Short communication: Linear discriminant analysis and type of oil added to dairy goat diets

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ABSTRACT

Gas chromatography fatty acid (FA) analysis of 112 milk fat samples from dairy goats fed a basal diet with no added oil or the same diet with 1 of 3 vegetable oils added [high oleic sunflower oil (HOSFO), regular sunflower oil (RSFO), or linseed oil (LO)] was used to identify the type of diet consumed through linear discriminant analysis. Twenty variables (19 FA and 1 FA ratio) were selected as valid predictors out of 84 variables tested. The Mahalanobis squared distance was minimal between HOSFO and RSFO groups and maximal between control and LO groups. Cross-validation showed that only one observation from RSFO group was misclassified into the HOSFO group. We concluded that linear discriminant analysis is a useful method to classify milk fat samples from dairy goats according to the particular vegetable oil (of the 3 oils tested here) added to the basal diet.

Key words: discriminant analysis, fatty acid, goat milk, vegetable oil

Short Communication

Discriminant analysis is a multivariate statistical technique that can be used to build a predictive model of group discrimination based on observed predictor variables and to classify each observation into one of the groups. Linear discriminant analysis (**LDA**) has been used successfully to differentiate milk and cheese from different species based on their mineral content (Martín-Hernández et al., 1992) as well as to detect milk fat adulteration (Ulberth, 1994; Gutiérrez et al., 2009).

It is well established that supplementation of goat diets with fat sources rich in unsaturated FA substantially modifies the FA profile of milk fat (Chilliard et al., 2007). Accordingly, enabling researchers to obtain information about the type of dietary lipids consumed by the animals from milk fat FA data would be of great interest. The aim of this work was to investigate the use of LDA to identify the type of plant oil consumed by goats from data of their milk fat FA profile determined by GC.

Milk fat FA GC analysis (up to 82 FA and 2 FA ratios per sample, Table 1) involving 112 goat milk samples from 16 goats (Martínez Marín et al., 2011), 12 goats (Martínez Marín et al., 2012), and 12 goats (our unpublished results) were used to perform the discriminant analysis. All goats were fed the same basal diet. The analyses were grouped into 4 classes (28 analyses in each class): basal diet with no added fat (control), diet rich in *cis*-9–18:1 (high oleic sunflower oil, **HOSFO**), diet rich in *cis*-9,*cis*-12–18:2 (regular sunflower oil, **RSFO**), and diet rich in 18:3n-3 (linseed oil, **LO**). Of the 28 analysis corresponding to each of the classes with added oil (HOSFO, RSFO, and LO), 22 corresponded to milk from goats supplemented with 48 g of oil per day, and 6 corresponded to milk from goats supplemented with 32 (3 goats) or 66 (3 goats) g of oil per day.

Statistical analysis was performed using SAS software version 9.1.3 (SAS Institute, 2004). First, PROC STEPDISC was used to select the FA and ratios to be included as predictor variables in the model. Probability to enter and stay in the model was set at 0.10 and 0.15, respectively. Following this, PROC DISCRIM was used to determine the coefficients for the optimal subset of FA and ratios included in the linear discriminant functions. In this procedure, the option CROSS-VALIDATE was included to assess the robustness of the linear discriminant functions obtained.

Nineteen FA and 1 ratio were selected as predictor variables (Table 2). Canonical discriminant functions 1 and 2 explained up to 89.2% of total variance be-

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Table 1. Milk FA composition (mean $\pm$ SD) and univariate test of equality between group means of the diet classes used in the study

Fatty acid	Diet ¹				<i>P</i> -value
	Control	HOSFO	RSFO	LO	
SFA					
4:0	2.469 $\pm$ 0.194	2.601 $\pm$ 0.301	2.643 $\pm$ 0.414	2.624 $\pm$ 0.320	0.230
5:0	0.022 $\pm$ 0.012	0.025 $\pm$ 0.011	0.021 $\pm$ 0.010	0.026 $\pm$ 0.019	0.459
6:0	2.761 $\pm$ 0.265	2.855 $\pm$ 0.286	2.910 $\pm$ 0.430	2.996 $\pm$ 0.383	0.150
7:0	0.041 $\pm$ 0.023	0.044 $\pm$ 0.021	0.037 $\pm$ 0.016	0.048 $\pm$ 0.035	0.457
8:0	3.029 $\pm$ 0.383	3.106 $\pm$ 0.366	3.183 $\pm$ 0.611	3.355 $\pm$ 0.443	0.118
4-Methyloctanoate	0.044 $\pm$ 0.025	0.043 $\pm$ 0.026	0.037 $\pm$ 0.020	0.046 $\pm$ 0.028	0.588
9:0	0.088 $\pm$ 0.051	0.090 $\pm$ 0.041	0.075 $\pm$ 0.031	0.095 $\pm$ 0.061	0.511
10:0	11.328 $\pm$ 0.991	10.244 $\pm$ 1.088	10.263 $\pm$ 1.765	10.764 $\pm$ 1.280	0.016
Methyldecanoate	0.071 $\pm$ 0.041	0.058 $\pm$ 0.034	0.051 $\pm$ 0.026	0.063 $\pm$ 0.037	0.229
12:0	5.218 $\pm$ 0.950	3.926 $\pm$ 0.554	4.073 $\pm$ 0.622	4.109 $\pm$ 0.806	<0.001
Methyldodecanoate	0.024 $\pm$ 0.012	0.023 $\pm$ 0.014	0.021 $\pm$ 0.009	0.023 $\pm$ 0.011	0.739
13:0 <i>iso</i>	0.020 $\pm$ 0.008	0.018 $\pm$ 0.007	0.018 $\pm$ 0.005	0.016 $\pm$ 0.005	0.200
13:0 <i>anteiso</i>	0.063 $\pm$ 0.032	0.038 $\pm$ 0.013	0.043 $\pm$ 0.015	0.042 $\pm$ 0.020	<0.001
14:0 <i>iso</i>	0.050 $\pm$ 0.010	0.046 $\pm$ 0.009	0.047 $\pm$ 0.014	0.043 $\pm$ 0.012	0.260
14:0	10.387 $\pm$ 0.866	8.635 $\pm$ 0.646	8.813 $\pm$ 0.914	8.560 $\pm$ 1.014	<0.001
Methyltetradecanoate	0.063 $\pm$ 0.033	0.048 $\pm$ 0.023	0.042 $\pm$ 0.016	0.050 $\pm$ 0.026	0.044
15:0 <i>iso</i>	0.136 $\pm$ 0.020	0.122 $\pm$ 0.020	0.130 $\pm$ 0.029	0.119 $\pm$ 0.017	0.049
15:0 <i>anteiso</i>	0.278 $\pm$ 0.056	0.255 $\pm$ 0.069	0.250 $\pm$ 0.072	0.244 $\pm$ 0.056	0.287
15:0	0.833 $\pm$ 0.231	0.724 $\pm$ 0.156	0.676 $\pm$ 0.143	0.713 $\pm$ 0.210	0.029
16:0 <i>iso</i>	0.145 $\pm$ 0.035	0.143 $\pm$ 0.095	0.125 $\pm$ 0.034	0.121 $\pm$ 0.038	0.361
16:0	32.562 $\pm$ 2.834	24.944 $\pm$ 3.588	24.31 $\pm$ 3.199	24.270 $\pm$ 2.831	<0.001
17:0	0.399 $\pm$ 0.056	0.377 $\pm$ 0.072	0.340 $\pm$ 0.076	0.358 $\pm$ 0.081	0.034
18:0 <i>iso</i>	0.035 $\pm$ 0.015	0.030 $\pm$ 0.016	0.037 $\pm$ 0.018	0.027 $\pm$ 0.011	0.077
10-keto-18:0	0.039 $\pm$ 0.018	0.312 $\pm$ 0.248	0.133 $\pm$ 0.129	0.108 $\pm$ 0.060	<0.001
18:0	5.778 $\pm$ 1.240	10.171 $\pm$ 2.212	9.120 $\pm$ 1.878	8.389 $\pm$ 1.708	<0.001
19:0	0.016 $\pm$ 0.015	0.017 $\pm$ 0.012	0.018 $\pm$ 0.015	0.047 $\pm$ 0.017	<0.001
20:0	0.111 $\pm$ 0.018	0.151 $\pm$ 0.024	0.139 $\pm$ 0.020	0.112 $\pm$ 0.015	<0.001
21:0	0.026 $\pm$ 0.005	0.027 $\pm$ 0.005	0.026 $\pm$ 0.008	0.024 $\pm$ 0.007	0.635
22:0	0.051 $\pm$ 0.012	0.082 $\pm$ 0.030	0.081 $\pm$ 0.022	0.047 $\pm$ 0.009	<0.001
MUFA					
<i>cis</i> -9-10:1/12:0 <i>iso</i> /11:0	0.392 $\pm$ 0.134	0.324 $\pm$ 0.085	0.326 $\pm$ 0.065	0.354 $\pm$ 0.099	0.062
<i>cis</i> -9-12:1/13:0	0.223 $\pm$ 0.100	0.158 $\pm$ 0.046	0.159 $\pm$ 0.043	0.171 $\pm$ 0.061	0.003
<i>cis</i> -9-14:1	0.216 $\pm$ 0.101	0.130 $\pm$ 0.051	0.158 $\pm$ 0.078	0.146 $\pm$ 0.073	0.002
<i>cis</i> -9-15:1	0.054 $\pm$ 0.016	0.045 $\pm$ 0.014	0.047 $\pm$ 0.013	0.047 $\pm$ 0.012	0.126
<i>trans</i> -8-16:1	0.049 $\pm$ 0.012	0.077 $\pm$ 0.033	0.078 $\pm$ 0.035	0.073 $\pm$ 0.021	0.001
<i>trans</i> -9-16:1/17:0 <i>iso</i>	0.336 $\pm$ 0.067	0.361 $\pm$ 0.092	0.557 $\pm$ 0.185	0.600 $\pm$ 0.149	<0.001
<i>cis</i> -7-16:1	0.241 $\pm$ 0.035	0.292 $\pm$ 0.047	0.257 $\pm$ 0.050	0.271 $\pm$ 0.045	0.001
<i>cis</i> -8-16:1	0.011 $\pm$ 0.003	0.010 $\pm$ 0.002	0.014 $\pm$ 0.003	0.030 $\pm$ 0.008	<0.001
<i>cis</i> -9-16:1/17:0 <i>anteiso</i>	1.321 $\pm$ 0.321	0.926 $\pm$ 0.149	0.913 $\pm$ 0.235	0.884 $\pm$ 0.191	<0.001
<i>cis</i> -13-16:1	0.282 $\pm$ 0.110	0.154 $\pm$ 0.055	0.167 $\pm$ 0.071	0.184 $\pm$ 0.091	<0.001
<i>cis</i> -9-17:1	0.212 $\pm$ 0.046	0.167 $\pm$ 0.062	0.138 $\pm$ 0.033	0.144 $\pm$ 0.051	<0.001
<i>trans</i> -4-18:1	0.013 $\pm$ 0.007	0.037 $\pm$ 0.020	0.025 $\pm$ 0.013	0.022 $\pm$ 0.011	<0.001
<i>trans</i> -5-18:1	0.014 $\pm$ 0.006	0.036 $\pm$ 0.020	0.023 $\pm$ 0.013	0.020 $\pm$ 0.010	<0.001
<i>trans</i> -6,7,8-18:1	0.169 $\pm$ 0.048	0.448 $\pm$ 0.173	0.364 $\pm$ 0.121	0.324 $\pm$ 0.091	<0.001
<i>trans</i> -9-18:1	0.195 $\pm$ 0.045	0.349 $\pm$ 0.101	0.372 $\pm$ 0.093	0.347 $\pm$ 0.089	<0.001
<i>trans</i> -10-18:1	0.330 $\pm$ 0.164	0.584 $\pm$ 0.387	0.901 $\pm$ 0.843	0.413 $\pm$ 0.171	0.001
<i>trans</i> -11-18:1	1.011 $\pm$ 0.425	1.767 $\pm$ 0.756	3.597 $\pm$ 1.832	3.732 $\pm$ 1.584	<0.001
<i>trans</i> -12-18:1	0.182 $\pm$ 0.053	0.372 $\pm$ 0.221	0.328 $\pm$ 0.104	0.412 $\pm$ 0.144	<0.001
<i>cis</i> -9-18:1	14.545 $\pm$ 1.651	20.477 $\pm$ 3.549	17.757 $\pm$ 3.319	16.19 $\pm$ 4.419	<0.001
<i>trans</i> -15/ <i>cis</i> -11-18:1	0.306 $\pm$ 0.064	0.346 $\pm$ 0.101	0.360 $\pm$ 0.128	0.571 $\pm$ 0.224	<0.001
<i>cis</i> -12-18:1	0.139 $\pm$ 0.051	0.101 $\pm$ 0.039	0.287 $\pm$ 0.229	0.477 $\pm$ 0.340	<0.001
<i>cis</i> -13-18:1	0.038 $\pm$ 0.009	0.042 $\pm$ 0.011	0.051 $\pm$ 0.011	0.058 $\pm$ 0.018	<0.001
<i>trans</i> -16/ <i>cis</i> -14-18:1	0.175 $\pm$ 0.036	0.228 $\pm$ 0.048	0.287 $\pm$ 0.064	0.441 $\pm$ 0.108	<0.001
<i>cis</i> -15-18:1	0.055 $\pm$ 0.010	0.059 $\pm$ 0.012	0.076 $\pm$ 0.017	0.324 $\pm$ 0.171	<0.001
<i>cis</i> -16-18:1	0.020 $\pm$ 0.004	0.026 $\pm$ 0.005	0.030 $\pm$ 0.014	0.034 $\pm$ 0.011	<0.001
<i>cis</i> -11-20:1	0.046 $\pm$ 0.010	0.067 $\pm$ 0.017	0.063 $\pm$ 0.017	0.050 $\pm$ 0.013	<0.001
PUFA					
<i>trans</i> -11, <i>trans</i> -15-18:2	0.040 $\pm$ 0.014	0.044 $\pm$ 0.015	0.038 $\pm$ 0.014	0.063 $\pm$ 0.038	0.001
<i>trans</i> -9, <i>trans</i> -12/ <i>cis</i> -9, <i>trans</i> -13/ <i>trans</i> -8, <i>cis</i> -12-18:2	0.165 $\pm$ 0.034	0.162 $\pm$ 0.046	0.216 $\pm$ 0.048	0.348 $\pm$ 0.112	<0.001
<i>trans</i> -8, <i>cis</i> -13-18:2	0.061 $\pm$ 0.010	0.065 $\pm$ 0.016	0.071 $\pm$ 0.020	0.143 $\pm$ 0.046	<0.001
<i>cis</i> -9, <i>trans</i> -12-18:2	0.030 $\pm$ 0.008	0.032 $\pm$ 0.011	0.034 $\pm$ 0.014	0.043 $\pm$ 0.017	0.006
<i>trans</i> -9, <i>cis</i> -12-18:2	0.031 $\pm$ 0.009	0.027 $\pm$ 0.006	0.039 $\pm$ 0.013	0.049 $\pm$ 0.020	<0.001

Continued

Table 1 (Continued). Milk FA composition (mean $\pm$ SD) and univariate test of equality between group means of the diet classes used in the study

Fatty acid	Diet ¹				P-value
	Control	HOSFO	RSFO	LO	
<i>trans</i> -11, <i>cis</i> -15-18:2	0.037 $\pm$ 0.012	0.056 $\pm$ 0.023	0.065 $\pm$ 0.038	0.936 $\pm$ 0.561	<0.001
<i>cis</i> -9, <i>cis</i> -12-18:2	1.725 $\pm$ 0.272	1.411 $\pm$ 0.329	2.203 $\pm$ 0.838	1.684 $\pm$ 0.532	<0.001
Other 18:2	0.063 $\pm$ 0.025	0.059 $\pm$ 0.016	0.050 $\pm$ 0.015	0.086 $\pm$ 0.031	<0.001
<i>cis</i> -9, <i>trans</i> -11-18:2	0.616 $\pm$ 0.246	0.839 $\pm$ 0.347	1.679 $\pm$ 0.837	1.660 $\pm$ 0.638	<0.001
<i>trans</i> -9, <i>cis</i> -11-18:2	0.013 $\pm$ 0.007	0.017 $\pm$ 0.008	0.021 $\pm$ 0.013	0.016 $\pm$ 0.007	0.016
<i>trans</i> -10, <i>cis</i> -12-18:2	0.007 $\pm$ 0.004	0.008 $\pm$ 0.004	0.009 $\pm$ 0.005	0.008 $\pm$ 0.004	0.410
<i>trans</i> -11, <i>cis</i> -13-18:2	0.011 $\pm$ 0.006	0.011 $\pm$ 0.006	0.012 $\pm$ 0.006	0.023 $\pm$ 0.011	<0.001
<i>trans</i> -12, <i>trans</i> -14-18:2	0.007 $\pm$ 0.003	0.007 $\pm$ 0.004	0.009 $\pm$ 0.006	0.017 $\pm$ 0.008	<0.001
<i>trans</i> -11, <i>trans</i> -13-18:2	0.006 $\pm$ 0.003	0.007 $\pm$ 0.004	0.007 $\pm$ 0.004	0.015 $\pm$ 0.008	<0.001
<i>trans</i> -9, <i>trans</i> -11-18:2	0.013 $\pm$ 0.006	0.017 $\pm$ 0.008	0.022 $\pm$ 0.014	0.019 $\pm$ 0.009	0.016
16:2	0.009 $\pm$ 0.005	0.011 $\pm$ 0.005	0.009 $\pm$ 0.005	0.051 $\pm$ 0.034	<0.001
18:3n-6	0.026 $\pm$ 0.008	0.024 $\pm$ 0.010	0.024 $\pm$ 0.007	0.043 $\pm$ 0.022	<0.001
18:3n-3	0.163 $\pm$ 0.037	0.128 $\pm$ 0.028	0.142 $\pm$ 0.067	0.614 $\pm$ 0.291	<0.001
<i>cis</i> -9, <i>trans</i> -11, <i>trans</i> -15-18:3	0.007 $\pm$ 0.003	0.007 $\pm$ 0.003	0.010 $\pm$ 0.009	0.044 $\pm$ 0.020	<0.001
<i>cis</i> -9, <i>trans</i> -11, <i>cis</i> -15-18:3	0.037 $\pm$ 0.009	0.036 $\pm$ 0.007	0.033 $\pm$ 0.008	0.104 $\pm$ 0.068	<0.001
20:2n-6	0.010 $\pm$ 0.005	0.010 $\pm$ 0.005	0.012 $\pm$ 0.006	0.011 $\pm$ 0.004	0.369
20:3n-3	0.006 $\pm$ 0.004	0.008 $\pm$ 0.005	0.008 $\pm$ 0.005	0.009 $\pm$ 0.005	0.306
20:4n-6	0.136 $\pm$ 0.024	0.117 $\pm$ 0.020	0.145 $\pm$ 0.037	0.111 $\pm$ 0.020	<0.001
20:5n-3	0.025 $\pm$ 0.006	0.023 $\pm$ 0.006	0.026 $\pm$ 0.010	0.039 $\pm$ 0.007	<0.001
22:4n-6	0.026 $\pm$ 0.007	0.076 $\pm$ 0.049	0.043 $\pm$ 0.027	0.030 $\pm$ 0.011	<0.001
22:5n-3	0.040 $\pm$ 0.009	0.035 $\pm$ 0.008	0.038 $\pm$ 0.015	0.045 $\pm$ 0.010	0.024
22:6n-3	0.021 $\pm$ 0.009	0.019 $\pm$ 0.008	0.026 $\pm$ 0.020	0.018 $\pm$ 0.009	0.127
Ratio					
<i>trans</i> -10-18:1/ <i>trans</i> -11-18:1	0.349 $\pm$ 0.161	0.346 $\pm$ 0.252	0.251 $\pm$ 0.188	0.119 $\pm$ 0.037	<0.001
LA:ALA ²	10.972 $\pm$ 2.280	11.138 $\pm$ 1.720	16.577 $\pm$ 5.434	2.988 $\pm$ 0.797	<0.001

¹Control = basal diet without added oil; HOSFO, RSFO, and LO = basal diet enriched with high oleic sunflower oil, regular sunflower oil, or linseed oil, respectively.

²Linoleic acid: α -linolenic acid.

tween groups (Figure 1). The 4 FA with the greatest discriminating ability were 19:0, *cis*-9-17:1, *trans*-11,*trans*-15-18:2, and 18:0 *iso*, and the ratio linoleic acid to α -linolenic acid (LA:ALA) in function 1; *cis*-9-18:1, *trans*-11-18:1, *cis*-9,*cis*-12-18:2, and *trans*-9,*cis*-12-18:2 in function 2; and *cis*-9-17:1, 18:0 *iso*, *trans*-5-18:1, and *trans*-9,*cis*-12-18:2 in function 3. Pooling within canonical structure (Table 2) showed that none of the predictor variables had an absolute correlation value >0.41 with any function. The higher correlation values between different FA and function 1 corresponded to 19:0, *cis*-8-16:1, *trans*-11-18:1, *trans*-9,*cis*-12-18:2, *trans*-11,*cis*-13-18:2, *cis*-9,*trans*-11,*trans*-15-18:3, and LA:ALA. According to class means (Table 2), this function clearly discriminated the LO group. Some of the above-cited milk FA (e.g., *trans*-11-18:1, *trans*-11,*cis*-13-18:2, and *cis*-9,*trans*-11,*trans*-15-18:3) are known to be related to the intake of diets rich in α -linolenic acid by dairy ruminants (Colomb et al., 2004; Chilliard et al., 2007; Gómez-Cortés et al., 2009). The best correlation values between different FA and function 2 corresponded to 20:0, *cis*-7-16:1, *cis*-9-17:1, *trans*-5-18:1, *trans*-11-18:1, *cis*-9-18:1, and LA:ALA. According to class means, this function clearly discriminated the control group from groups

HOSFO and RSFO. Known FA that decrease with oil treatments, such as those of microbial origin, showed higher negative correlation values with function 2 (e.g., *cis*-9-17:1). In contrast, FA of direct or indirect dietary origin, such as *trans*-11-18:1, oleic acid, or LA:ALA showed a higher than average positive correlation value with this function. The higher correlation values between different FA and function 3 corresponded to *cis*-9,*cis*-12-18:2, 20:4n-6, *trans*-11-18:1, *trans*-5-18:1, *cis*-7-16:1, and *cis*-9-18:1, and to LA:ALA. According to class means, this function discriminated HOSFO from RSFO groups. The ratio LA:ALA and some FA with known direct or indirect origin in linoleic acid-rich diets (e.g., *cis*-9,*cis*-12-18:2, *trans*-11-18:1) were negatively correlated with function 3, whereas *cis*-9-18:1 was positively correlated, which suggests that HOSFO diets supplied more preformed *cis*-9-18:1 and stearic acid to the mammary gland.

Fisher's linear discriminant functions are shown in Table 3. The Mahalanobis squared distance was minimal between HOSFO and RSFO groups (26.99) and maximal between control and LO groups (146.26). The *F*-test of the distances was highly significant in all cases ($P < 0.0001$). Only one observation from the RSFO group was misclassified into the HOSFO group, both

Table 2. Total sample standardized canonical coefficients and pooled within canonical structure (where 1, 2, and 3 are canonical functions)

FA	Standardized canonical coefficients			Canonical structure		
	1	2	3	1	2	3
4:0	−0.180	0.722	0.547	0.025	0.067	−0.016
14:0 <i>iso</i>	−0.011	−0.049	−0.727	−0.042	−0.029	−0.031
16:0 <i>iso</i>	−0.574	−0.365	0.472	−0.033	−0.022	0.054
18:0 <i>iso</i>	0.965	0.320	−1.133	−0.042	−0.001	−0.111
19:0	1.076	−0.104	0.190	0.191	−0.045	0.041
20:0	−0.043	0.608	0.460	−0.076	0.288	0.113
<i>cis</i> -7-16:1	−0.203	−0.442	0.288	0.021	0.104	0.168
<i>cis</i> -8-16:1	0.762	0.056	−0.096	0.390	−0.077	−0.069
<i>cis</i> -9-17:1	−1.046	−0.829	1.278	−0.080	−0.166	0.087
<i>trans</i> -5-18:1	−0.232	−0.262	1.024	−0.018	0.183	0.205
<i>trans</i> -11-18:1	0.634	1.249	−0.498	0.151	0.164	−0.236
<i>cis</i> -9-18:1	0.668	2.029	−0.123	−0.023	0.211	0.165
<i>trans</i> -11, <i>trans</i> -15-18:2	−0.973	−0.398	0.743	0.092	−0.026	0.074
<i>trans</i> -9, <i>cis</i> -12-18:2	−0.257	0.945	−0.918	0.133	−0.013	−0.139
<i>cis</i> -9, <i>cis</i> -12-18:2	−0.464	−1.011	0.191	0.000	0.035	−0.291
<i>trans</i> -11, <i>cis</i> -13-18:2	0.475	−0.470	−0.275	0.147	−0.030	0.026
<i>cis</i> -9, <i>trans</i> -11, <i>trans</i> -15-18:3	0.743	−0.645	0.429	0.317	−0.073	0.023
20:3n-3	0.026	0.595	0.503	0.034	0.042	0.032
20:4n-6	0.357	−0.483	−0.118	−0.068	0.004	−0.237
LA:ALA ¹	−0.772	0.184	−0.315	−0.255	0.235	−0.408
Eigenvalues	20.34	7.84	3.43			
Canonical correlation	0.976	0.942	0.880			
Variance explained (%)	64.35	24.80	10.85			
Class means ²						
Control	−3.654	−4.074	−0.253			
HOSFO	−2.390	2.312	2.505			
RSFO	−0.937	2.518	−2.478			
LO	8.022	−0.984	0.377			

¹Linoleic acid:α-linolenic acid.
²Control = basal diet without added oil; HOSFO, RSFO, and LO = basal diet enriched with high oleic sunflower oil, regular sunflower oil, or linseed oil, respectively.

Figure 1. Canonical discriminant plot of the first 2 canonical variables. Control = basal diet without added oil; HOSFO, RSFO, and LO = basal diet enriched with high oleic sunflower oil, regular sunflower oil, or linseed oil, respectively.

Table 3. Coefficients of Fisher's linear discriminant functions for classifying milk fat samples

Selected variable	Diet ¹			
	Control	HOSFO	RSFO	LO
Constant term	−197.712	−293.826	−252.267	−256.248
4:0	87.435	105.961	97.035	88.928
14:0 <i>iso</i>	−871.073	−1,075.907	−760.097	−935.903
16:0 <i>iso</i>	4.470	−26.318	−83.582	−127.807
18:0 <i>iso</i>	−441.419	−432.658	24.476	299.977
19:0	−176.505	−94.471	−54.180	656.837
20:0	871.176	1,131.872	1,017.772	956.473
<i>cis</i> -7–16:1	78.035	27.031	−13.538	−1.278
<i>cis</i> -8–16:1	−64.094	170.676	526.629	1,941.017
<i>cis</i> -9–17:1	481.334	417.845	252.023	194.111
<i>trans</i> -5–18:1	213.186	277.982	−135.904	−2.993
<i>trans</i> -11–18:1	4.535	10.310	13.166	13.078
<i>cis</i> -9–18:1	2.390	6.414	7.012	6.572
<i>trans</i> -11, <i>trans</i> -15–18:2	370.627	291.897	54.289	−183.546
<i>trans</i> -9, <i>cis</i> -12–18:2	−155.147	90.123	429.152	−206.191
<i>cis</i> -9, <i>cis</i> -12–18:2	−15.865	−27.826	−31.195	−31.328
<i>trans</i> -11, <i>cis</i> -13–18:2	−1,267.342	−1,695.760	−1,429.482	−736.150
<i>cis</i> -9, <i>trans</i> -11, <i>trans</i> -15–18:3	−245.105	−430.183	−540.298	398.369
20:3n-3	2,509.141	3,604.659	3,112.623	3,024.257
20:4n-6	−149.711	−261.963	−223.797	−50.861
LA:ALA ²	1.461	1.250	1.402	−1.260

¹Control = basal diet without added oil; HOSFO, RSFO, and LO = basal diet enriched with high oleic sunflower oil, regular sunflower oil, or linseed oil, respectively.

²Linoleic acid:α-linolenic acid.

in original and cross-validated classification matrices, resulting in 98.9% of original grouped cases being classified correctly.

Out of the 84 variables, LDA allowed us to identify 20 variables as useful predictors. The LDA was a useful method to classify milk fat samples according to the particular vegetable oil added to a basal diet, among the 3 studied, from several FA quantified in milk fat.

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