

Compound-specific stable isotope analysis and radiocarbon dating of Irish bog butters reveal four millennia of dairy surplus and deposition

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Supplementary Table S1:

Lipid composition and $\delta^{13}\text{C}$ values of analysed Irish bog butters. Key to major lipid components: FFA C_x are straight chain free fatty acids of carbon length x , OHFA C_x are hydroxy fatty acids of carbon length x ; DAG C_x are diacylglycerols of carbon length x ; TAG C_x are triacylglycerols of carbon length x .

Code	Major lipid components	$\delta^{13}\text{C}_{16:0}$ fatty acid (‰)	$\delta^{13}\text{C}_{18:0}$ fatty acid (‰)	Assignment
IB1	FFA($\text{C}_{12}\text{-C}_{20}$); OHFA(C_{18}); TAG($\text{C}_{44}\text{-C}_{54}$)	-31.84	-35.24	Possible dairy fat
IB2	FFA($\text{C}_{12}\text{-C}_{18}$); OHFA(C_{18}); TAG($\text{C}_{44}\text{-C}_{54}$)	-30.95	-36.16	Dairy fat
IB3	FFA($\text{C}_{12}\text{-C}_{20}$); OHFA(C_{18}); TAG($\text{C}_{44}\text{-C}_{54}$)	-29.70	-34.53	Dairy fat
IB4	FFA($\text{C}_{12}\text{-C}_{18}$); OHFA(C_{18}); TAG($\text{C}_{42}\text{-C}_{54}$)	-28.89	-33.60	Dairy fat
IB5	FFA($\text{C}_{12}\text{-C}_{18}$); OHFA(C_{18}); TAG($\text{C}_{42}\text{-C}_{54}$)	-29.17	-33.48	Dairy fat
IB6	FFA($\text{C}_{12}\text{-C}_{20}$); OHFA(C_{18}); DAG($\text{C}_{32}\text{-C}_{36}$); TAG($\text{C}_{42}\text{-C}_{54}$)	-29.53	-35.04	Dairy fat
IB7	FFA($\text{C}_{12}\text{-C}_{18}$)	-28.92	-33.70	Dairy fat
IB8	FFA($\text{C}_{12}\text{-C}_{18}$)	-30.53	-33.66	Possible dairy fat
IB9	FFA($\text{C}_{12}\text{-C}_{18}$)	-28.03	-33.79	Dairy fat
IB10	FFA($\text{C}_{12}\text{-C}_{18}$); DAG($\text{C}_{32}\text{-C}_{36}$); TAG($\text{C}_{44}\text{-C}_{54}$)	-28.34	-33.77	Dairy fat
IB11	FFA($\text{C}_{12}\text{-C}_{18}$); DAG($\text{C}_{32}\text{-C}_{36}$); TAG($\text{C}_{44}\text{-C}_{54}$)	-29.59	-33.33	Dairy fat
IB12	FFA($\text{C}_{12}\text{-C}_{18}$)	-29.28	-34.30	Dairy fat
IB13	FFA($\text{C}_{14}\text{-C}_{20}$); DAG($\text{C}_{30}\text{-C}_{36}$); TAG($\text{C}_{42}\text{-C}_{54}$)	-29.01	-33.72	Dairy fat
IB14	FFA($\text{C}_{14}\text{-C}_{18}$)	-29.88	-34.55	Dairy fat
IB15	FFA($\text{C}_{12}\text{-C}_{18}$)	-28.39	-34.01	Dairy fat
IB16	FFA($\text{C}_{12}\text{-C}_{18}$)	-28.85	-33.89	Dairy fat
IB17	FFA($\text{C}_{12}\text{-C}_{18}$)	-29.27	-33.10	Dairy fat
IB18	FFA($\text{C}_{12}\text{-C}_{18}$)	-30.21	-34.01	Dairy fat
IB19	FFA($\text{C}_{14}\text{-C}_{18}$); DAG($\text{C}_{30}\text{-C}_{36}$); TAG($\text{C}_{42}\text{-C}_{54}$)	-28.37	-32.76	Dairy fat
IB20	FFA($\text{C}_{14}\text{-C}_{18}$); DAG($\text{C}_{32}\text{-C}_{36}$); TAG($\text{C}_{42}\text{-C}_{54}$)	-27.78	-33.34	Dairy fat

IB21a	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-32.29	-35.21	Possible dairy fat
IB21b	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-32.01	-35.09	Possible dairy fat
IB22tp	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈); TAG(C ₄₄ -C ₅₄)	-28.10	-34.00	Dairy fat
IB22bm	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈); TAG(C ₄₄ -C ₅₄)	-28.28	-33.96	Dairy fat
IB23	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈); TAG(C ₄₄ -C ₅₄)	-28.49	-34.97	Probable dairy fat
IB24	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-28.92	-34.45	Dairy fat
IB25	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-29.46	-35.16	Dairy fat
IB26	FFA(C ₁₀ -C ₁₈); OHFA(C ₁₈); DAG(C ₃₂ -C ₃₆); TAG(C ₄₄ -C ₅₄)	-29.33	-34.53	Dairy fat
IB27	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-29.68	-33.47	Dairy fat
IB28	FFA(C ₁₂ -C ₁₈)	-32.34	-36.53	Dairy fat
IB29	FFA(C ₁₂ -C ₂₀); OHFA(C ₁₈); DAG(C ₃₀ -C ₃₆); TAG(C ₄₂ -C ₅₄)	-28.67	-34.54	Dairy fat
IB30	FFA(C ₁₂ -C ₂₀); OHFA(C ₁₈); TAG(C ₄₂ -C ₅₄)	-28.74	-35.13	Probable dairy fat
IB31	FFA(C ₁₂ -C ₁₈); OHFA(C ₁₈)	-28.85	-33.59	Dairy fat
IB32	FFA(C ₁₂ -C ₂₀); OHFA(C ₁₈); TAG(C ₄₂ -C ₅₄)	-27.08	-33.54	Probable dairy fat

Supplementary Table S2: Radiocarbon determinations for Irish and Scottish bog butters. All measurements calibrated using OxCal v4.3.2 and IntCal13 atmospheric curve (1, 2)

Code	Townland	County	¹⁴ C age BP and associated lab code (this study)	Calibrated date range (2σ)	Associated ¹⁴ C determination (years BP)	Calibrated date range (2σ)	NMI accession no.	Container * Earwood 1997 type	Refs
IB1	Esker More	Offaly	3069±16; BRAMS-1087.1	1405-1275 BC			1998:62		
			3050±30; BRAMS-1087.4.1 (C _{16.0} FA)	1410-1220 BC					
			3018±35; BRAMS-1087.4.2 (C _{18.0} FA)	1400-1120 BC					
IB2	Knockdrin	Offaly	3431±34; BRAMS-1088.1	1880-1840, 1830-1640 BC	3368±22; UBA-9617; butter	1740-1715, 1695-1615 BC	1998:63	Bark adhering to surface	
IB3	Ballindown	Offaly	3308±34; BRAMS-1089.1	1670-1500 BC			1986:125		
			3239±28; BRAMS-1089.2.1 (C _{16.0} FA)	1610-1440 BC					
			3319±31; BRAMS-1089.2.2 (C _{18.0} FA)	1690-1510 BC					
IB4	Baunaghra	Laois	1924±34; BRAMS-1090.1	20 BC-AD 170, AD 200-210			1986:40		3
IB5	Colt	Laois	1962±34; BRAMS-1091.1	50 BC-AD 80, AD 100-130	1880±40; GrN-28752; butter	AD 50-240	1986:58		3-5
IB6	Muckanagh	Mayo	1153±25; BRAMS-1092.1	AD 770-970			2013:148.1-.2	Wooden container	
			1201±29; BRAMS-1092.2.1 (C _{16.0} FA)	AD 719-750, 760-900, 930-940					
			1168±34; BRAMS-1092.2.2 (C _{18.0} FA)	AD 770-970					
IB7	Drinaun	Galway	2422±26; BRAMS-1093.1	750-680, 670-640, 550-400 BC			1983:29.1-.2	Bladder?	3
IB8	Shannagurraun	Galway	1027±27; BRAMS-1153.1	AD 900-920, 960-1040			1983:28	Bladder	3
IB9	Newtownbert	Kildare	1923±27; BRAMS-1154.1	AD 20-140			1967:102-103	Wicker basket	3
IB10	Tawnagh Beg	Mayo	814±25; BRAMS-1094.1	AD 1170-1270			1940:44	Mether	3
IB11	Mullagh	Mayo	670±25; BRAMS-1095.1	AD 1270-1320, 1350-1390			1929:1343	Wooden	
IB12	Rosmoylan	Roscommon	1971±15; BRAMS-1096.1	25-10 BC, 5 BC-AD 75	1940±50; GrA-5458; wood	50 BC-AD 180, 190-220	1962:101	Keg *K2	3, 6-7
			1919±37; BRAMS-1096.2.1 (C _{16.0} FA)	AD 0-180, 190-220					
			1967±40; BRAMS-1096.2.2 (C _{18.0} FA)	50 BC-AD 130					
IB13	Corlea	Monaghan	401±25; BRAMS-1097.1	AD 1430-1520, 1590-1620			1965:275	Keg *K5	3, 8
IB14	Tullamore	Kerry	2087±26; BRAMS-1098.1	180-40 BC	2160±35; GrN-28744; butter	360-90 BC	1954:16.1-.2	Tub *T2	3-5

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IB15	Hawkfield	Kildare	1959±26; BRAMS-1099.1	40 BC-AD 90, 100-120			1986:36		3
IB16	Killeenan More	Galway	2035±26; BRAMS-1100.1	160-130 BC, 120 BC-AD 30, 40-50			1939:994	Bowl *FRB	9
IB17	Sheskin	Mayo	945±25; BRAMS-1101.1	AD 1020-1160			1958:11	Bladder with bark	3
IB18	Rosberry	Kildare	2192±15; BRAMS-1102.1	360-270, 260-190 BC	2270±30; GrN-23287; butter 2740±50; GrA-5457; wood	400-350, 310-210 BC 1000-800 BC	1970:32	Alder keg *K1 with alder cord	3, 10-11
			2165±29; BRAMS-1102.3.1 (C _{16.0} FA)	360-150, 140-110 BC					
			2124±29; BRAMS-1102.4.1 (C _{16.0} FA)	350-320, 210-50 BC					
			2199±37; BRAMS-1102.3.2 (C _{18.0} FA)	380-170 BC					
			2211±35; BRAMS-11-2.4.2 (C _{18.0} FA)	380-190 BC					
IB19	Teernakill Bog (Teernakill North or South)	Galway	509±15; BRAMS-1103.1	AD 1410-1440	840±50; GrA-6015; wood	AD 1040-1100, 1110-1280	1925:14	Plunge churn *PC1	3, 9
			536±37; BRAMS-1103.2.1 (C _{16.0} FA)	AD 1310-1360, 1380-1450					
			499±32; BRAMS-1103.3.1 (C _{16.0} FA)	AD 1320-1340, 1390-1450					
			486±38; BRAMS-1103.2.2 (C _{18.0} FA)	AD 1320-1350, 1390-1470					
			476±29; BRAMS-1103.3.2 (C _{18.0} FA)	AD 1410-1460					
IB20	Ards Beg	Donegal	1198±25; BRAMS-1104.1	AD 720-740, 760-900			1987:112	Tub *T	7
IB21a	Ballyguin	Mayo	899±27; BRAMS-1155.1	AD 1040-1210			1943:314-5	Two bladders in wooden container	3
IB21b			912±27; BRAMS-1155.2	AD 1030-1190					
IB22tp	Derrycoogh	Tipperary	1827±27; BRAMS-1156.1	AD 90-100, 120-260	1850±40; GrN-28754; butter	AD 60-260	1991:13	Bark wrappings	3-5
IB22bm			1829±27; BRAMS-1156.2	AD 90-100, 120-250					
IB23	Derryloughan	Mayo	1177±25; BRAMS-1105.1	AD 770-900, 920-950			M1948:4	Wooden	
IB24	Killinagh	Kildare	2173±26; BRAMS-1106.1	360-160 BC			1929:1298	Wooden	
IB25	Glennacowan	Limerick	1813±26; BRAMS-1107.1	AD 120-260, 300-320			1943:54		
IB26	Ardanew	Meath	1865±26; BRAMS-1108.1	AD 70-230			1930:195	Keg *K2	7
IB27	Rosdoagh	Mayo	448±25; BRAMS-1109.1	AD 1420-1470			1968:440A	Hazel stave tub	3, 7, 12
IB28	-----	Leitrim	887±25; BRAMS-1110.1	AD 1040-1100, 1110-1220			2018:29-30	Bark	
IB29	Gowlaune	Mayo	357±25; BRAMS-1111.1	AD 1450-1530, 1550-1640			2018:27-28	Bark	
IB30	Cloncoose	Sligo	2211±26; BRAMS-1112.1	370-200 BC			2007:38	Bark	
IB31	Derragh	Mayo	959±25; BRAMS-1113.1	AD 1020-1160			2007:39		
IB32	Knockmoyle	Mayo	1399±26; BRAMS-1114.1	AD 600-670			1986:39	Keg *K4	3

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	Inchimacteige	Kerry			2090±50; GrN-28742	360-300 BC, 210 BC-AD 30	1941:1118	'Firkin'	4, 5
	Lonart	Kerry			1265±35; GrN-28743	AD 660-780, 790-870	M1948:1	Wooden	4
	Goolamore	Mayo			615±30; GrN-28745	AD 1290-1410	1955:45.1-.2	Mether	4, 5
	Enagh	Cavan			925±30; GrN-28746	AD 1020-1190	1959:747	Bladder	4, 5
	Rathbaun	Sligo			1980±50; GrN-28747	120 BC-AD 130	1967:144	Bladder	4, 5
	Crovehy	Donegal			265±30; GrN-28748	AD 1510-1600, 1610-1670, 1780-1800	1967:212.1-.2	Animal skin?	4, 5
	Canburrin	Kerry			970±30; GrN-28749	AD 1010-1160	1971:1006	Cylindrical bark envelope	4
	Annaghbeg	Kerry			2150±50; GrN-28750	360-50 BC	1975:235	Tub	4
	Corragarrow	Longford			670±25; GrN-28751	AD 1270-1320, 1350-1390	1984:152	Wooden keg	4, 5
	Killoran	Tipperary			1840±35; GrN-28753	AD 70-250	1990:119	Wicker	4, 5
	Inchiboy	Kerry			1205±30; GrN-28755	AD 710-750, 760-900, 930-940	1995:97	Bark	4
	-----	-----			1970±50; GrN-28757	110 BC-AD 140			4, 5
	Clonava	Westmeath			3061±33; UBA-9610	1420-1230 BC	2016:223		
	Drinagh	Offaly			2981±22; UBA-9618	1270-1120 BC	1977:2176	Bark and withies?	
	Morvern	Argyle			1802±35; UB-3185	AD 120-330	NMS ME166	Alder keg	3, 4, 13
	Kyleakin	Skye			1730±35; UB-3186	AD 230-400	NMS ME167	Alder keg	4, 13-14
	High Borve	Lewis			949±20; UB-3737	AD 1025-1155		Two balls wrapped in intestine	3-4, 15

References for Supplementary Table S2

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