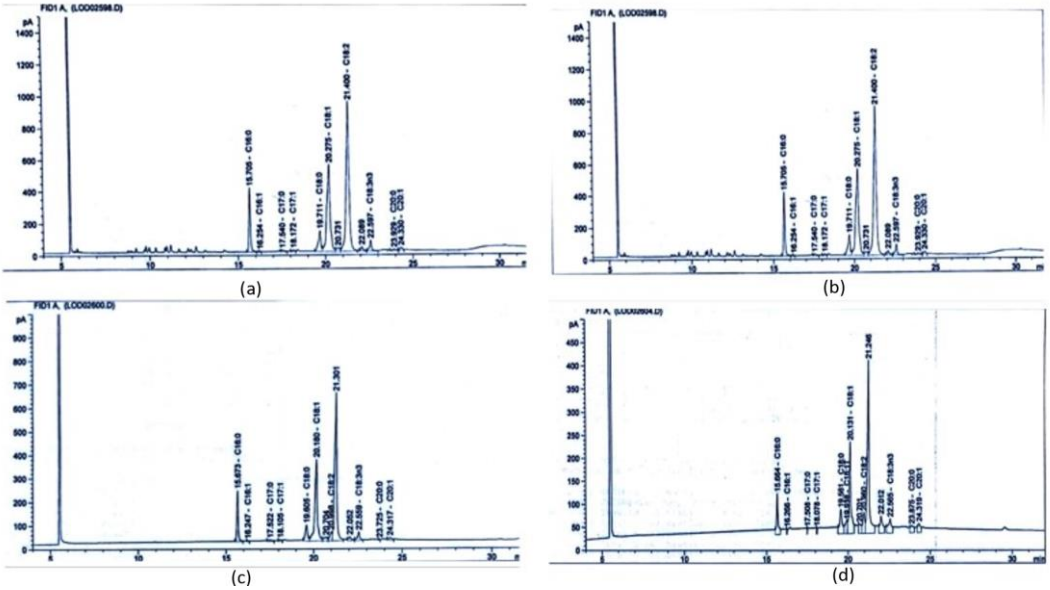

Fig. 2. i(a) Gas chromatogram of fatty acids composition of soya glucose polyester (SGPE), (b) Gas chromatogram of fatty acids composition of soya sucrose polyester (SSPE), (c) Gas chromatogram of fatty acids composition of soya maltose polyester (SMPE) and (d) Gas chromatogram of fatty acids composition of soya lactose polyester (SLPE).

Structure confirmation of sugar polyesters Infra-red absorption spectra (IR):

The IR spectra of glucose, sucrose, maltose, lactose sugar, and soy (SLPE, SMPE, SSPE, SGPE) sugar esters are shown in Table (5) and Figs. (3, 4, 5, and 6).

In the range of 3000-2860 cm^{-1}, methyl and methylene groups of fatty acid chains were seen to be stretched asymmetrically and to vibrate in a stretched state. However, hydroxyl groups absorption band at 3335 cm^{-1} in IR spectra of all sugar (glucose, sucrose, maltose, and lactose). However, the ester carbonyl absorption band at 1740 cm^{-1} in the IR spectrum of all sugar was absent in the IR spectrum of sucrose, glucose, maltose, and lactose. Whereas, the ester carbonyl absorption band at 1740 cm^{-1} in the IR spectrum of soya (SLPE, SMPE, SSPE, SGPE) has appeared. These findings suggest that the sugar was esterified to the fatty acid chains seen in sugar polyester. The IR spectrum of polyesters did not have an absorption band of the hydroxyl group at 3335 cm^{-1} as it did in the IR spectra of sugar, respectively. According to the results, all of the hydroxyl groups in the sugars glucose, sucrose, maltose, and lactose were esterified.

Our results were similar to Song *et al.*, (2006) reported the final SE products' IR spectra showed a prominent, broad peak (the O-H stretch of free hydroxyl in sucrose) at 3.362 cm^{-}

[1]. Additionally, it had peaks at 2.857, 2.928, 2.945 cm^{-1} (methyl C–H stretch), 1.056, 1.107 cm^{-1} (C–O stretch of C–O–C), 995 cm^{-1} (sucrose glycosidic bond stretch) and 1.728 cm^{-1} (C–O stretch of ester), indicating the effectiveness of esterification. So 1.728 and 995 cm^{-1} seemed to indicate that the goods were SE. & Amer *et al.,* (2005) found that it has been common practice to employ proton NMR (^{1}H-NMR) and infrared (IR) spectroscopy to clarify the structure of synthetic safflower oil sucrose polyesters. SPE synthesized from mixed fatty acids appears to have no prior reports of spectral data

Table 5. Infra-red spectrum (IR)of chemical groups:

Groups	Absorption (cm^{-1})
Hydroxyl group (-OH)	3335
Methyl group (-CH_3)	3000-2860
Methylene group (⟩CH2)	3000-2860
Ester carbonyl (CO, ester)	1740

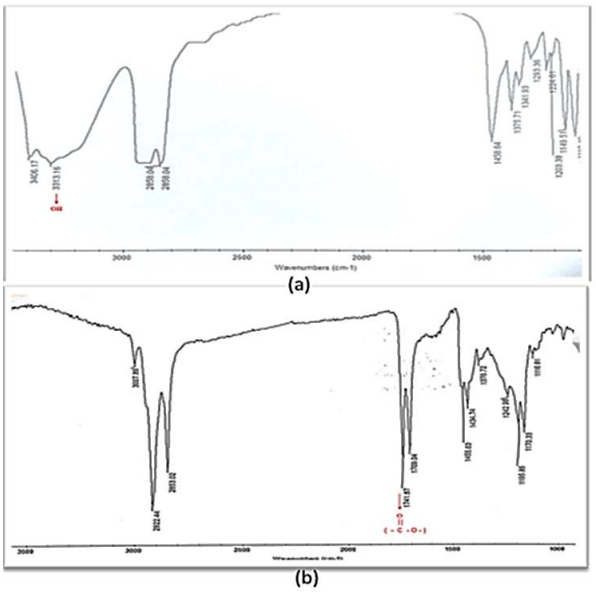

Fig. 3. (a) Infra-red spectrum of glucose sugar , and (b) Infra-red spectrum of soya glucose polyester (SGPE)

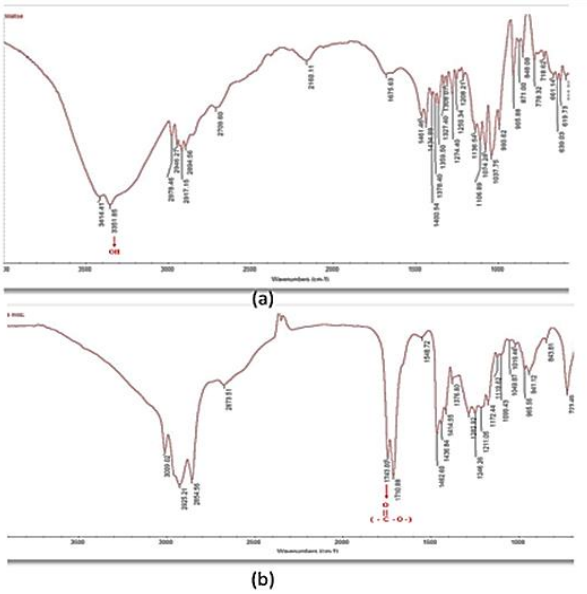

Fig. 4. (a) Infra-red spectrum of maltose sugar, and (b) Infra-red spectrum of soya maltose polyester (SMPE).

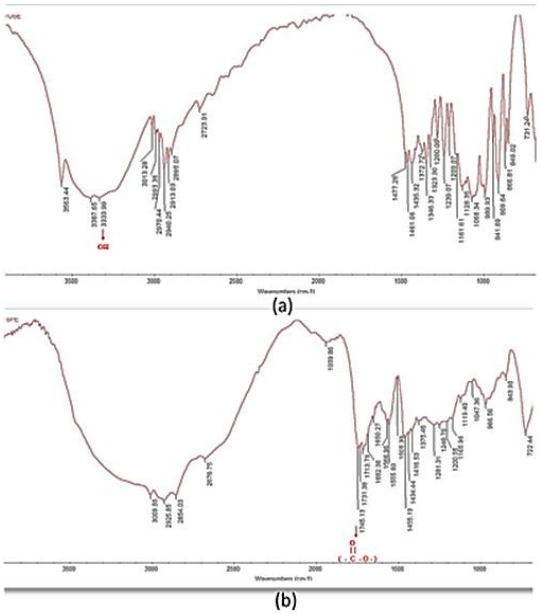

Fig. 5. (a) Infra-red spectrum of sucrose sugar, and (b) Infra-red spectrum of soya sucrose polyester (SSPE).

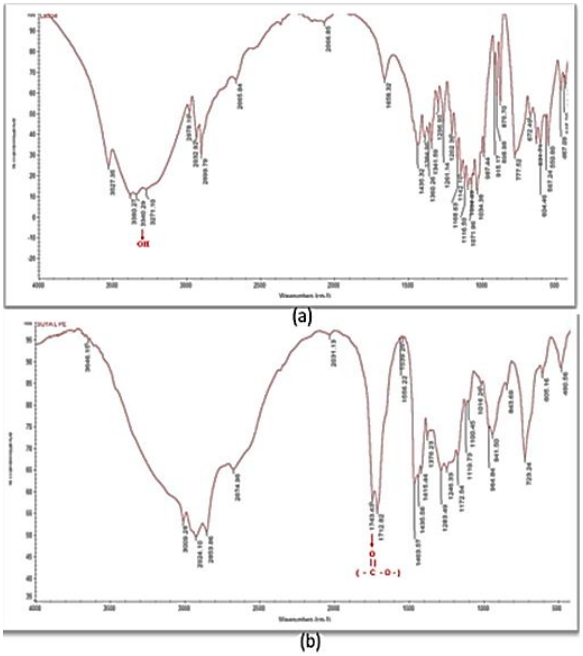

Fig. 6. (a)Infra-red spectrum of lactose sugar, and (b) Infra-red spectrum of soya lactose polyester (SLPE).

Proton-nuclear magnetic resonance (^{1}H-NMR):

The ^{1}H-NMR spectra of glucose, sucrose, maltose, lactose sugar, and soya (SLPE, SMPE, SSPE, SGPE) are shown in Table (6) and Fig (7).

There were detected signals of methylene group protons of fatty acid chains (1.226–1.226 ppm), methyl group protons on the omega end of fatty acid chains (0.799–0.826 ppm), and methylene group protons connected to a double-bonded carbon (1.933–1.945 ppm). among other characteristics. In the spectra of sugar, signals from hydroxyl group protons were seen at 4.2– 4.7 ppm, but not in the spectrum of polyesters. The findings demonstrate that fatty

acids were esterified to sugar molecules and that there are no hydroxyl groups in the molecules of sugar polyesters.

The obtained results are similar to Abdelaziz *et al.,* (2023) who found that sucrose stearate's methyl groups have their protons chemically displaced as usual at 0.87– 0.99 ppm. The (-CH_2) methylene groups produced proton signals in the (1.17–2.02) ppm range. The range of (3.34-5.40) ppm is where glucose protons of glucopyranose are found.

Table 6. ^{1}H-NMR spectra of chemical groups.

Protons of group	Spectrum (ppm)
Hydroxyl group (-OH)	4.2 - 4.7
Methyl group (-CH_3)	0.799 – 0.826
Methylidene (=CH_2)	1.933 – 1.945
Methylene group (- CH_2 -)	1.201 – 1.226

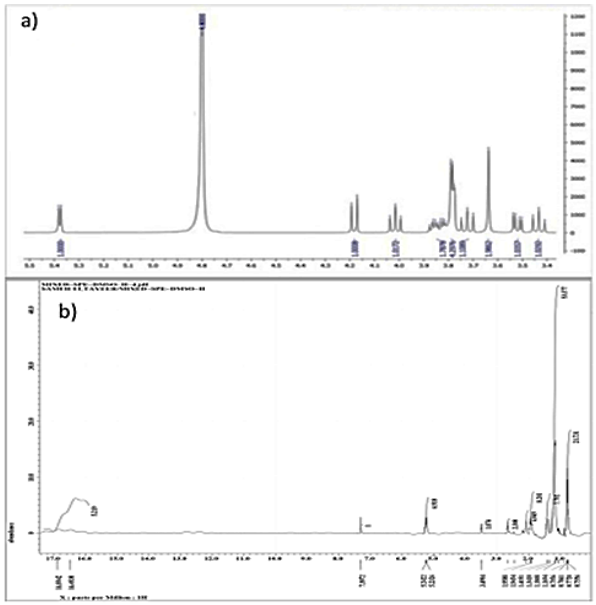

Fig. 7. a) H^1-nuclear magnetic resonance spectrum of sucrose sugar & b) H^1-nuclear magnetic resonance spectrum of Soya Sucrose polyester (SSPE).

Both the IR and ^{1}H-NMR spectra indicate that SPE and GPE were successfully synthesized by interesterification. Our data from IR and ^{1}H-NMR spectrum is similar to those of Akoh and Swanson, (1989 and 1990), Chung *et al.,* (1996), and Shieh and Lai (2001).

Physiochemical properties of sugar esters and raw soap stock:

The physiochemical properties of raw soybean soap stock were found to be similar to those of the corresponding conventional sugar esters Table (7). The sugar esters are liquids at room temperature (ca. 22^o C).

Carbohydrate polyesters must contain at least half unsaturated fatty acid to be liquid at ambient temperatures Akoh and Swanson (1990).

The obtained results show the refractive index (at 40^{o}C) of soybean sugar polyesters varieties were from 1.4402 to 1.4519 respectively, However, specific gravity at 25^{o}C was ranged between 0.888 to 0.964. These results are in harmony with Asemave *et al.,* (2012).

Overall, the refractive index and the specific gravity of soybean sugar ester increased with an increase in the degree of unsaturation and decreased with blending due to a decrease in the degree of unsaturation Akoh and Swanson (1990) & Jandacek and Webb (1978).

Table 7. Some Physochemical properties of soybean sugar esters, Soya lactose poly ester (SLPE), Soya maltose polyester (SMPE), Soya Sucrose polyester (SSPE), Soya glucose poly ester (SGPE), as compared to raw soybean soap stock.

soap stock	Refractive index (at 40^{o}C)	Specific gravity at 25^{o}C
Soya bean	1.4509	0.888
Soya lactose polyester (SLPE)	1.4486	0.905
Soya maltose polyester (SMPE)	1.4487	0.964
Soya sucrose polyester (SSPE)	1.4519	0.944
Soya glucose polyester (SGPE)	1.4402	0.901

CONCLUSION

In conclusion, the current study supports the presence that soybean soap stock waste products have several significant in water, soap, neutral oil, phosphatides, and un-saponifiable matter, they can be used in the food industry combined with carbohydrates to prepare SEs which can be rich in heart-healthy fats such as omega-3 and omega-6 fatty acids. Also, can be used to improve heart health by lowering cholesterol, reducing high blood pressure, and losing weight called fat substitute zero calory reduction.

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تخليق وتوصيف بعض سكريات البولي أستر من المخلف الصابوني لزيت فول الصويا وتقدير خواصها الطبيعية والكيميائية

هبه الله محمد عيد شنانة ، ايناس محمود مكاوي وعبد الله السيد الحضري

قسم الكيمياء الحيوية – كلية الزراعة – جامعة بنها – مصر

الملخص

توجد بدائل الدهون الغذائية منذ أكثر من عقد من الزمن ، وقد تم تطوير العديد من بدائل الدهون خلال السنوات السابقة. يمكن استخدام الكربوهيدرات أو البروتينات أو الدهون أو مزيج من هذه المواد كبدائل للدهون . استخدمت الدراسة الحالية العديد من السكريات المختلفة مع الأحماض الدهنية المنفصلة عن المخلف الصابوني لزيت فول الصويا لإنتاج البوليستر. تم استخلاص الاحماض الدهنية من المخلف الصابوني لزيت فول الصويا والتعرف عليها : كان إنتاج الأحماض الدهنية الحرة من مخزون صابون فول الصويا ١٧.١٦٪ ، رقم الحمض ١٩٩,١ ملجم KOH/g ، رقم اليود ١٢٣,٣ ملجم 100 / I2 جم، وكان رقم التصبن ١٩١,٠٠ mg KOH/g . وتم تقديرها بواسطة التحليل الكروماتوجرافي للغاز (GC) , ثم تم تخليق البوليستر من الجلوكوز والسكروز والمالتوز واللاكتوز عن طريق الأسترة . وتراوح إنتاج بوليستر السكر بين (٢٥,٩٤، ٦٨,٥%) . تم التعرف على الأحماض الدهنية التي تم الحصول عليها من عينات استرات السكر بواسطة GC. احتوت أصناف بوليستر سكر الصويا على كميات عالية من الأحماض الدهنية غير المشبعة تتراوح بين (٨٢,٢٣ - ٨٤,٣٪) من الأحماض الدهنية الكلية . بينما تراوحت نسبة الأحماض الدهنية المشبعة الكلية بين (١٥,٦٨ – ١٧,٧٥%) . تم تأكيد تكوين بوليستر السكر بواسطة التحليل الطيفي للأشعة تحت الحمراء (IR) والرنين المغناطيسي النووي (H1 – NMR) لكلا المكونين. وكانت الخواص الفيزيائية والكيميائية للبوليستر مماثلة للأحماض الدهنية الموجوده في المخلف الصابوني لزيت فول الصويا.