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CHARACTERIZING QUALITY OF RENDERED DUCK FAT

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Abstract

Characteristics of rendered duck fat (RDF) were compared to other commercial sources of fats and oils (e.g. butter, tallow, lard, soybean oil, and olive oil). Tocopherol content was determined by HPLC. Fatty acid composition and conjugated linoleic acid (CLA) content was determined using GC. The oxidative stability was determined by measuring peroxide values (PV) and p-anisidine values (AV) during storage at 50 in the dark. Under these conditions, the lengths of time prior to severe oxidation were as follows: RDF (8 days), lard (40 days), tallow (32 days), butter (36 days), soybean oil (10 days), and olive oil (38 days). The range of total tocopherol concentrations in the fats and oils varied from 0.02 to 27.8 mmol α−tocopherol/kg lipid. The relative polyunsaturation index varied from 6.0 to 119.4. No CLA was found in RDF.

Introduction

Rendered duck fat, a by-product of duck meat production, has potential for increased use in various food applications. However, little is known about its composition and oxidative stability. Conjugated linoleic acid (CLA) content is of interest because of potential impacts on human health. CLA has been reported to decrease the risk of cancer (Ip, C., 1997 and Banni, S., 1999). There are anecdotal claims that rendered duck fat (RDF) is resistant to oxidation at room temperature, but supporting evidence is lacking. Proper marketing claims are needed to promote RDF. Thus the objective of this work was to determine the oxidative stability of RDF compared to competing sources of cooking oils and fats. Basic research into the quality characteristics of duck fat will benefit the duck industry by establishing the unique properties associated with the duck compared to other sources of fats and oils. A better understanding of factors affecting lipid oxidation of duck fat could also provide the basis for improving product quality and shelf life.

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Objectives

1. Determine oxidative stability of fresh raw duck fat and rendered duck fat compared to other fat sources.
2. Determine fatty acid composition and conjugated linoleic acid (CLA) content in the various fats.
3. Examine tocopherol contents in duck fat and other fat sources.

Materials and Methods

Chemicals and materials: Isooctane, glacial acetic acid, chloroform, methanol, ammonium thiocyanate, iron(Ⅱ) sulfate, barium chloride, p-anisidine from Sigma Chemical Co.(St. Louis, MO). Methanolic-HCl-3N (Supelco); Methyl alcohol anhydrous 99.8% (Acros); GC reference standard FAME mixture #463,and CLA isomers #UC58M from Nu-Chek-Prep Inc. (Elysian,MN). Rendered duck fat and raw duck fat were supplied by Maple Leaf Farms ™. Tallow, lard, butter, soybean oil, and olive oil were bought from local store (tallow was rendered after purchase). Fats and oils were stored at -20 before experiments.

Methods

Peroxide value (PV)

To prepare the iron(Ⅱ) chloride solution, 0.4g barium chloride dihydrate was dissolved in 50 mL water. This solution was added slowly and with constant stirring to an iron (Ⅱ) sulfate solution (0.5g $FeSO_4 \cdot 7H_2O$ dissolved in 50mL water). Two milliliters of 10N hydrochloric acid was added to the resulting solution. The barium sulfate precipitate was filtered off to give a clear iron(Ⅱ) solution, which was stored in a brown bottle and kept in the dark. (Shantha N. C. and Decker E.A. 1994).

To prepare the ammonium thiocyanate solution, 30g ammonium thiocyanate was dissolved in water, and the volume was up to 100 mL.

To determine the peroxide value, the sample (0.05-0.3g, depending on the extent of peroxidation) was mixed in a disposable glass tube with 9.8mL chloroform-methanol (7:3, v/v) on a vortex mixer for 2-4 s. 100μL Ammonium thiocyanate solution was added, and the sample was mixed on a vortex mixer for 2-4 s. Then, 100μL iron (Ⅱ) solution was added, and the sample was mixed on a vortex mixer for 2-4 s. After 5 min incubation at room temperature, the absorbance of the sample was determined at 500nm against a blank that contained all the reagents except the sample by using a spectrophotometer (UV-2401 PC, Shimadzu Co.). The entire procedure was conducted in subdued light and completed within 10 min.

The peroxide value, expressed as milliequivalents of peroxide per kilogram of sample, was calculated by using the following formula:

Peroxide value = $(A_s - A_b) \cdot m / (55.84 \cdot m_0 \cdot 2)$

A_s-- absorbance of the sample; Ab-- absorbance of the blank; m—slope, obtained from the calibration curve= 41.52; m_0 – mass in grams of the sample; 55.84—atomic weight of iron.

Anisidine Value (AV)

Oil sample (0.5-1 g) was weighed into a 25 mL volumetric flask and made up to the mark with isooctane. The absorbance (A1) was measured at 350nm against a pure isooctane blank using spectrophotometer. 5mL aliquots of the oil solution or 5mL isooctane (blank) were then transferred to each of three 10mL test tubes and 1mL para-anisidine solution (0.25 w/v solution in glacial acetic acid) was added to each tube. The test tubes were stoppered, shaken, and allowed to stand for 10 minutes. The absorbance (A2) was measured at 350 nm against the isooctane blank containing para-anisidine (Rossell, J. B. 1986). The AV was calculated by using the following equation:

Anisidine value(AV) = $25 \cdot (1.2A_2 - A_1)$/sample weight

Fatty Acid Analysis

Acid-catalyzed methylation procedure: Weigh 5-30 mg of test portion into a screw-caped vial. Dissolve test portion in 1 mL toluene, add 2 mL of anhydrous 4% HCl/ methanol, and heat for 20 min at 60 . Add H_2O to make a 95:5 mixture of methanol/ H_2O that expels hexane. Add 2-3 mL hexane and mix well, allow layers to separate, and remove hexane layer containing the FAME. Dry hexane layer over Na_2SO_4 and use directly for GC analysis.

Gas chromatograph system equipped with FID, split/splitless injection ports, autosampler (Hewlett-Packard, model 7673), and a Hewlett-Packard ChemStation software data system was used. CP Sil 88 flexible fused column (100 m×0.25mm i.d. ×0.2um film thickness) was employed. 1- 3 L volumes sample were injected (Kramer J. K.G. et al 2002). Percentage of each fatty acid was calculated by normalization of total fatty acid methyl esters (Livisay, S. A. et al. 2000 and Emken, E. A. et al. 2002).

Tocopherol determination by HPLC

Tocopherol contents in the oils were separated and quantified by a high-pressure liquid chromatography (HPLC) system, Agilent 1100 series HPLC, incorporating Alltech Alltima silica 5u (4.6*250 mm) column, fluorescence detector, and DAD detector. 1% 2-propanol in hexane was used as mobile phase at flow rate 1ml/min. The amount of injection of sample was 20uL. The effluent was monitored with the fluorescence spectrophotometer set at an excitation wavelength (λ ex) 295nm and emission wavelength (λ em) 325nm and DAD detector set at wavelength 295nm (Carpenter, A.P. 1979, Petillo, D.et al 1998 , Nesaretnam K. et al, 2004).

Results and Discussion

Oxidative stability of the various fats and oils

In order to investigate oxidative stability, the different fats and oils were subjected to an accelerated storage condition (50 , dark) which is representative of the autoxidation process during normal shelf life (Hrncirik, K. 2005). The PV and AV of oils were determined once every two days. The results are shown in Table 1 and 2 and expressed as mean ± SD (n=3). Lard and butter were much more resistant to PV and AV formation compared to RDF. Soybean oil was slightly more resistant to PV and AV formation compared to RDF. Tallow was more resistant to PV and AV formation compared to rendered duck fat. Olive oil was more resistant to PV and AV formation than both rendered duck fat and tallow during storage. However, oxidation values in olive oil samples were somewhat elevated between day 0 and 6 compared to rendered duck fat and tallow.

Table 1. PV (meq./kg)of oils and fats during accelerated storage (50 , dark)

Oil & fats/days	0	6	8	10	12	14	16	20	32	36	38	40	44	50	60	80
RDF	2.08	11.4	**41.3**	85.3	145	216										
Lard	6.06	6.9	7.48	5.49	8.86	8.43	10.1	13.2				**34.2**	87.7	164		
Butter	0.24	0.74	1.01	1.15	1.48	1.6	2.3	3.03				**56**	195			
Soybean oil	0.84	2.04	8.26	**29.5**	58.5	60.3	175	204								
Olive oil	4.12	10.3	11.7	12.9	14.1	16.3	17.8	20.6				**36.9**	39.4	50.3	55.9	67.7
Tallow	1.28	1.41	1.65	1.83	2.08	2.31	2.59	3.45	**36.9**	151						

Table 2. AV of oils and fats during accelerated storage (50 , dark)

Oil & fats/days	0	6	8	10	12	14	16	18	20	24	40	44	50	58	80
RDF	2.2	3.88	10.1	20.6	33.9	53									
Lard	0.52	1.36	1.33	1.1	1.6	1.36	1.6		1.91		5.10	9.42	80.9		
Butter	3.60	0.20	0.73	0.86	1.24	0.89	1.09	1.24	1.36			44.1	47.6		
Soybean oil	2.30	1.57	2.56	3.39	5.65	7.67	10.8	14.7	18.4	42.0					
Olive oil	1.90	5.84	5.73	5.90	5.71	6.28	5.98		6.16	5.67	5.43	5.64		6.87	7.00
Tallow	0.55	0.77	0.89	0.92	0.72	0.95	1.02		1.26	1.55	35.5	39.4			

According to the peroxide value of the oils during incubation at 50 , we selected the time (day) when the PV of oil increased suddenly (exceeded 30-35 meq./kg) as an index of the oxidative stability of the oil (Fig. 1).

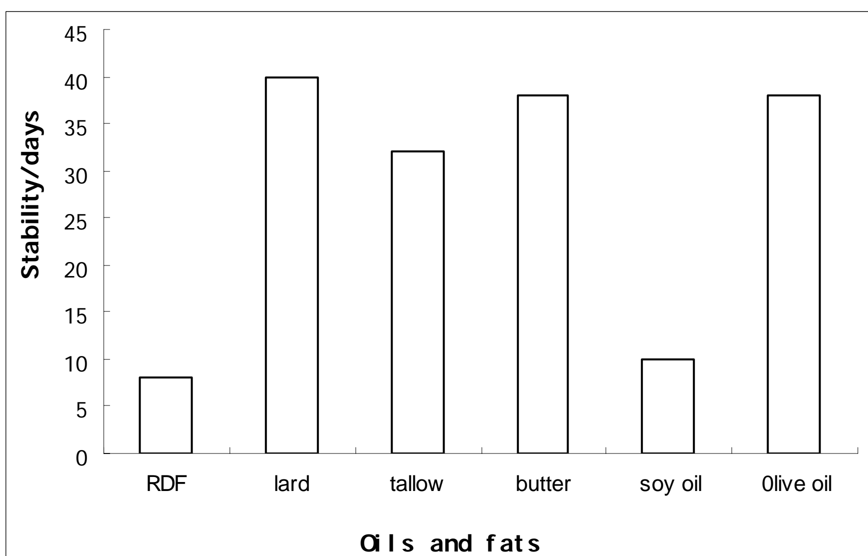

Fig. 1. **Oxidative stability of various fats and oils based on time of elevation in peroxide value beyond 30 meq/kg.**

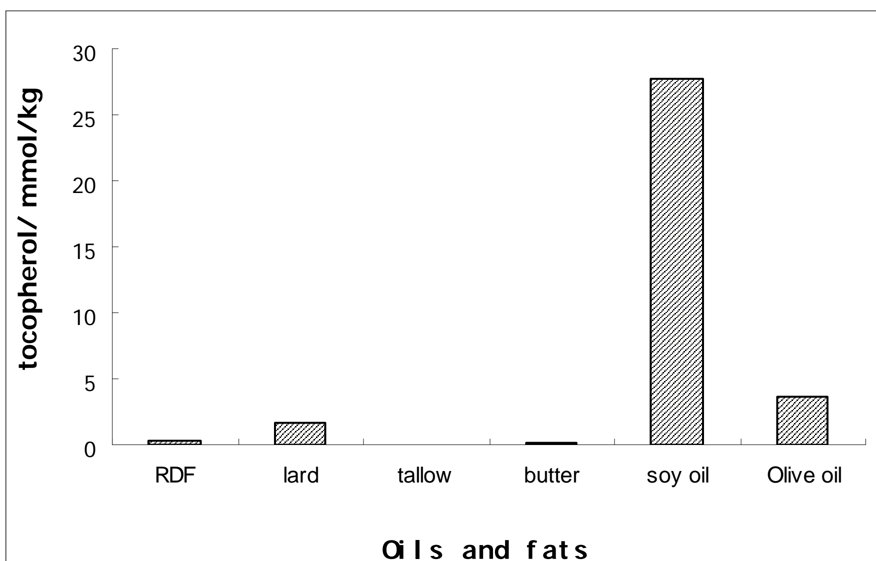

Fig. 2. **Concentration of V_E (as α-tocopherol) in oils and fats**

Tocopherol content and fatty acid composition

In order to help explain the varying oxidative stabilities in the different fats and oils, we determined the tocopherol content (Fig. 2) and fatty acid composition (Table 3). Soybean oil had a very high tocopherol content (27mmol/kg) followed by olive oil (3.7mmol/kg) while duck fat, lard, tallow, and butter had lower tocopherol contents.

Fatty acid composition datum is shown in Table 3. It indicated that there were higher unsaturated fatty acid contents, especially polyunsaturated fatty acids such as linoleic

acid (18:2), in duck fat (20.49%) and soybean oil (49.35%). Fatty acid composition of duck fat was similar to vegetable oil: high unsaturated fatty acids: 16:1(3.67%), 18:1(41.61%), high polyunsaturated fatty acids: 18:2 (20.49%), 18:3 (1.05%), and low saturated fatty acids: 18:0 (6.27%). Additionally, total 18:3 fatty acids in duck fat (1.05%) are higher than other oils except soybean oil.

Table 3. Fatty Acid Composition of fats and oils.

Oil/FA	duck fat	lard	tallow	butter	olive oil	soybean oil
5:0			1.72			
8:0			1.09			
10:0			2.42			
12:0			2.78			
14:0	0.76	1.27	3.25	9.64		
14:1	0.67		0.37	1.24		
16:0	22.83	19.25	25.90	28.79	14.45	11.99
16:1	3.67	1.98	2.03	1.56	0.92	
17:0	0.20	0.54	1.12	0.70		0.12
18:0	6.27	18.96	30.57	14.25	4.08	5.70
18:1	41.61	39.45	29.90	26.09	65.4	23.52
18:2	20.49	12.92	2.66	2.12	10.74	49.35
CLA		0.14	0.34	0.71		
18:3	1.05	0.62		0.57	0.66	6.90
20:0		0.32	0.23	0.24	0.58	0.48
20:1	0.52			0.16	0.30	0.24
20:2	0.17	0.57				
20:3	0.15	0.20		0.10		
22:0				0.20	0.63	
22:1	0.39	0.21		0.14		
22:4	0.19	0.11				
24:0					0.16	
Other	1.79	2.70	3.23	4.58	2.67	0.91

From the results of fatty acids composition in Table 3, we calculated total polyenes by the following equation: Total polyenes =Σ percentage of polyunsaturated fatty acids × number of double bond.

The total polyenes results are shown in Table 4. Soybean oil had the highest polyene value (119.4) while rendered duck fat had a polyene value of 45.68. Polyene value was lowest in tallow (6.0). CLA contents of lard, tallow, and butter were 0.14%, 0.34%, and 0.71% respectively. No CLA was detected in rendered duck fat, olive oil and soybean oil.

Table 4. Total Polyene, and CLA content in the various fats and oils

Oil	duck fat	lard	tallow	butter	olive oil	soybean oil
Σ Polyene	45.68	30.16	6.0	6.25	24.06	119.4
CLA (%)	ND	0.14	0.34	0.71	ND	ND

ND- Not detected

Duck fat was easily oxidized (Fig. 1) because of its high percentage of polyunsaturated fatty acids (Table 4) and low content of tocopherol (Fig. 2) relative to the other fats and oils examined. Soybean oil had similar oxidative stability compared to duck fat (Fig. 1). The high content of tocopherol probably increased the oxidative stability of soybean oil inspite of its high content of linoleic acid. The relatively low percentage of 18:2 fatty acid and elevated tocopherol content in olive oil produced high oxidative stability.

Conclusion

The oxidative stability of rendered duck fat (RDF), lard, tallow, butter, olive oil, and soybean oil were 8, 40, 32, 36, 38, and 10 days, respectively. Our test results indicated that duck fat was not resistant to oxidation. Both tocopherol content and fatty acids composition impact oxidative stability of oils. Tocopherol appeared to inhibit oil oxidation. High percentage of 18:2 fatty acids in RDF and soybean oil appeared to accelerate oxidation. Only olive oil contained more 18:1 than RDF. Saturated fatty acid content was low in RDF. Only soybean oil contained more 18:3 than RDF. These attributes provide a fatty acid profile in RDF that should be perceived as healthy. No CLA was found in duck fat. More research works need to be done to extend shelf life of duck fat products when processing in industry.

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