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Determination of the Specific Heat Capacity of Vegetable Oil and Sunflower Oils by Using Calorimetry Temperature between 27 and 35°C (at Low Temperature)

Getachew Kuma[1], Berhanu Aymalo[2] and Tamirat Ontoro[3*]

Wolaita Sodo University, college of natural and computational science, department of physics, Wolaita sodo, Ethiopia, Pox 138, Ethiopia

**Corresponding author*

Abstract

The feasibility of using calorimeter was to determine the specific heat capacity of vegetable and sunflower oils. We got the water before we worked for others (oils). We used experimental methods to present in this work. The specific heat capacity of vegetable oil and sunflower are 3.22904 KJ/kg °C and 3.1927KJ/kg °C respectively at low temperature.

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Keywords

Specific heat capacity, Vegetable oil, Sunflower oil, Density, Temperature, AC circuit, Calorimeter.

Introduction

Specific heat capacity is the amount of heat energy required to raise the temperature of a substance per unit of mass. The specific heat capacity of a material is a physical property. It is also an example of an extensive property since its value is proportional to the size of the system being examined. Its SI units is the amount of heat in joules required to raise 1 gram of a substance 1 Kelvin. It may also be expressed as J/kg·K. Specific heat capacity may be reported in the units of calories per gram degree Celsius, too.

Heat capacity is defined as the ratio of the amount of energy transferred to a material and the change in temperature that is produced:

$C=Q / \Delta T$……………………………………1

where C is heat capacity, Q is energy (usually expressed in joules), and ΔT is the change in temperature (usually in degrees Celsius or in Kelvin). Alternatively, the equation may be written:

$Q= mc\Delta T$……………………………….………2

The specific heat c of a substance is the heat capacity per unit mass (Jewett. (2004)). Specific heat capacity determines the heat supplied to (removed from) the body that causes heating (cooling) of 1 kg of substance by 1 K; it is not a characteristic of a particular subject, but the material itself. A substance with a high specific heat capacity effectively possesses a high thermal inertia. Consequently, it will undergo a smaller temperature change for a given amount of heat absorbed or released. Without the huge amount of water in the oceans which cover the major part (about 71 %) of the Earth's surface, the day-night temperature would swing wildly between a high maximum and a low minimum. These temperature variations would make planet Earth inhospitable to life. Not for nothing is the Earth also known as the water planet.

It is better to know the thermal behavior of the edible vegetable oils and sunflower oil, their chemical composition and physical properties for a rigorous control of processes and setting up standards for each specific use (Giese, 1996; Moreira *et al.*, 1999 and Hamm and Hamilton, 2000).

The specific heat capacity (Cp) can be considered as one of the possible physical properties.

The knowledge of the specific heat capacities of the oils and fats are quite useful to determine their behavior during different technological processes.

About 79% of the over 100 million tons of edible oils and fats produced world-wide annually are derived from plant sources and are referred to as vegetable oils According to Hamm and Hamilton 2000. In other way (Moreira *et al.*, 1999) Vegetable oils play important functional and sensory roles in food products, and they act as carrier of fat soluble vitamins A, D, E, and K.

Vegetable oils are mostly used for cooking and frying of foods and snacks. In both applications, the oils are subjected to elevated temperatures in the range of 35 to 180°C.The optimum design of heating and cooling systems for cooking and frying, and the fundamental understanding of cooking and frying processes require that the thermo-physical properties of the major ingredients involved (such as vegetable oil) (Singh and Heldman, 2001) in these processes be known.

Objectives

i. To determine specific heat capacity of vegetable oil, sunflower oil.

ii. To characterize using its density of water and sunflower before and after the experiments.

iii. To show graphically the relationship between specific heat capacity vs. temperature using MATLAB.

Materials and Methods

Methods

Experimental materials

Edible vegetable oil samples, sunflower and water, in addition to calorimeter setup

Analysis

Data analyzing by using graphically (MATLAB) and analytically

Procedure (Steps to determine the specific heat capacity).

1. Measure (100-106)g of water (mw),(100-106) g of vegetable oli (100-106) g of sunflower oil . Then measure the mass the container of calorimeter (mc) and pour mass of oil/water/ into it.
2. Connect the heating coil into the circuit the Dc voltage source , Ammeter and voltmeter
3. With the power supply still off, choose such combination of voltage and resistance of the coil so that the electrical current in the circuit is about 2A (Connect a 26V DC power supply).
4. Before turning the power supply on measure the temperature of oil/water in calorimeter; leave the thermometer in the calorimeter during the whole measurements.
5. Turn off the power supply and at the same begin to measure the time of the heating. Also take note of voltage and current values.
6. After about 3minutes turn the power supply off, quickly stir the oil/water with a stirrer and read the final temperature of the water.

Results and Discussions

The specific heat capacity of Water

The above table 2 shows that the experimental value the specific heat capacity of water was around 4.1225J/kg^{o}c. The truth of the specific heat capacity of water is 4.184 kg^{o}C (this value is truth value).

%error= $\frac{(4.1225-4.184)}{4.184}$ *100=1.50 % (error) which is acceptable because less than (5-10) %. We had confidence to continue to the next two liquids (water as a standard). Most university instructors will be accepting a less than 5% error. But this is only a guideline. When we were observed that the specific heat capacity was an error less, than 5% so it can be acceptable on the range.

The specific heat capacity of vegetable oil

Similarly Table 3 shows that the specific heat capacity of vegetable oil is 3.229K J/kg oc. We have not done this before, but our believes this will be the first. As shown in table 3, this average value is our experimental value. Between theses range the specific heat capacity of vegetable oil was 3.229KJ/kgºC. The specific heat capacity of vegetable oil at 25 degree Celsius is 2.0 J/g C. When measured at a different temperature, the specific heat capacity will vary https://www.reference.com/food/specific-heat-capacity-vegetable-oil-e804b0dee02518ed

Table.1 Data for water

Measurement no	temp(ºC)	current(A)	Voltage(V)	time(s)
1	27	2.51	26.1	180
2	27	2.47	26.1	210
3	27.5	2.47	26.1	200
4	27	2.41	26.1	190
5	28	2.45	26.1	185
6	29	2.44	26.1	195

Table.1 Data for sunflower oil

Measurement no	temp(ºC)	current(A)	Voltage(V)	time(s)
1	27	2.42	26.1	180
2	35	2.44	26.1	210
3	33	2.45	26.1	200
4	32	2.4	26.1	190
5	30	2.47	26.1	185
6	31	2.43	26.1	195

Table.2 Sample of vegetable oil

Measurement no	temp(ºC)	current(A)	Voltage(V)	time(s)
1	29	2.5	26	180
2	30.5	2.53	26.1	210
3	31	2.46	26.1	200
4	32	2.54	26.2	190
5	33	2.56	26.2	185
6	35	2.55	26.2	195

Table.3 The specific heat capacity of water

Measure ment no	Temp (°C)	Current (A)	Voltage (V)	Time (s)	Mw (kg)	ΔT	v*I*ΔT	MC*cc* ΔT	v*I*ΔT-MC*cc*ΔT	m*ΔT	v*I*ΔT-MC*cc*ΔT /m*ΔT
1	27	2.51	26.1	180	0.102	0	11792	0	11791.98	2.754	4281.8
2	27	2.47	26.1	210	0.105	0.5	13538	147.84	13390.23	2.835	4723.2
3	27.5	2.47	26.1	200	0.103	-0.5	12893	-147.84	13041.24	2.833	4604.1
4	27	2.41	26.1	190	0.106	1	11951	295.68	11655.51	2.862	4072.5
5	28	2.45	26.1	185	0.101	1	11830	295.68	11534.145	2.828	4078.6
6	29	2.44	26.1	195	0.102	-29	12418	-8574.7	20993.1	2.958	7097.1
Average of $C_{w=}$ $\frac{v*I*\Delta T - m_c*c_c*\Delta T}{m_w*\Delta T}$ =4122.5J/g°c(4.184J/kg°C)											4122.5

Table.4 The specific heat capacity of vegetable oil

m/ no	Temp (oC)	current (A)	Voltage (V)	Time (s)	m_{vo}	ΔT	v*I*ΔT	MC*cc* ΔT	v*I*t-MC*cc*ΔT	m*ΔT	v*I*ΔT-MC*cc*ΔT /m*ΔT
1	29	2.5	26	180	0.102	5	11700	147.84	11552.1	2.958	3905.4
2	34	2.53	26.1	210	0.105	0.5	13866.93	47.04	13819.8	3.57	3871.1
3	33.5	2.46	26.1	200	0.103	-2.5	12841.2	-230.72	13071.9	3.450	3788.4
4	31	2.54	26.2	190	0.106	-2.5	12644.12	-237.44	12881.5	3.286	3920.1
5	30	2.56	26.2	185	0.101	3	12408.32	271.48	12136.8	3.03	4005.6
6	33	2.55	26.2	195	0.102	3	13027.95	274.17	12753.7	3.366	3789.0
											3,229.04

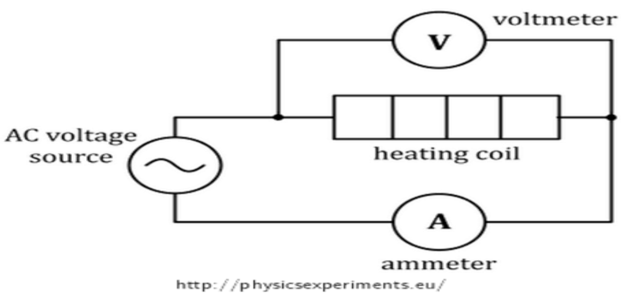
Table.5 The specific heat capacity of Sunflower oil

m/t no	Tem p (oC)	current (A)	Voltage(V)	time(s)	msf	ΔT	v*I*ΔT	MC*cc*ΔT	v*I*t-MC*cc*ΔT	m*ΔT	v*I*ΔT-MC*cc*ΔT/m*ΔT
1	27	2.42	26.1	180	0.102	8	11369.16	2365.44	9003.72	2.754	3269.324619
2	35	2.44	26.1	210	0.105	-2	13373.64	-59.136	13432.78	3.675	3655.177143
3	33	2.45	26.1	200	0.103	-1	12789	-29.568	12818.57	3.399	3771.276258
4	32	2.4	26.1	190	0.106	-2	11901.6	-59.136	11960.74	3.392	3526.160377
5	30	2.47	26.1	185	0.101	1	11926.4	29.568	11896.83	3.03	3926.345545
6	31	2.43	26.1	195	0.102	-31	12367.49	-916.608	13284.09	3.162	4201.167932
Cav=3192.8											3192.778839

Table.6 Comparison densities before and after experiment

	before			after			before			after			before			after		
no	M (g)	Vw	Mw (g)	w(ml)	ρ w (g/ml) =mw/ vw	ρ w (g/ml)	Mso (g)	Vso (ml)	Mso (g)	Vso (ml)	ρ so (g/ml)	ρ so (g/ml)	Mvo (g)	V Vo (ml)	MVo (g)	V vo (ml)	ρ vo (g/ml)	ρ Vo (g/ml)
1	102	100	103	100.5	1.02	1.025	35	40	35	41	0.875	0.854	44	50	44	51	0.88	0.863
2	105	100	104	100.5	1.05	1.035	37	40	37	41	0.925	0.902	46	50	44	51	0.92	0.863
3	103	100	103	100.5	1.03	1.025	37	40	37	41	0.925	0.902	46	50	45	51	0.92	0.882
4	106	100	106	100.5	1.06	1.055	36	40	36	41	0.9	0.878	45	50	45	51	0.9	0.882
5	101	100	101	100.5	1.01	1.005	37	40	37	41	0.925	0.902	45	50	44	51	0.9	0.863
6	102	100	101	100.5	1.02	1.005	38	40	38	41	0.95	0.927	45	50	46	51	0.9	0.902
					1.03	1.02					0.92	0.9					0.90	0.88

Fig.1 Calorimeter set up



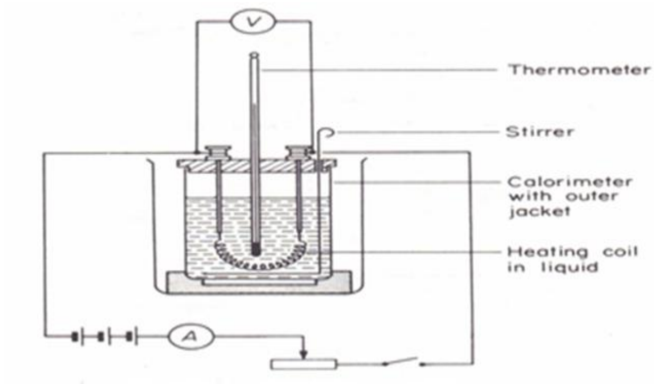


Fig.1 The specific heat capacity of water

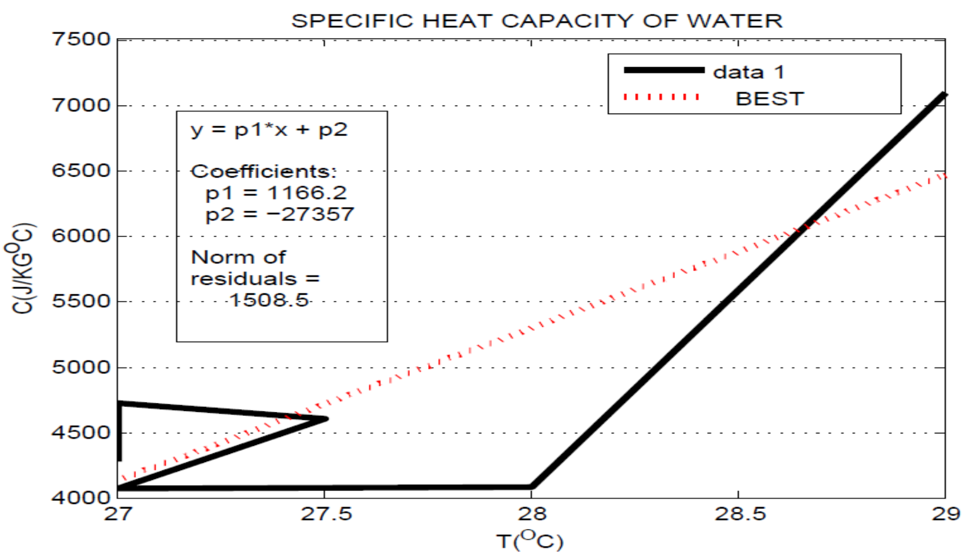


Fig.2 The specific heat capacity of vegetable oil

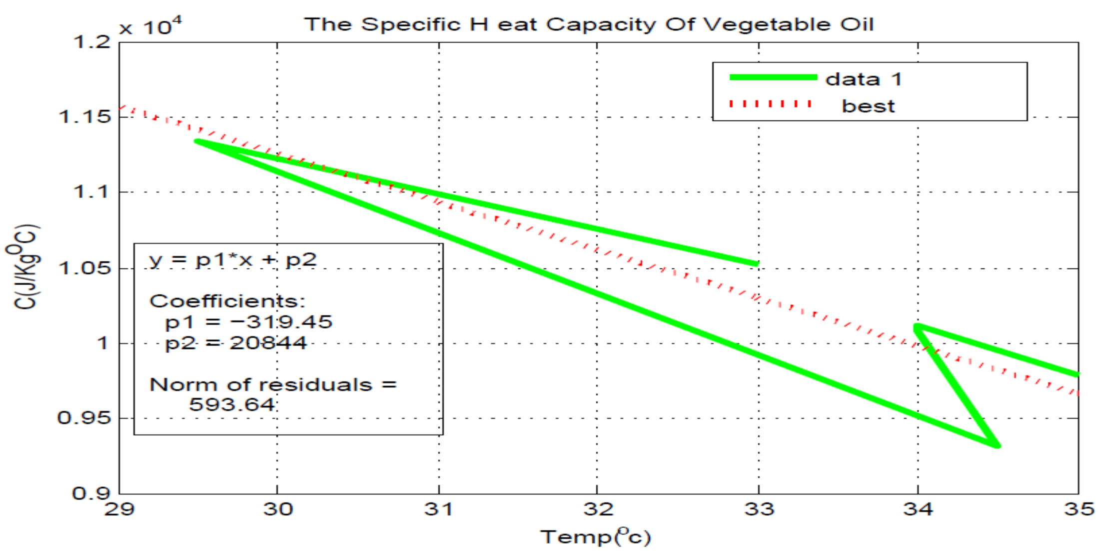


Fig.3 The specific heat capacity of sunflower oil

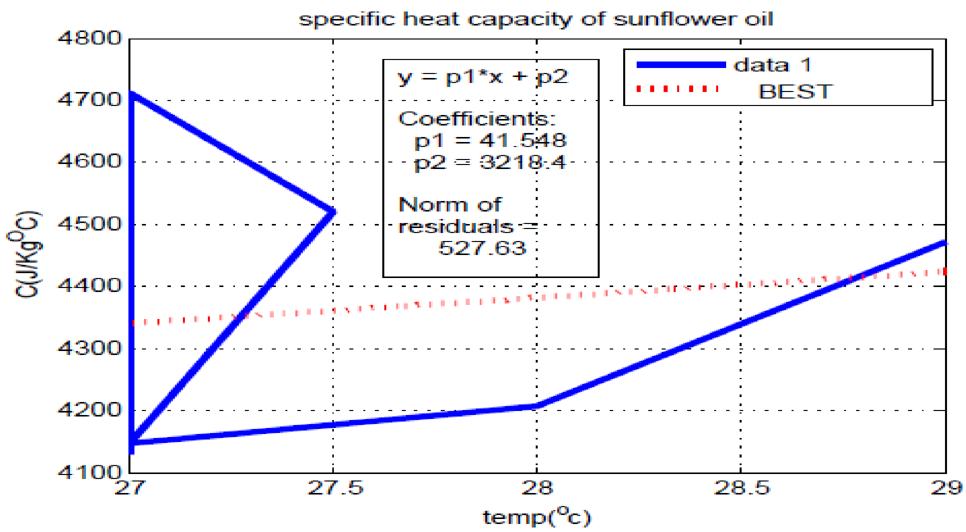


Photo.1 Sunflower (Egypt product)

The specific heat capacity of sunflower oil

Table 3 shown that the specific heat capacity of sunflower is 3.1927KJ/kg ^{o}c .We have not done this before, but we believe that this will be the first. As shown in table 3 this average value is our experimental value. Specific heat was studied in the range 35^{0}C to 120^{0}C for sunflower oil specific heat varies from 2.244 to 2.491K J/kg ^{o}C (Bockisch, 1998). When we compared our result with them they did their experiment between 35 to 120^{0}c but ours was 27 up to 35^{o}c. But between theses range the specific heat capacity of sunflower was 3.1927 KJ/kg K.

Density of water, sunflower oil and vegetable oils before and after experiment

Density is one of the characteristics or properties to determine some liquid. We know that the density of water is 1g/cm^{3}. Before the experiment but after the experiment we had 1.02g/cm^{3}. We have the value 0.90g/cm^{3} for vegetable oil and after experiment we had around 0.88g /cm^{3}.

Density of sunflower oil before and after the experiment is 0.92/cm^{3} and 0.9 /cm^{3} respectively

Graphically

The specific heat capacity of water

Fig 2 was the summary of the specific heat capacity obtained for different temperature. And shows if data point (solid line) is far from the best fitting line (broken line) then the error is maximum. Again this graph shows the best fitting line approaches (close) the data line around 27^{o}C which is 4200J/kg^{o}c (4.2K J/kg^{o}c). At constant temperature the specific heat capacity increases i.e. at the temperate 28.75^{o}C the specific heat capacity in incredible high.

The specific heat capacity of vegetable oil

Fig 3 shows the specific heat capacity of vegetable oil. The broken line indicates the best line. The solid one is experimental data so this line far from the best fitting line (broken line) around the temperature 34.5^{o}C then the error is Maximum. Again this graph shows the best fittig line intersect the data line around 34.25^{o}C. At constant temperature the specific heat capacity increases i.e. at the temperate 30.75^{o}C the specific heat capacity in incredible high

The specific heat capacity of sunflower oil

Fig 4 is the specific heat capacity obtained for different temperature. And shows if data point (solid line) is far from the best fitting line (broken line) then the error is maximum. Shows the best fitting line intersect the data line around 27.5^{o}C which is 4350J/kg^{o}C (4.35K J/kg^{o}C). At constant temperature the specific heat capacity increases i.e. at the temperate 28^{o}C the specific heat capacity increasing.

In conclusion, the study shows that, the specific heat capacity of water is 4186J/kg$^{\mathbf{o}}$C (4.186KJ/g^{o}C). Using this as a slandered we are determined the two edible oils (vegetable and sunflower oil). The specific heat capacities of vegetable and sunflower oil are 3,229.04 J/kg^{o}C and 3192.7 J/kg^{o}C respectively. Not all edible oils are suitable for cooking. Knowing the specific heat capacity of the oils are very important because it is better to know the thermal behavior of the edible vegetable oils and sunflower oil, their chemical composition and physical properties for a rigorous control of processes and setting up standards for each specific use

Density is one of the characteristics of fluids, so the density is changed before and after the experiments this because little change of volume while raising the temperature.

Generally we have input to the physics department

According to our Manual the error was 150% so try to change this as much as possible.
No AC circuit power supply tries to buy it.
The experimental room is not conducive to perform the experiment (not clean, material arrangements were not good).

Acknowledgment

I would to thank all participants and my wife Wogayehu Abera to finshed this work.

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