

MIXING REOMMETRY DATA FOR THE VISCOUS EMULSION FLOW CURVE OF CABALLA (*Scomber Scombrus*)

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Abstract - This contribution contains data associated with the research article entitled "Rheometrical characterization of Caballa emulsion (*Scomber Scombrus*)" (Jaimes et al., 2012) Caballa is a fish where most of its emulsions contain emulsifiers, such as proteins or low molecular weight surfactants, substances with surface activity that have the property of being absorbed at the interface forming a layer surrounding the drop, therefore, the tension surface between both fluids are significantly reduced, which facilitates the formation of the emulsion and prolongs it. Here the rheological characterization data for a *Scomber Scombrus* emulsion are presented are exposed by a mixture rheometry showing the energy consumption for the emulsion during mixing with the anchor stirrer and the helical ribbon type stirrer.

Palabras Clave: Rheometry, Emulsions, Fluids, Food.

MEZCLA DE DATOS DE REOMETRÍA PARA LA CURVA DE FLUJO DE EMULSIÓN VISCOSA DE CABALLA (*Scomber Scombrus*)

Resumen - Esta contribución contiene datos asociados con el artículo de investigación titulado "Caracterización reométrica de la emulsión de Caballa (*Scomber Scombrus*)" (Jaimes et al., 2012) Caballa es un pescado donde la mayoría de sus emulsiones contienen emulsionantes, como proteínas o tensioactivos de bajo peso molecular, sustancias con actividad superficial que tienen la propiedad de ser absorbidas en la interfaz formando una capa que envuelve la gota, por lo tanto, la superficie de tensión entre ambos fluidos se reducen significativamente, lo que facilita la formación de la emulsión y la prolonga. Aquí se presentan los datos de caracterización reológica de una emulsión *Scomber Scombrus* que se exponen mediante una reometría de mezcla que muestra el consumo de energía de la emulsión durante la mezcla con el agitador de ancla y el agitador de tipo cinta helicoidal.

Palabras Clave: Reometria, Emulsiones, Fluidos, Alimentos.

Specifications Table

Subject area	Complex fluid engineering
More specific subject area	Rheology, microstructure and processing of food products
Type of data	Table
How data was acquired	Characterization by mixing rheometry. A controlled deformation rotational rheometer ARES (rheometrics scientific, UK) with a propeller agitator with a diameter of 0.0385 m was used. and an anchor agitator with a diameter of 0.0385 m. Controlled effort rheometer (RheoScope1 Haake, Germany), using cone sensors of 35 and 60°, the effort imposed was from 0 to 350 Pa with a time 600 seconds.
Data format	Analyzed
Experimental factors	To prepare the emulsion, Caballa proteins solubilized in a 0.1 mM AcH solution, sunflower oil and distilled water were used. The oil is added to the aqueous phase, which contains the emulsifier, for 2 min. It was mixed for 5 min, using an Ultra-Turrax T-50 homogenizer (Ika, Germany), equipped with a rotor-stator turbine S50N-G45F, at agitation speeds of 7,600, 6,500 a 5,200 rpm.
Experimental features	The following formula was used: $P = 2N (T-T_0)$ where N is Number of revolutions per unit of time (S-1), calculated from the number of turns measured in the rheometer. (T-T ₀) represents the value Torque measured at the rheometer at experimental shear rates and calculated by the mathematical relationship $C: (Tg) / 10^5$, where C is the torque value (N / m), T the calculated value from the rheometer and g the gravity.
Data source location	Huelva (Spain)
Data accessibility	Rheometrical characterization of Caballa emulsion (<i>Scomber Scombrus</i>). Available at: http://www.redalyc.org/articulo.oa?id=169823914128

Value of the Data

- These data allow the characterization of rheological emulsions with Caballa proteins, by means of rheometry of mixing.
- The data makes it possible to obtain the viscosity values from measurements of the torque.
- Access to viscous flow behavior in a range of shear speeds comparable to that obtained through rotational rheometry techniques.

Data

Data on the rheological characterization of emulsion from *Scomber scombrus* are presented by mixing rheometry. The emulsion was prepared using the Caballa proteins solubilized in a solution of 0.1 mM AcH, sunflower oil and distilled water. The characterization of the power consumption for the emulsion during the mixing with anchor stirrer and helical tape type is maintained.

Experimental Design, Materials, and Methods

For the preparation of calibration fluids, CMC solutions were used (3%), Gomar Guar (1%), Gum Xantán (1%), Carbopol (1%) and Glycerin, to which the behavior in viscous flow in steady state. Glycerin as a

Mixing reometry data for the viscous emulsion flow curve of Caballa (*Scomber Scombrus*) Newtonian fluid and the aforementioned solutions were measured for the equipment calibration (ARES rheometrics controlled rotational rheometer, UK) using concentric cylinders as sensors, in addition a helical ribbon stirrer whose diameter was 0.0380 m. And an anchor agitator with a diameter of 0.0385 m (Franco et al., 1998).

To calculate the power consumption the following formula was used: $P = 2N (T-T_0)$ where N is Number of revolutions per unit of time (S-1), calculated from the number of turns measured in the rheometer, the expression (T-T₀) represents the torque value measured in the rheometer at experimental shear rates and calculated by the mathematical relationship C: $(T \cdot g) / 10^{-5}$, where C is the torque value (N/m), T the value calculated from the rheometer (g · cm) and g the severity (Velez et al., 2003).

The viscosity values for the fluids were measured in Rheometers (RheoScope1 Haake, Germany) at a temperature of 25 ° C for non-Newtonian fluids, while for the test sample it was calculated by the equation (Muñoz et al., 2001).

As for the preparation of emulsions, there are products used and formulation of emulsions: To prepare the emulsions studied, the Caballa proteins solubilized in a solution of 0.1 mM AcH, sunflower oil (Ybarra SA, Seville) have been used and distilled water. And preparation of the experimental emulsions: The emulsions were prepared on a laboratory scale. Glass vessels 6 cm in diameter and 14.5 in height were used. The total amount of product obtained was 150 g. Starting with fresh protein, thawed protein or lyophilized protein. The methodology followed for the emulsification process was as follows. The oil was slowly added to the aqueous phase, which contains the emulsifier, for 2 minutes. It has been emulsified for a total of 5 minutes, using an Ultra-Turrax T-50 homogenizer (Ika, Germany), equipped with a rotor-stator turbine S50N-G45F. It has been processed at agitation speeds of 7,600, 6,500 or 5,200 rpm. The emulsions were stored at 4 ° C in a refrigerator (Jansen et al., 2001).

The rheological measurements were carried out by steady-state viscous flow tests at room temperature (25°C). The measurement was made in a controlled effort equipment (RheoScope 1 Haake, Germany), using sensor sensors of 35 and 60°, the imposed effort was 0 - 350 Pa with a time 600 seconds. These tests were carried out in duplicate (Mentreddi & Cooley, 2007).

Finally, the measurements of the density of the emulsion and the substances used during the calibration of the rheometer (ARES Rheometrics Scientific, UK), were measured by pycnometry, using a calibrated pycnometer with a volume of 25 cm³ (Cortada et al., 2017; Pakzad et al., 2013).

Experimental characterization data of power consumption during mixing (Anchor-type agitator), depending on the agitation speed

The equipment used to carry out this characterization was ARES I, where the following data shown in Table 1 was obtained.

Table 1: Power Consumption (J/s) with anchor type agitator

N(1/s)	Glycerin	Gum Xanthan	Gum Guar	CMC	Carbopol	E. Caballa
0,1667	0,00031359	0,000789093	0,001378257	0,002831664	0,002170921	0,000826083
0,3333	0,00124275	0,001930176	0,00358874	0,007444915	0,005174766	0,004040098
0,5000	0,00278104	0,003233864	0,006206515	0,012744075	0,008746009	0,010154333
0,6667	0,00491659	0,004702652	0,009090165	0,01836281	0,013248337	0,019689421
0,8333	0,00768591	0,006276398	0,012193372	0,024573618	0,018156551	0,032845169
1,0000	0,01096755	0,007879448	0,015489613	0,031308884	0,024797353	0,049482933
1,1667	0,01492771	0,009573553	0,018943916	0,038674285	0,031431481	0,070144236
1,3333	0,01942167	0,011415001	0,022548828	0,046540077	0,038669356	0,095579219
1,5000	0,02453445	0,013342924	0,026245698	0,054913375	0,046985966	0,125690344
1,6667	0,03029946	0,015331366	0,03014318	0,064025996	0,052828858	0,160471507

Determination of the Metzner-Otto constant (Anchor-type agitator)

For the determination of the constant K_s by means of the Metzner - Otto method, we must start from the value of the torque C , obtained by means of a controlled deformation rheometer, through which we can find the power value (P), to later find the power number (N_p).

With the value of the power (P), we cleared the ec.1, the η_{eff} that by looking at Figure 1 of the flow curve and depending on the curve we can obtain the value of shear velocity, which represents it against N , gives the value of the slope that corresponds to K_s .

$$\eta \cdot P_{nN} = \mu_a \cdot P_N \quad (1)$$

Now we represent the values that have been obtained to find the different values of K_s , for each of the non-Newtonian fluids.

Table 2: Guar gum calibration fluid data to calculate the K_s values

Gum Guar				
N(1/S)	P	N_p	Apparent viscosity	K_s
0,1667	0,001378257	3517384,39	4,18419782	28,90764293
0,3333	0,00358874	1144831,56	2,74913642	26,47462575
0,5000	0,006206515	586642,716	2,12460514	25,5860822
0,6667	0,009090165	362477,806	1,76012918	25,16731793
0,8333	0,012193372	248945,002	1,51030776	25,10256604
1,0000	0,015489613	183010,673	1,34452186	24,73431936
1,1667	0,018943916	140950,057	1,20812981	24,73376096
1,3333	0,022548828	112394,127	1,10528537	24,6022179
1,5000	0,026245698	91879,8349	1,01840101	24,60676903
1,6667	0,03014318	76926,9792	0,94708986	24,5881567

Mixing reometry data for the viscous emulsion flow curve of Caballa (*Scomber Scombrus*)
 Table 3: Calibration fluid data Xantan rubber to calculate the K_S values

Rubber Xantan				
N(1/S)	P	Np	Apparent viscosity	Ks
0,1667	0,000789093	2018506,432	2,395576459	30,58286597
0,3333	0,001930176	617175,955	1,478601748	27,95095896
0,5000	0,003233864	306379,7735	1,107011566	26,75649825
0,6667	0,004702652	187959,8062	0,910574811	25,61746761
0,8333	0,006276398	128440,6673	0,777413569	24,97212943
1,0000	0,007879448	93313,42551	0,68394803	24,42365172
1,1667	0,009573553	71397,18816	0,61054401	24,12661915
1,3333	0,011415001	57030,61664	0,559533884	23,54332246
1,5000	0,013342924	46819,37009	0,51773998	23,05996212
1,6667	0,015331366	39217,77252	0,481706993	22,71234824

Table 4: CMC calibration fluid data to calculate the K_S values

CMC				
N(1/S)	P	Np	Apparent viscosity	Ks
0,1667	0,002831664	7150731,82	8,59654074	35,8984497
0,3333	0,007444915	2350057,53	5,70314019	37,34885276
0,5000	0,012744075	1191937,01	4,36253282	40,17899907
0,6667	0,01836281	724549,267	3,55559184	43,41898573
0,8333	0,024573618	496441,218	3,04376229	45,84663489
1,0000	0,031308884	366034,972	2,71765853	46,77476927
1,1667	0,038674285	284732,419	2,46641482	47,67545039
1,3333	0,046540077	229543,966	2,28127448	47,95326451
1,5000	0,054913375	190221,393	2,13078107	48,14951608
1,6667	0,064025996	161683,273	2,01167796	48,02222119

Table 5: Carbopol calibration fluid data to calculate the K_S values

Carbopol				
N(1/S)	P	Np	Apparent viscosity	Ks
0,1667	0,002170921	6159587,16	6,59061577	194,095822
0,3333	0,005174766	1835305,26	3,964103793	189,446889
0,5000	0,008746009	919080,957	2,99392092	182,724646
0,6667	0,013248337	587339,199	2,565276128	167,940728
0,8333	0,018156551	412126,868	2,248925048	159,75535
1,0000	0,024797353	325731,057	2,152447802	141,035971
1,1667	0,031431481	260002,979	2,004512088	132,761609
1,3333	0,038669356	214291,318	1,895472067	125,038221
1,5000	0,046985966	182872,427	1,823177084	116,980109
1,6667	0,052828858	149892,124	1,65986716	119,118774

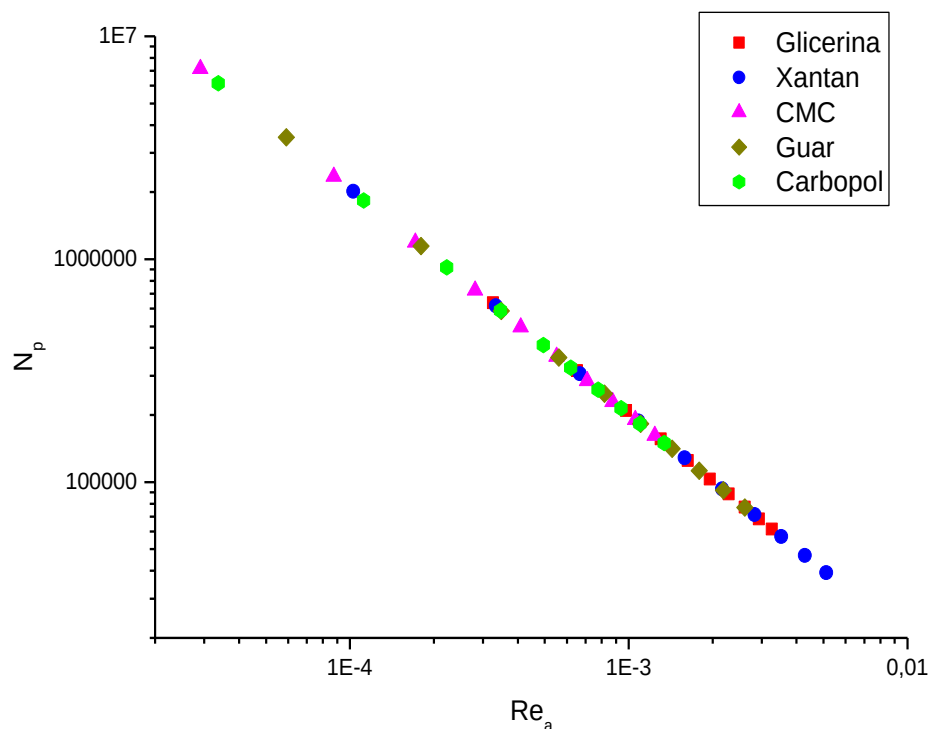


Figure 1: Variation of the power number number as a function of the apparent Reynolds number for an anchor agitator

Experimental characterization of the power consumption during mixing (Helical ribbon type stirrer), depending on the stirring speed. The equipment used to perform this characterization has been the ARES I, in which the following data have been obtained.

Table 6: Power Consumption (J / s) with Helical Belt Type Agitator

N(1/s)	Gliceryn	Rubber Xantan	Gum Guar	CMC	Carbopol	E. Caballa
0,1667	1,44E-05	0,002279144	9,54E-07	4,59E-05	0,006596856	0,003206326
0,3333	6,41E-05	0,003671355	8,36E-06	1,98E-04	0,004749474	0,001488934
0,5000	1,93E-04	0,006077819	1,62E-05	5,31E-04	0,00829474	0,005168194
0,6667	3,87E-04	0,008718594	3,12E-05	1,01E-03	0,013064338	0,007565726
0,8333	6,39E-04	0,011676542	5,05E-05	1,56E-03	0,017377225	0,010244184
1,0000	1,53E-03	0,015853894	1,06E-04	3,10E-03	0,025027146	0,013589844
1,1667	2,68E-03	0,019968201	1,78E-04	4,63E-03	0,034038373	0,016265222
1,3333	4,09E-03	0,02380651	2,57E-04	6,11E-03	0,041771875	0,019949103
1,5000	5,70E-03	0,027863524	3,72E-04	7,57E-03	0,050483692	0,022405777
1,6667	7,59E-03	0,031721341	4,75E-04	9,10E-03	0,058586013	0,025371734

Determination of the Metzner-Otto constant (Helical Belt Stirrer)

For the determination of the constant K_s by means of the Metzner - Otto method we must start from the torque value C given by our equipment, by means of which we can find the value of P , to later find the value of N_p , with the value of P we can clear, in ec. 1, the η_{eff} that by looking at Figure 2 of the flow curve and depending on the curve we can obtain the value of shear velocity, representing it versus N , gives the value of the slope that corresponds to K_s .

$$\eta \cdot P_{nN} = \mu_a \cdot P_N \quad (1)$$

Now we represent the values that have been obtained to find the different values of K_s , for each of the non-Newtonian fluids.

Table 7: Guar gum calibration fluid data to calculate the K_s values

Goma Guar				
N(1/S)	P	N_p	Apparent viscosity	K_s
0,1667	9,53879E-07	2434,34832	0,06291137	12236,16627
0,3333	8,35594E-06	2665,59831	0,12402946	2300,581808
0,5000	1,6157E-05	1527,16706	0,07981443	2894,6861
0,6667	3,11554E-05	1242,34634	0,07657042	2304,775926
0,8333	5,0532E-05	1031,68154	0,07532795	1887,801252
1,0000	0,00010552	1246,72641	0,06546538	1925,711582
1,1667	0,000178077	1324,95802	0,06323916	1734,982975
1,3333	0,00025713	1281,66048	0,05989211	1641,847445
1,5000	0,000372441	1303,82517	0,06223665	1380,863109
1,6667	0,000474917	1212,01198	0,0595735	1323,612

Table 8: Calibration fluid data Xantan rubber to calculate the K_s values

Rubber Xantan				
N(1/S)	P	N_p	Apparent viscosity	K_s
0,1667	0,002279144	5830069,963	150,3168587	0,173173372
0,3333	0,003671355	1173919,795	54,49492828	0,30779788
0,5000	0,006077819	575819,1069	30,02399501	0,432298644
0,6667	0,008718594	348472,5559	21,42764624	0,494268179
0,8333	0,011676542	238949,608	17,40621573	0,51273182
1,0000	0,015853894	187751,8739	9,835860541	0,872115538
1,1667	0,019968201	148917,9028	7,091178276	1,125238757
1,3333	0,02380651	118939,9804	5,545133238	1,338938896
1,5000	0,027863524	97771,11996	4,656128131	1,480699958
1,6667	0,031721341	81143,4795	3,979122623	1,621834646

Mixing reometry data for the viscous emulsion flow curve of Caballa (*Scomber Scombrus*)
 Table 9: CMC calibration fluid data to calculate the K_S values

CMC				
N(1/S)	P	Np	Apparent viscosity	Ks
0,1667	4,59176E-05	115954,59	3,02841371	231,311941
0,3333	0,000198372	62617,9417	2,94448796	121,6083658
0,5000	0,00053065	49631,0305	2,62137429	99,77377026
0,6667	0,001009284	39823,7378	2,48051149	82,58724765
0,8333	0,00155896	31494,4282	2,32394103	74,22795834
1,0000	0,003103997	36289,1078	1,92574026	86,52656689
1,1667	0,004628077	34073,3817	1,6435392	98,42180601
1,3333	0,006108437	30127,9039	1,42280825	111,4154092
1,5000	0,007573848	26236,0096	1,26562618	122,0618943
1,6667	0,009098708	22976,7442	1,14134127	132,1244525

Table 10: Carbopol calibration fluid data to calculate the K_S values

Carbopol				
N(1/S)	P	Np	Apparent viscosity	Ks
0,1667	0,006596856	18717360,6	435,0839095	0,782967583
0,3333	0,004749474	1684469,23	70,4977459	4,29250569
0,5000	0,00829474	871658,931	40,97542637	5,843697308
0,6667	0,013064338	579181,963	32,108159	6,04090085
0,8333	0,017377225	394437,319	25,90422046	6,41035857
1,0000	0,025027146	328749,558	15,52700702	10,47558817
1,1667	0,034038373	281567,334	12,0878274	12,48273973
1,3333	0,041771875	231484,331	9,729717084	14,53210558
1,5000	0,050483692	196485,803	8,43606659	15,5848497
1,6667	0,058586013	166226,99	7,349025009	16,81800338

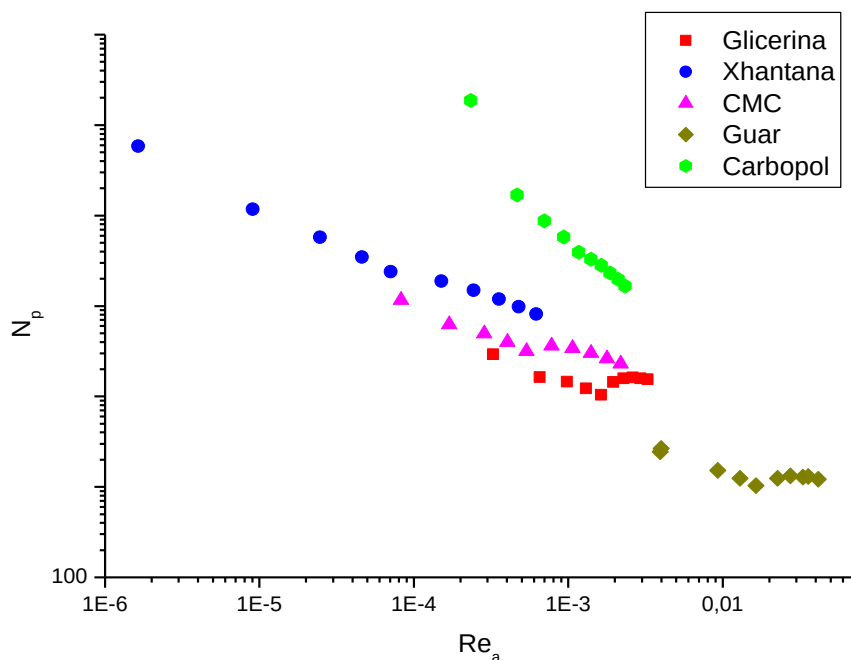


Figure 2: Variation of the power number as a function of the apparent Reynolds number for a helical ribbon type stirrer

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