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Determination of ether extract digestibility and energy content of specialty lipids with different fatty acid and free fatty acid content, and the effect of lecithin, for nursery pigs[1]

B. J. Kerr*[2] and G. C. Shurson†
*USDA-ARS National Laboratory for Agriculture and the Environment, Ames, IA 50011; †Department of Animal Science, University of Minnesota, St. Paul 55108

ABSTRACT

Various specialty lipids are commercially available and used in nursery pig diets but may have fatty acid profiles and FFA content that affect their caloric value. In each of 2 experiments, 54 barrows (28 d of age) were fed a common diet for 7 d, allotted to dietary treatments, and fed their respective experimental diets for an additional 17 d followed by a 4-d total fecal and urine collection period to determine DE, ME, and ether extract (EE) digestibility of various lipid products or lipid-lecithin combinations. In Exp. 1, 5 sources of specialty lipid products were evaluated. Small differences in DE and apparent total-tract digestibility of EE were observed among these products, with the product containing high FFA derived from animal fat having greatest DE, ME, and apparent total-tract digestibility of EE ($P < 0.05$). In Exp. 2, a refined soybean oil (SO) and a SO containing high FFA content (SO-FFA) were fed with or without a de-oiled soybean-based lecithin (LEC). There was an interaction between lipid source and lecithin where LEC decreased DE, DE as a percentage of GE, and ME when included with SO-FFA, but not when added to SO ($P < 0.01$). When no LEC was added, there was no difference in energy or EE digestibility between SO-FFA and SO. In conclusion, the specialty lipid products evaluated were poorly digested, the addition of LEC to SO or SO-FFA did not improve lipid or energy digestibility, and the presence of high FFA in SO did not negatively affect lipid or energy digestibility.

Key words: digestibility, energy, lipid, nursery pig

INTRODUCTION

Lipid digestion and metabolism is a complex process (Borgstrom and Erlanson, 1973; Brindley, 1984; Kerr et al., 2015), but our understanding of these processes is imperative because lipids provide a concentrated source of energy and EFA, reduce dust, and improve palatability in commercial swine diets (Pettigrew and Moser, 1991; Lin et al., 2013). Most lipids are considered to be highly digestible (Li et al., 1990; Jorgensen and Fernandez, 2000; Mendoza and van Heugten, 2014) but vary in digestibility and subsequent energy value based on fatty acid (**FA**) profile, unsaturated FA–to–SFA ratio (**UFA:SFA**), and FFA content (Powles et al., 1995; Wiseman et al., 1998). In addition, the apparent total-tract digestibility (**ATTD**) of lipids fed to nursery pigs increases with age and is generally greater for more saturated animal fats compared with more unsaturated vegetable oils (Cera et al., 1988a,b, 1989, 1990). Many specialty lipid products are highly variable in FA composition and FFA concentration due to their origin and processing method (Kerr et al., 2015; Shurson et al., 2015). Some of these products are manufactured to be free flowing and solid at room temperature to facilitate ease of handling, are marketed to achieve specific functional purposes, and may be consist of by-products from the food industry. In addition, some specialty lipid products, such as a high FFA product generated from the soybean oil (**SO**) processing or the oleo-chemical industry, may contain high concentrations of FFA due to their method of processing. Emulsifiers such as lecithin, lysolecithin, and carnitine have been used in an attempt to improve lipid and energy digestibility in some of these products, but their results have been variable (Jones et al., 1992; Overland et al., 1993a,b, 1994; Gatlin et al., 2005). Therefore, the objectives of this study were to determine the energy and lipid digestibility of various specialty lipids varying in FA composition and FFA content, and to evaluate if an exogenous emulsifier would improve digestibility of SO or a high FFA SO product.

MATERIALS AND METHODS

Experimental Design

All procedures were approved by the Institutional Animal Care and Use Committee at Iowa State University. In Exp. 1, 5 sources of specialty lipids were obtained from

[1] Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the University of Minnesota or the USDA, and does not imply approval to the exclusion of other products that may be suitable. The USDA is an equal opportunity provider and employer.

[2] Corresponding author: brian.kerr@ars.usda.gov

Table 1. Composition of lipid samples[1]

Item	FPOL-FFA	POL	MDE	SAF	SAF-FFA	SO	SO-FFA	LEC
Crude fat,[2] %	99.87	97.14	85.54	96.86	99.65	99.79	99.96	63.16
FFA,[2] %	101.9	1.40	0.69	2.80	98.10	0.02	89.60	6.30
FA,[2] % of total fat								
Valeric (C5:0)	ND	ND	ND	ND	0.29	ND	ND	ND
Caprylic (C8:0)	ND	ND	ND	ND	0.39	ND	0.45	0.35
Perlagonic (C9:0)	ND	ND	ND	ND	0.80	ND	ND	ND
Capric (10:0)	ND	ND	ND	ND	0.16	ND	0.39	0.26
Lauric (12:0)	ND	ND	0.40	0.70	0.26	ND	3.08	0.57
Myristic (14:0)	2.42	1.02	0.36	3.55	3.84	0.07	1.75	0.32
Pentadecanoic (15:0)	0.14	ND	ND	0.52	0.61	ND	ND	ND
Palmitic (16:0)	79.86	76.63	16.18	26.74	37.8	10.25	16.29	21.76
Palmitoleic (*cis*-9 16:1)	0.15	ND	ND	0.16	0.33	0.08	ND	0.12
Margaric (17:0)	0.08	0.14	0.21	2.11	1.87	0.09	ND	ND
Margaroleic (17:1)	ND	ND	ND	0.06	0.06	ND	ND	ND
Stearic (18:0)	1.61	4.80	80.25	55.28	41.18	4.64	3.55	3.67
Oleic (*cis*-9 18:1)	8.50	12.47	1.29	9.18	8.60	24.11	22.23	17.35
Linoleic (18:2n-6)	6.61	4.35	0.30	0.11	1.01	52.84	45.51	50.15
Linolenic (18:3n-3)	0.63	0.28	ND	0.21	0.18	6.52	4.97	4.37
Nonadecenoic (19:1)	ND	ND	ND	ND	ND	0.23	ND	ND
Arachidic (20:0)	ND	0.30	0.53	0.61	0.57	0.35	ND	0.18
Gadoleic (20:1)	ND	ND	ND	ND	ND	0.19	ND	ND
Behenoic (22:0)	ND	ND	0.38	ND	ND	0.35	0.67	0.41
Lignoceric (C24:0)	ND	ND	0.09	ND	ND	0.13	0.72	0.30
Other fatty acids	ND	ND	ND	1.37	2.12	0.14	ND	0.19
Moisture,[3] %	0.91	0.65	3.72	0.59	1.61	0.87	1.94	1.64
Insolubles,[3] %	0.10	0.07	3.09	0.10	0.36	2.87	3.19	2.05
Unsaponifiables,[3] %	0.11	0.02	0.50	0.10	0.05	0.31	3.00	1.17
Peroxide value,[3] Meq/kg	6.81	8.35	11.03	7.57	5.83	2.30	23.91	8.61
Anisidine value[3,4]	ND	6.5	ND	0.4	17.9	7.6	173.3	55.8
Hexanal,[3] µg/g	0.08	1.02	1.22	1.21	3.27	1.72	13.50	2.62

[1]FPOL-FFA = fractionated palm oil FFA product containing 6% lecithin; POL = palm oil–based lipid product containing 6% lecithin; SAF = an animal-based lipid product containing a high percentage of C16:0 and C18:0 fatty acids (FA); SAF-FFA = an animal-based lipid product containing a high percentage of C16:0 and C18:0 FFA; MDE = mono-diglyceride emulsifier containing a high percentage of C16:0 and C18:0 FA; SO = refined soybean oil; SO-FFA = SO FFA; LEC = de-oiled soybean-based lecithin. No other FA were detected besides those listed. ND = not detected.

[2]Analyzed by Barrow-Agee (Memphis, TN).

[3]Analyzed by the University of Missouri, Columbia.

[4]There are no units for anisidine value.

commercial suppliers, and included a fractionated, high FFA palm oil product containing 6% lecithin (**FPOL-FFA**), a palm oil–based lipid product containing 6% lecithin (**POL**), an animal-based lipid product containing a high percentage of C16:0 and C18:0 FA (**SAF**), an animal-based lipid product containing a high percentage of C16:0 and C18:0 FFA (**SAF-FFA**), and a mono-diglyceride emulsifier containing a high percentage of C16:0 and C18:0 FA (**MDE**). In Exp. 2, a refined SO and a SO containing high FFA content (**SO-FFA**) were obtained from commercial suppliers and fed with or without a de-oiled soybean-based lecithin (**LEC**). All lipids were analyzed for a wide array of chemical composition and quality measures (Table 1).

A basal diet (Table 2) was formulated to contain 1.30% standardized ileal digestible Lys, with AA ratios, energy, and mineral content adequate to meet the requirements for 11-kg pigs (NRC, 2012). In each experiment, dietary treatments consisted of the control diet (100% basal diet) or one of the experimental diets consisting of 90% basal plus 10% of experimental lipid. Throughout each experiment, all diets were fed in meal form and pigs had access to water from a nipple waterer at all times. In each experiment, 54 weanling barrows were obtained from a commercial farm at weaning (28 d of age) and transported and housed at the Iowa State University Swine Nutrition Farm. Similar to previous experiments (Kerr et al., 2016), for the first 7 d (d 1 to 7), pigs were housed in pens and