Processing cookies formulated with goat cream enriched with conjugated linoleic acid

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Abstract

Goat fat is one of the most important sources of conjugated linoleic acid (CLA), a fatty acid which has health benefits. However, CLA consumption is limited to meats and milk products as CLA is generated in ruminants. This study aimed to replace vegetable fat by goat cream enriched with CLA. Four cookie recipes were developed with only the fat source being different: CVF – vegetable fat; CB – butter; CGC – goat cream without CLA; CGCLA – goat cream with CLA. Cookies were evaluated according to physical (color and texture) and physical-chemical parameters (lipids, proteins, total sugars, fiber, ash, moisture and Aw), Consumer Testing (n = 123) and lipid profile. The CGCLA presented higher values in the color parameters, and the higher and the lower scores in relation to hardness were 5.54 (CB) and 2.21 (CVF), respectively. Lipids and total sugars varied inversely, and the highest percentages of lipids were in the CVF and CG samples, which obtained lower total sugar content. There was no difference in the acceptance and preference of the four formulations, and the formulations with the goat creams (CG and CGCLA) were as accepted as CFV. The lipid profile of the cookies presented CFV with the highest percentage of trans fatty acids (TFA) with 16.76 %. CGCLA presented 70 % more CLA in relation to CB and CGC, thus certifying that CLA was present in relevant quantities in the CGCLA, even after cooking. The CGCLA is a biscuit with higher levels of CLA, and in this study it was possible to verify that the goat milk cream enriched with CLA can be used in producing cookies which adds functional and nutritional properties to them and offers other alternatives to produce food from goat's milk cream.

Keywords: Goat milk, biscuits, rumen trans fatty acid.

Introduction

The trans-industrial fatty acids (TFA) present in hydrogenated vegetable fat are associated with adverse health impacts, particularly on changes in the lipoprotein profile in blood plasma which are directly related to cardiovascular diseases and other non-chronic diseases communicable diseases (CNCD). Trans-rumen fatty acids (TFAr) are the TFA formed by the biohydrogenation process of linoleic and linolenic acids in ruminants, and by the enzymatic action of Δ 9 -dessaturase on vaccinic acid such as conjugated linoleic acid (CLA) [1]. CLA is scientifically known as having functional anti-carcinogenic, anti-obese, abdominal fat reducing, anti-atherogenic and immunomodulatory properties [2, 3].

Due to TFAr production occurring in ruminants, CLA is characteristic of these animals and is found in the lipids fraction of its milk or meat. Caprine fat is one of the main sources of CLA, in addition to having other physiological benefits such as lowering cholesterol levels without altering triglycerides, HDL, TGO or TGP levels, inducing neurodevelopment stimulus, reducing anxiety and reducing intestinal inflammation in rats [4-6].

Hydrogenated vegetable fat is used industrially in most bakery and confectionery products such as biscuits and cookies, and the use of this fat is associated with the physicochemical and technological properties of food such as texture, plasticity and high melting point [7, 8]. Due to these characteristics of industrial trans fats, it is a challenge to develop products such as biscuits, and especially those rich in fat as cookies are, using other lipid sources. Cookies are biscuits that have high levels of sugar and fat and low levels of water (1-5%), and can be elaborated from different flavors [9, 10].

In this context, the objective of this work was to develop cookie type biscuits elaborated from the caprine cream enriched with CLA, aiming to obtain an alternative matrix for the consumption of this TFAr which is only found in dairy and meat products.

Material and methods

Material

The samples of goat's milk cream were supplied by the Brazilian Agricultural Research Company of goats and sheep, Sobral - CE. The production of enriched CLA cream was enabled by manipulating the diet of the animals with the addition of soybean oil by EMBRAPA [11].The other ingredients used in the cookie formulations were purchased from markets in Joao Pessoa-PB and Recife-PE.

Lipid profile of fats

Samples of fats (VF, vegetable fat, B, butter, G, goat cream, and GCLA, goat cream enriched with CLA) were analyzed for their lipid profiles. The procedure of transesterification of the samples was performed according to Sukhija and Palmquist (1988) and Palmquist and Jenkins (2003), with adaptations [12. 13]. The fatty acids were analyzed according to methyl esters by gas chromatography with flame ionization detection (GC-FID), using a QP2010-plus Shimadzu chromatograph (Shimadzu, Kyoto, Japan) equipped with a silica-fused (SP-2560, 100 m × 0.25 mm × 0.20 µm, Supelco, Bellefonte, PA, USA).

During the analysis, the injector and detector were maintained at 250°C and 280°C, respectively. Helium was used as the entrainment gas at a constant flow rate of 1 ml/min and 1 µl of sample was injected. The oven temperature was programmed to start at 50°C, then increased by 50°C every minute until it reached 150°C, remaining for 20 minutes, next increased by 1°C every minute until it reached 190°C for 1 minute, then increased 2ºC every minute until reaching 220ºC, and finally remaining at 220°C for 30 minutes. The identified fatty acids were express as percentages and are shown in Table 1.

97 **Table 1**. **Fatty acid profile present in fats in percentage.**

FATTY ACIDS	VF [a]	B [b]	G [c]	NCLA [d]
SATURATED				
C4:0	-	3,32	2,29	2,61
C6:0	-	2,06	2,75	2,27
C8:0	0,01	1,19	3,27	1,84
C10:0	0,01	2,58	11,14	5,28
C12:0	0,07	2,98	4,37	1,95
C14:0	0,13	10,91	10,15	6,14
C15:0	0,02	1,92	1,38	1,01
C16:0	12,77	31,01	25,55	21,01
C17:0	0,03	1,43	1,09	0,97
C18:0	11,20	11,32	12,13	21,20
C20:0	0,39	0,15	0,29	0,37
C21:0	0,03	0,03	0,04	0,04
C22:0	0,44	0,06	0,07	0,11
C23:0	0,05	0,03	0,02	0,02
C24:0	0,16	0,05	0,03	0,02
TOTAL SFA	25,32	69,01	75,41	64,81
MONOUNSATURATED				
C14:1C9	-	0,94	0,11	0,05
C16:1C7	0,01	0,23	0,27	0,29
C16:1C9	0,06	1,38	0,41	0,31
C17:1C9	0,01	0,26	0,16	0,10
C18:1T6+T8	3,98	0,26	0,16	0,52

C18:1T9	3,04	0,19	0,14	0,46
C18:1T10	7,90	0,26	0,16	0,45
C18:1T11	4,81	1,90	0,65	4,45
C18:1T12	3,31	0,26	0,17	0,60
C18:1C9	30,86	21,41	19,21	22,79
C18:1T15	1,60	0,18	0,10	0,35
C18:1C11	2,25	0,44	0,30	0,34
C18:1C12	8,90	0,13	0,09	0,24
C18:1C13	0,46	0,06	0,02	0,05
C18:1T16+C14	0,47	0,30	0,18	0,48
C18:1C15	0,44	0,10	0,03	0,09
C20:1	0,16	0,04	0,04	0,06
TOTAL MUFA	67,80	28,27	22,15	31,57
POLYUNSATURATED				
C18:2N6	6,22	1,16	1,56	1,52
C18:3N-6	-	0,02	0,02	0,01
C18:3N3	0,20	0,40	0,22	0,14
CLAC9T11	**-**	**0,87**	**0,34**	**1,69**
C20:3N-6	-	0,04	0,02	0,01
C20:4N-6	-	0,08	0,16	0,13
C20:5N-3	-	0,03	0,02	0,01
C22:5N-3	-	0,06	0,05	0,04
C22:6N-3	-	0,01	0,02	0,03
TOTAL PUFA	6,42	2,66	2,43	3,58
TRANS	25,11	3,34	1,54	7,31

98

99 [a] VF: vegetable fat; [b] B: butter, [c] G: goat cream; [d] GCLA: goat cream with CLA, expressed as a

100 percentage.

101

102 Cookie production

103 Four formulations of cookies were developed by only varying the fat source between

104 each of them, being CVF - vegetal fat; CB - butter; CG - goat cream without enrichment of

105 CLA; CGCLA - goat cream with CLA enrichment. Preliminary tests were carried out until the

106 ideal formulations were determined before the final composition of the cookies. The inputs and

107 quantities used are describe in Table 2. After preparation, the cookies were baked for 15 minutes

108 at 165°C in a conventional oven.

109

110 **Table 2. Ingredients used in the formulations of cookies for 100 g of fresh dough.**

Ingredients (g)	Cookies			
	CVF[a]	CB[b]	CG[c]	CGCLA[d]
Maize starch	17,84	17,84	17,84	17,84
Rice flour	11,74	11,74	11,74	11,74
Vegetable fat	18,78	-	-	-
Butter	-	18,78	-	-
Goat cream whitout enrichment of CLA	-	-	18,78	-
Goat cream with enrichment of CLA	-	-	-	18,78
Brown sugar mascavo	18,78	18,78	18,78	18,78

Chestnut	11,74	11,75	11,74	11,74
Raisin	9,4	9,4	9,4	9,4
Egg	9,4	9,4	9,4	9,4
Xanthan gun	0,47	0,47	0,47	0,47
Cinnamon powder	0,24	0,24	0,24	0,24
Clove powder	0,24	0,24	0,24	0,24
Yeast chemical	0,94	0,94	0,94	0,94
Salt	0,47	0,47	0,47	0,47

[a] CVF - vegetable fat; [b] CB - butter; [c] CG - goat cream; [d] CGCLA - goat cream with CLA.

Physical analyses

Instrumental color

Determination of the cookies' instrumental color was performed in a CR-300 Minolta colorimeter (MinoltaCo., Osaka, Japan) according to the CIE-lab system [14]. In the CIELAB colorimetric space defined by L*, a*, b*, the L* coordinate corresponds to the brightness, ranging from 0 (black) to 100 (white), while a* and b* refer to the green (-) chromaticity coordinates/red (+) and blue (-)/yellow (+), respectively. The measurements were performed with the apparatus previously calibrated in the reflectance modality with specular reflection excluded and using reference plates. A colon at the top of the cookies was for the measurement and then a dot at the bottom.

Instrumental texture

Determination of the cookies' texture was performed in a TA XT Plus texturometer from Extralab Brazil. The data obtained were analyzed by StableMicroSystems

software/TE32L/Version 6.1.4.0, England. Each sample was placed horizontally on the platform and cut in half with a blade probe (HDP/3PB), pre-test speed of 1 mm/s and 3 mm/s, and a post-test speed of 10 mm/s, sheer force of $5x10^{-3}$ g and 5.0 mm distance, with the force of rupture or breaking (hardness) being recorded.

Physicochemical Analysis

Proteins, lipids, total sugars, fibers, ashes and moisture

The centesimal composition was determined according to the methodology described by the Association of Official Analytical Chemist Methods [15]. The following tests were carried out: the micro-Kjedahl method, total sugars by the Fehling reduction, the fibers by Henneberg and Stohmann; moisture and total dry extract (EST) by drying in an oven stabilized at 105º C until obtaining constant weight; determination of ash content by carbonization followed by incineration in a muffle furnace at 550º C; determination of lipids by Folch, Lees, and Stanley (1957); and water activity was performed at 25° C in Aqualab® [16].

Sensory evaluation

The sensorial tests were performed after approval by the Research Ethics Committee of the Health Sciences Center of the Federal University of Paraiba, under reference number 052900/2015. For Sensory Analysis, the Acceptance, Intention of Purchase and Ordering tests were performed by 123 untrained judges, being 76.4 2 % women and 23.57 % men. The samples were coded with random 3-digit numbers and served in plastic containers in a comparative way, in complete and balanced blocks. In addition to the samples, each evaluator received a glass with water to clean their palate during the evaluation. The tests were conducted at the Mauricio de Nassau Faculty (Joao Pessoa) and the Federal University of Paraiba, Joao Pessoa campus,

both in the Dietetic Technique laboratory of each institution. The judges were between the ages of 18 and 61 and were in perfect health.

The judges received a sheet through which they evaluated each sample according to the attributes of appearance, color, aroma, flavor, texture and overall evaluation using a hedonic scale of 9 points, where 9 would be the maximum score represented by "I liked it very much", and 1 is the minimum grade, representing "very disgusting", containing intermediate points between these values. For purchase intent, participants responded to a 5-point scale expressing their willingness to consume, to buy or not buy the product offered to them, where terms were defined between "likely to buy" with a score of 5, and "probably would not buy" with a score of 1, and "maybe I would buy" at the intermediate point with a score of 3.

For the Ordination test carried out together with the Acceptance and Purchase Intention test, the judges were instructed to place the samples in ascending order according to their preference, with 1st place being the most preferred and 4th place the least preferred. Sensory tests were performed according to Dutcosky (2013) [17].

Lipid profile of cookies

The samples of the cookies elaborated with different lipid sources (CVF - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA) were analyzed for their lipid profiles. The transesterification procedure of the samples was carried out according to Sukhija and Palmquist (1988) and Palmquist and Jenkins (2003), with adaptations [12. 13]. The fatty acids were analyzed according to methyl esters by gas chromatography with flame ionization detection (GC-FID) using a QP2010-plus Shimadzu chromatograph (Shimadzu, Kyoto, Japan) equipped with a silica-fused (SP-2560, 100 m × 0.25 mm × 0.20 µm, Supelco, Bellefonte, PA, USA). During the analysis the injector and detector were maintained at 250°C and 280°C, respectively. Helium was used as the entrainment gas at a constant flow rate of 1 ml/min and 1

177 µl of sample was injected. The oven temperature was programmed to start at 50°C, then
178 increased by 50°C every minute until it reached 150°C, remaining for 20 minutes, and next
179 increased by 1°C every minute until it reached 190°C and remained for 1 minute, and then
180 increased 2ºC every minute until reaching 220ºC, and finally remaining at 220ºC for 30 minutes.
181 The identified fatty acids were express as percentages and are shown in Table 1.
182

183 Statistical analyses

184 The analysis data were submitted to analysis of variance (ANOVA) followed by Tukey
185 test to verify if there was a significant difference between the samples, considering $p < 0.05$ and
186 using Sigma Stat 3.1 software [18]. The results of the sensory order-preference tests were
187 analyzed according to the Friedman test using the Newell MacFarlane Table [19]. Physical and
188 physico-chemical analyzes were performed in triplicate. All data sets were submitted to
189 Principal Component Analysis (PCA) using correlation matrix and Statistica 7.0 software
190 (Statsoft Inc., Tulsa, OK,USA).
191

192 Results and discussion

193 Physical analyzes

194 Color

195 The color data are shown in Table 3. Values of L* above 50 tend to be lighter in color
196 as observed herein. Only the CB presented a difference in relation to the other formulations,
197 with the lowest value (55.66), while the other treatments ranged from 58.34 (CGCLA), to 57.68
198 (CG) and 57.66 (CVF). Extreme values of L* may interfere with sensory perception, since they
199 are either too dark or too light. The increase in the parameter a* and decrease in L* indicate the
200 progress of the darkening, however this darkening associated to the increase of * and decrease
201 of L* was not observed in cookies [20].
202

Table 3. Physical parameters of cookies with different lipid sources.

Variable	Cookies			
	CVF	CB	CG	CGCLA
L	57,66^{a} ±0,87	55,66^{b} ±0,66	57,68^{a} ±0,99	58,34^{a} ±0,91
a*	14,05 ±0,76	14,44 ±0,54	14,29 ±0,84	14,21 ±0,95
b*	29,47^{c} ±0,91	30,57^{ab} ±0,99	29,76^{b} ±0,95	30,89^{a} ±0,94
Texture (Kg)	2,21^{c} ±0,45	5,54^{a} ±0,66	4,41^{b}±0,42	4,05^{b} ±0,48

Means ± standard deviation with different letters on the same line differed by Tukey's test ($p < 0.05$). CVF - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.

The parameter a* presented no significant difference ($p > 0.05$), however it did obtain positive values which are associated with red pigments, since the parameter b* obtained a significant difference between the formulations; furthermore, the values were positive, being related to yellow pigments. According to Marques (2016), positive values of a* and b* are expected in cakes, since they present red and yellow pigments, respectively, due to the caramelization reactions of sugars and Maillard [21].

The Maillard reaction is an interaction between sugars and amino acids, and together with the caramelization reaction of sugars produce brown pigments during the cooking process, which are associated with luminosity, and more red and yellow staining [22].

The variation in L* and b* did not interfere in the sensorial perception of the appearance and color (Table 5), as will be presented in the subitem “Consumer Test”. According to Sharma and Gurjral (2013), browning reactions are influenced by other factors such as moisture, water activity, pH, sugars, type and proportion of starch, cooking time and temperature [23].

Instrumental texture

The cookies' hardness (evaluated by the instrumental method) is proportional to the force applied to cause deformation. This strength varies according to the composition (quality and quantity of flour, sugars, fats, liquids and other ingredients), cooking time and temperature, humidity, and storage conditions. Hardness is one of the factors that is associated with texture to determine the acceptability of foods, so it is desirable that their values are not very high [24]. The values of the instrumental texture are presented in Table 3.

The CB formulation presented the highest hardness value (5.54 kg) and CFV presented the lowest value (2.21 kg). The CG and CGCLA formulations presented values of 4.41 kg and 4.05 kg, respectively ($p > 0.05$). These data demonstrate that the cookies made with the goat cream independent of the CLA content did not differ statistically from each other. An extreme increase of hardness as very soft or very hard can sensorially interfere in the products. Fragile and crunchy foods are known to have irregular and irreproducible relationships with the force versus deformation relationship [25].

The results obtained in the present study were similar to that of the control group (C). The results showed that the order of hardness was MGCO>C>GCO, and with the addition of oil (GCO) or microencapsulated oil (MGCO), the acceptance was C>MGCO>GCO, with the most accepted sample being that which obtained an intermediate degree of hardness [26]. According to Bertolin (2013), high values in texture negatively influence the overall acceptance of cookies. In the present work, this relationship of hardness with acceptance was not observed, considering that there was no significant difference in the sensory perception of texture (Table 5) [27]. Regarding hardness, the order was CB>CG = CGCLA>CFV (Table 3).

247 # Physico-chemical analysis

248 The physicochemical data are shown in Table 4, in which CVF and CB presented the
249 highest lipid percentages with 28 % and 25.8 %, respectively. The fact that CVF and CB have
250 higher lipid levels is related to the lower percentages of sugars and moisture. A correlation of
251 the fat processing with the lipid content variation of the cookies can be made, since the cream
252 is the emulsion of fat in water and the lipid content can vary from 12 to 60 %, since other
253 elements like sugars can pass next to the fat globules in the milk skimming. Unlike the cream,
254 the butter should contain a minimum percentage of 80 % lipids, and the hydrogenated vegetable
255 fat is composed of 100 % lipids [28].

256

257 **Table 4 – Physico-chemical parameters of cookies made with different lipid sources.**

	Cookies			
Variable	**CVF**	**CB**	**CG**	**CGCLA**
Lipids	28,00^{a} ± 0,00	25,80^{b} ± 0,66	21,16^{c} ± 0,24	20,86^{c} ± 0,68
Proteins	5,43 ± 0,25	5,50 ± 0,32	5,90 ± 0,08	5,79 ± 0,30
Total Sugars	51,38^{c} ± 0,32	54,42^{b} ± 0,36	56,38^{a} ± 0,33	55,02^{b} ± 0,12
Fibers	0,24 ± 0,01	0,25 ± 0,01	0,26 ± 0,01	0,25 ± 0,00
Ashes	1,61 ± 0,24	1,70 ± 0,16	1,63 ± 0,27	1,59 ± 0,28
Humidity	4,39^{c} ± 0,29	4,64^{c} ± 0,22	6,52^{a} ± 0,23	5,35^{b} ± 0,07
Aw	0,35^{b} ± 0,47	0,43^{ab} ± 0,03	0,53^{a} ± 0,17	0,47^{ab} ± 0,26

258 Averages ± standard deviation with different letters on the same line differed by Tukey's test
259 ($p<0.05$). CVF - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.

260

The humidity and Aw presented significant differences, with CG and CGCLA having the highest humidity values with 6.25 % and 5.35%, respectively, and CG had the highest Aw (0.53). These higher percentages can be associated with the characteristic of the lipids used in these formulations (Table 1), as previously mentioned. These variations may occur because other elements such as diversity and type of ingredients, cooking time and temperature directly interfere with moisture and Aw. Protein, fiber and ash contents did not vary significantly between formulations.

In the case of oatmeal-rich biscuits, the water content of the oatmeal oil was similar to that of oysters. According to Chung, Cho, and Lim (2014), the moisture of the biscuit cookie should vary between 2 and 8 g/100 g [29]. Therefore, the four cookie formulations are suitable for this variation. Foods have a sigmoid relationship with water and Aw, since the moisture content and Aw have a strong effect on the perception of sharpness and the mechanical sensations of dry and brittle foods as in biscuits [30, 31].

Sensory evaluation

The evaluation of the mean scores obtained in the sensory analysis (Table 5) showed that the formulations did not differ significantly between the parameters (appearance, color, aroma, flavor, texture and overall evaluation) ($p > 0.05$). Despite the use of different types of fats with different and peculiar characteristics such as goat cream in the preparation of cookies, these changes were not perceptibly noticeable to the judges. The formulations were only qualitatively and not quantitatively altered in relation to the fat added to the cookies (Table 1), although there was a significant difference ($p < 0.05$) in the lipid content of these formulations (Table 4).

Table 5. Mean values of sensory acceptance and purchase intention tests.

Attribute	Cookies			
	CVF	CB	CG	CGCLA
Appearance	7,47 ±1,36	7,35 ±1,43	7,46 ±1,45	7,32 ±1,38
Color	7,62 ±1,18	7,37 ±1,32	7,41 ±1,40	7,40 ±1,29
Aroma	6,83 ±1,86	6,83 ±1,70	7,09 ±1,51	6,72 ±1,90
Flavor	6,81 ±2,12	6,80 ±1,83	7,15 ±1,67	6,96 ±1,76
Texture	7,00 ±1,98	7,03 ±1,58	7,14 ±1,75	7,03 ±1,56
Overall assessment	7,20 ±1,62	7,13 ±1,48	7,53 ±1,32	7,10 ±1,60
Purchase intention	3,60^{ab} ±1,30	3,52^{b} ±1,22	3,96^{a} ±1,11	3,67^{ab} ±1,26

Averages ± standard deviation with different letters on the same line differed by Tukey's test ($p<0.05$). CVF - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.

When developing biscuits formulated with different concentrations of oats and palm oil, Bertolin et al. (2013) found that higher concentrations of oats (51 %) and lower concentrations of palm oil (8 %) negatively interfered in the sensorial acceptance of this biscuit [27]. Similar data regarding the fat content in biscuits were observed by Biguzzi, Schlich and Lange (2014) when evaluating the sensorial perception in biscuits with a reduction of different concentrations of fats (15 % and 25 %) compared to the standard biscuits, observing that the cookies made with lower fat percentage (25 % reduction) obtained sensorial difference in relation to the formulation with lower fat reduction and the standard formulation [32].

The difference in sensory perception in the reduction of the fat content in cookies was observed by Drewnowski, Nordensten and Dwyer (1998), who reported the decrease in the acceptance of biscuits with a reduction of 50 % fat; a fact that did not interfere when the reduction was 25 % [33].

The references mentioned above demonstrate that the amount of fat above a reduction percentage interferes in the judges' acceptance. However, through this study it was observed that the variation in fat type could not be perceived by the judges, as there was no interference in the sensorial acceptance, or a significant difference among the evaluated attributes. Thus, the use of fats with a better lipid profile such as G and GCLA (Table 1) offers great nutritional and technological impact, adding value to the cookies without altering their flavor.

Among the analyzed attributes, the biscuit elaborated with the goat cream presented greater intention of purchase, resembling the cookies containing vegetable fat and goat cream enriched with CLA ($p<0.05$). In addition, all formulations scored between 4 "I would possibly buy" and 3 "I would maybe buy/I would maybe not buy," with at least a 50 % chance of acquiring cookies.

According to the Prediction Order Analysis data (Table 6), there was no significant difference between the four formulations ($p> .05$). The CG and CGCLA samples are as preferred as the CVF, which was elaborated with VF, and which is more used in the preparation of biscuits and cookies by industries [34]. These data indicate that cookies can be elaborated from better sources of fat such as goat cream, which has a better lipid profile (Table 1) and which brings benefits to consumer health. In addition, the characteristic odors and flavors of goat origin products were not sensorially perceived when compared to the other formulations.

Table 6. Distribution of the scores according to the order of general preference by the tasters (n = 123) in the sensory analysis of cookies.

Cookies formulations	Number of testers by order*				Total orders**
	1	2	3	4	
CVF	32	27	22	42	320
CB	34	36	34	19	284
CG	22	35	27	39	329
CGCLA	35	25	40	23	297

* 1 = least preferred, 4 = most preferred.

** Sum of the orders of each sample = (1 x number of tasters) + (2 x number of tasters) + (3 x number of tasters) + (4 x number of tasters).

CGV - Vegetable fat; CM - Butter; Caprine CNCLA - Goat cream enriched with CLA).

The use of goat cream is a lipid source that can be applied to cookies, thus adding value and functionality to goat milk derivatives, which are normally used in dairy products. In this way, the present work will serve as a subsidy for the use of this fat in developing various confectionery and bakery products.

Chromatographic analysis of cookies

The fatty acid profiles of the cookies are shown in Table 7. The CB, CG and CGCLA presented higher percentages of SFA in comparison to the CVF. However, when comparing CG with CGCLA, it is observed that CGCLA reduced 7.89 % of the SFA, and this reduction is associated with the addition of soybean oil in the goat diet, which altered the lipid profile of goat cream [11].

345 **Table 7. Profile of fatty acids present in cookies in percentage.**

FATTY ACIDS	CVF[a]	CB[b]	CN[c]	CNCLA[d]
SATURATED				
C4:0	0,01	1,29	1,61	1,86
C6:0	-	1,31	1,87	1,54
C8:0	0,01	0,76	2,10	1,35
C10:0	0,02	1,70	6,81	3,57
C12:0	0,01	1,97	2,65	1,22
C14:0	0,19	6,86	6,14	3,50
C15:0	0,04	0,99	0,88	0,62
C16:0	14,84	26,44	22,93	19,89
C17:0	0,09	0,77	0,70	0,57
C18:0	10,07	10,93	11,19	14,85
C20:0	0,33	0,18	0,25	0,25
C21:0	0,02	0,01	0,02	0,02
C22:0	0,31	0,05	0,06	0,08
C23:0	0,04	0,02	0,02	0,02
C24:0	0,13	0,03	0,04	0,03
TOTAL SFA	26,11	53,29	57,26	49,37
MONOUNSATURATED				
C14:1C9	0,01	0,53	0,07	0,04
C16:1C7	-	0,43	0,54	0,74
C16:1C9	0,25	1,02	0,45	0,47
C17:1C9	0,04	0,14	0,11	0,08

C18:1T6+T8	2,40	0,18	0,10	0,34
C18:1T9	2,23	0,13	0,10	0,32
C18:1T10	5,10	0,21	0,11	0,33
C18:1T11	3,31	0,79	0,45	2,47
C18:1T12	2,11	0,20	0,12	0,33
C18:1C9	33,03	25,92	26,68	29,67
C18:1T15	1,30	0,17	0,10	0,16
C18:1C11	1,79	0,61	0,55	0,62
C18:1C12	5,82	0,11	0,06	0,26
C18:1C13	0,30	0,04	0,01	0,04
C18:1T16+C14	0,30	0,18	0,11	0,26
C18:1C15	0,29	0,06	0,02	0,05
C20:1	0,13	0,06	0,06	0,07
TOTAL MUFA	58,11	30,75	29,62	36,20
POLYUNSATURATED				
C18:2N6	15,20	15,17	12,18	12,93
C18:3N-6	-	0,02	0,20	0,013
C18:3N3	0,181	0,25	0,20	0,17
CLAC9T11	-	0,25	0,21	0,95
C20:3N-6	0,01	0,04	0,02	0,02
C20:4N-6	0,07	0,13	0,21	0,16
C20:5N-3	-	0,01	0,01	0,01
C22:5N-3	-	0,03	0,04	0,03
C22:6N-3	0,02	0,03	0,04	0,12
TOTAL PUFA	15,48	15,92	13,11	14,39

TRANS	16,76	1,87	1,09	4,21

[a] CGV (cookie with vegetable fat); [b] CB (cookie with butter); [c] CG (cookie with goat cream); [d] CGCLA (cookie with goat cream enriched with CLA).

It is common for fats of animal origin such as those used in these cookies to be a source of SFA. Palmitic acid was the predominant FA in CB, CB and CGCLA, representing about 20 % of total FA. Capric acid (C10: 0) and caprylic (C8: 0) acids are characteristic of goat fat, being identified in greater proportions in G with 11.14 % and 3.27 %, and in GCLA with 5.28 % and 1.84 %, respectively (Table 1).

The decrease of the medium chain fatty acids (MCFA) (10 to 16 carbons) is associated with the manipulation of the goat diets, since the addition of calcium salts of fatty acids in the goat's feed can present a decrease in the capric and myristic concentration and one an increase in linoleic fatty acids (C18: 2 n6), CLA (C18: 2 c9t11), omega-6 (n-6) and PUFA [35]. In the elaborated cookies in the present research, the decrease of C10: 0 and the increase of CLA were also perceived in both CG and CGCLA. This fat naturally enriched with CLA used in the elaboration of the CGCLA also obtained similar treatment, where the caprine ration was added with soybean oil [11].

High consumption of SFA is commonly associated with risk factors for cardiovascular disease. However, they should not be excluded from feeding, since they are necessary for energy synthesis and make up the cell membranes.[36] Short chain saturated fatty acids (4 to 8 carbons) also exert beneficial effects on intestinal health due to rapid uptake and oxidation by colon cells, thereby stimulating cell proliferation in this tissue, as well as playing a role in disease prevention for cardiovascular, cancer and inflammatory diseases [37].

The MUFA presented a higher percentage in CGV with 58.11 %, and these values were related to the TFA, which obtained high percentages when compared to CB, CG and CGCLA. The iTFA present in vegetable fat are associated with CNCD, since the organism does not have the capacity to metabolize these compounds, leading to atheromas. The TFA content ranged from 16.76 % (CVF) to 1.1 % (CG), with CGCLA being the second highest percentage of TFA with 4.21 %. Although CGCLA showed an increase in TFA when compared to CB and CG, this change in lipid profile increased in the cookies related to the fat used in its formulation, which has a higher percentage of essential fatty acids such as CLA.

The high percentage of AGV of CGV is related to the lipid profile of GV used in the elaboration of CGV. The process of vegetable fat hydrogenation increases the percentage of industrial trans fatty acids (iTFA), with these fatty acids being found in industrialized foods such as cookies and wafers that use this fat in their composition.[34] When evaluating the percentages of TFA in processed foods in the Portuguese market, Costa et al. (2016) observed that Trans-C18: 1 and its isomers were present in higher amounts in these foods.[7]

Elaidic acid (C18: 1 trans-9) is the main constituent of iTFA. Oleic acid (C18: 1) is an MUFA present in oils of vegetable origin. After the hydrogenation process, the oleic acid changes its spatial and biochemical conformation, forming elaidic acid.[38] These iTFA are associated with cardiovascular diseases, obesity, and CNCD. [39]

The PUFA percentage did not have much quantitative variation, with the highest percentage of CVF (15.48 %) and the lowest of CG (13.10 %); however, the lipid profile qualitatively differs between formulations. Among the PUFA, CGCLA and CG presented higher percentages of docosahexaenoic acid (DHA) (C22: 6n-3), which is associated with cardio-protective effect, neurological development, and anti-inflammatory properties.[26]

Another essential PUFA is CLA (C18: 2 c9t11), which was only present in ruminant fat, since isomerization and biohydrogenation of linoleic acid (C18: 2) and linolenic acid (C18: 3)

394 only occur in rumen or mammary glands of these animals. Meat or dairy products are the main
395 source of consumption of these TFAr [40, 41].

396 This natural transfat derived from ruminants exerts functional health properties such as
397 plasma antioxidant activity, antimutagenic and anticarcinogenic action, acting in the reduction
398 of cytotoxic agents in cancer cells. In addition, CLA triggers immune response stimuli against
399 atherosclerosis, diabetes mellitus and obesity prevention [3, 42].

400 After the preparation of the cookies, there was a reduction in CLA contents of 74 %
401 compared to fat enriched with CLA before cooking. This loss occurred in all cookies containing
402 CLA, however, the CGCLA still maintained a higher content of 70 % of this fatty acid
403 compared to the others. Therefore, the cookie with caprine enriched with CLA is an alternative
404 for the consumption of this essential fatty acid, since CLA is usually consumed through dairy
405 and meat products. Thus, the cookies with CLA diversify and add value to products of goat
406 origin and can help to produce a food with functional potential.

407

408 Principal component analysis

409 Figure 1 shows the graph resulting from Principal Component Analysis (PCA). The
410 first two factors explain 90.03 % of the variance, allowing relevant discrimination of the
411 samples as a function of the attributes evaluated, according to Piclin et al. (2008) and Nurgel et
412 al. (2004) [43, 44]. The first factor (A) explained 56.29 % of the variance, being positively
413 characterized by "b*", "proteins", "sugars", "moisture", "ashes", "fibers", "Aw", “purchases",
414 "SFA", “overall assessment" and "purchase intention", and negatively by "lipids", "MUFA" and
415 “TFA”. The second factor (B) explained 33.74 % of the total variance, relating positively to
416 "L", and negatively by "texture", "ashes" and "PUFA".

417

418 **Fig 1. PCA of the data for physical-chemical, physical, sensory and chromatographic of**
419 **the cookies**.
420 CVF (cookie with vegetable fat); CB (cookie with butter); CG (cookie with goat cream) and
421 CGCLA (cookie with enriched goat cream with CLA).
422
423 It can be observed that the analysis was able to separate the samples according to
424 similar characteristics, with the CVF formulation correlated with the monounsaturated fatty
425 acids and trans fatty acids; CB was related to polyunsaturated fatty acids and ashes; the CG and
426 CGCLA formulations obtained more attributes in common such as Aw, moisture, proteins,
427 fibers, purchase intention and overall evaluation. CGCLA was correlated with CLA,
428 considering that this formulation was the one that obtained the highest percentage of this PUFA.
429 The principal components among the four formulations corroborate the data obtained in the
430 analyzes described above.
431

432 Conclusion

433 The substitution of the hydrogenated vegetable fat and butter by goat cream in cookies
434 is feasible, since it does not alter the flavor, maintaining the sensorial acceptance and improving
435 the profile of fatty acids of the food, and increasing the levels of essential fatty acids like CLA.
436 This fact raises the biological properties of this food and may increase the demand for this
437 product by consumers seeking to eat tasty foods with functional potential.

438 Acknowledgments

439 This study was supported by Coordination of Improvement of Higher Level Personnel -
440 CAPES.

References

1. Mohamed H, El-Salam ABD, El-Shibiny S. Conjugated linoleic acid and vaccenic acid contents in cheeses: An overview from the literature. J. Food Compos. Anal. 2014; 33: 117–126.
2. Koba K, Yanagita T. Health benefits of conjugated linoleic acid (CLA). Obes Res Clin Pract. 2014; 8: 525-532.
3. Park Y, Pariza M, The bioactivities and potential mechanisms of action of the conjugated linoleic acid. Food Sci Biotechnol. 2009; 18: 586-593.
4. Lopez-Aliaga I, Alferez MJM, Nestares MT, Ros PB, Barrionuevo M, Campos MS. Goat milk feeding causes an increase in biliary secretion of cholesterol and a decrease in plasma cholesterol levels in rats. J. Dairy Sci. 2005; 88: 1024-1030.
5. Soares JKB, Melo APR, Medeiros, MAC, Queiroga RCRE, Bomfim MAD, et al. Anxiety behavior is reduced, and physical growth is improved in theprogeny of rat dams that consumed lipids from goat milk: An elevatedplus maze analysis. Neurosci. Lett.**.** 2013; .552: 25– 29.
6. Assis POA, Guerra JCB, Araujo, DFS, Junior RFA, Machado TADG, Araujo AA, et al. Intestinal anti-inflammatory activity of goat milk and goat yoghurt in the acetic acid model of rat colitis. Int Dairy J. 2016; 56: 45-54.
7. Costa N, Cruz R, Graça P, Breda J, Casal S. Trans fatty acids in the Portuguese food market. Food Control. 2016; 64: 128-134.
8. Tarancón P, Fiszman SM, Salvador A, Tárrega A. Formulating biscuit with healthier fats. Consumer profiling of textural and flavor sensations during consumption. Food Res. Int. 2013; 53 (1): 134-140.

464 9. Pareyt B, Talhaoui F, Kerckhofs G, Brijs K, Goesaert H, et al. The role of sugar and
465 fat in sugar-snap cookies: Structural and textural properties. J Food Eng. 2009; 90 (3)
466 400-408.
467 10. Gökmen V, Serpen A, Açar OÇ, Morales FJ. Significance of furosine as eat-induced
468 marker in cookies. J Cereal Sci. 2008; 48 (3): 843-847.
469 11. Bomfim MAD, Queiroga RCE, Aguila MB, Medeiros MC, Fisberg M, et al.
470 Abordagem multidisciplinar de P,D&I para o desenvolvimento de produto lácteo
471 caprino com alto teor de CLA e alegação de propriedade funcional. R. Bras. de
472 Zootec. 2011; 40: 98-106.
473 12. Sukhija PS, Palmquist DL. Rapid method for determination of total fatty acid content
474 and composition of feedstuffs and feces. J Agric Food Chem. 1988; v: 36 -1202-1206.
475 13. Palmquist DL, Jenkins TC. Challenges with fats and fatty acid methods. J Anim Sci.
476 2003; 12: 3250-3254.
477 14. Commission International de L'eclairage (CIE): "Recommendations on Uniform
478 Color Spaces, Color Difference Equations, Psychometric Color Terms". Supplement
479 No. 2 to CIE Publication No. 15, Colorimetry, Bureau Central de la CIE, Paris, 1978.
480 15. Association of Official Agricultural Chemists. Official methods of analysis of
481 Association of Official Agricultural Chemists. 19th ed., Ass. Off. Analytical. Chem.,
482 Washington, USA. 2012.
483 16. Folch J, Lees M, Stanley GHS. A simple method for the isolation and purification of
484 total lipids from animal tissues. J Biol Chem. 1957; 226: 497-509.
485 17. Dutcosky SD. Análise sensorial de alimentos. Curitiba: Champagnat, 4 ed; 2013.
486 18. Sigmastat (programa de computador). Versão 3.1. 2009; Point Richmond (Califórnia):
487 Comercial.

19. Faria EV, Yotsuyanagi K. Técnicas de Análise Sensorial**,** Campinas: ITAL/LAFISE, 2002.

20. Lara E, Cortes P, Briones V, Perez M. Structural and physical modifications of corn biscuits during baking process. LWT. 2011; 44: 622–630.

21. Marques GA, Brilhante JFB, Silva DA, Silva EMN. Whey protein as a substitute for wheat in the development of no added sugar cookies. LWT. 2016; 67: 118-126.

22. Laguna L, Salvador A, Sanz T, Fiszman SM. Performance of a resistant starch rich ingredient in the baking and eating quality of short-dough biscuits. LWT. 2011; 44: 737-746.

23. Sharma P, Gujral HS. Extrusion of hulled barley affecting b-glucan and properties of extrudates. Food Bioprocess Tech. 2013; 6: 1374-1389.

24. Bick MA, Fogaça AO. Cookies with different concentrations of quinoa flour in partial replacement of wheat flour. Braz. J. Food Technol. v. 17, n. 2, p. 121-129, 2014.

25. Peleg M, Normand MD. Symmetrized dot-patterns (SDP) of irregular compressive stress strain relationship. J. Texture Stud. 1992; 23: 427–438.

26. Umesha SS, Sai MR, Indiramma AR, Akshitha S, Naidu KA. Enrichment of biscuits with microencapsulated omega-3 fatty acid (Alpha-linolenic acid) rich Garden cress (*Lepidium sativum*) seed oil: Physical, sensory and storage quality characteristics of biscuits. LWT. 2015; 62: 654-661.

27. Bertolin TE, Centenaro A, Giacomelli B, Reinehr C, Gutkoski LC. Elaboration of biscuits with oatmeal and fat palm with added L-leucine and calcium for sarcopenia. LWT. 2013; 33: (2) 345-354.

28. Ripolles D, Parron JA, Calvo M, Perez MD, Fitzgerald RJ, et al. Antioxidant activity of co-products from milk fat processing and their enzymatic hydrolysates obtained with different proteolytic preparations. Int Dairy J. 2016; 60: 70-77.

513 29. Chung H, Cho A, Lim S. Utilization of germinated and heat-moisture treated brown
514 rices in sugar-snap cookies. LWT. 2014; 57: 260 - 266.
515 30. Arimi JM, Duggan E, O'sullivan M, Lyng JG, O'riordan ED. Effect of water activity
516 on the crispiness of a biscuit (Crackerbread): Mechanical and acoustic evaluation.
517 Food Res. Int. 2010; 43:1650-1655.
518 31. Laguna L, Primo-martín C, Varela P, Salvador A, Sanz T. HPMC and inulin as fat
519 replacers in biscuits: Sensory and instrumental evaluation. LWT. 2014; 56: 494-501.
520 32. Biguzzi C, Schlich P, Lange C. The impact of sugar and fat reduction on perception
521 and liking of biscuits. Food Qual Prefer. 2014; 35: 41–47.
522 33. Drewnowski A, Nordensten K, Dwyer J. Replacing sugar and fat in cookies: Impact
523 on product quality and preference. Food Qual Prefer. 1998; 9: 13–20.
524 34. Santos LAT, Cruz R, Casal, S. Trans fatty acids in commercial cookies and biscuits:
525 An update of Portuguese Market. Food Control. 2015; 47:141-146.
526 35. Gomes LC, Alcalde CR, Santos GT, Feihrmann AC, Molina BSL. et al. Concentrate
527 with calcium salts of fatty acids increases the concentration of polyunsaturated fatty
528 acids in milk produced by dairy goats. Small Rumin. Res. 2015; 124: 81–88.
529 36. Ruiz-Nunez BDA, Dijck-Brouwer J, Muskiet FAJ. The relation of saturated fatty acids
530 with low-grade inflammation and cardiovascular disease. J. Nutri. Biochem. 2016;
531 36: 1-20.
532 37. Gómez-Cortés P, Juárez M, Fuente MA. Milk fatty acids and potential health benefits:
533 An updated vision. Trends Food Sci Technol. 2018; 81: 1-9.
534 38. Ganguly R, Pierce GN. The toxicity of dietary trans fats. Food Chem Toxicol. 2015;
535 78: 170–176.

536 39. Ganguly R, Lavallee R, Maddaford TG, Devaney B, Bassett CMC, et al. Ruminant
537 and industrial trans-fatty acid uptake in the heart. J. Nutriti. Biochem.2016; 31: 60–
538 66.
539 40. Park Y. Conjugated linoleic acid (CLA): Good or bad trans fat?. J Food Composit
540 Anal. 2009; 22: 4–12.
541 41. Mele MC, Cannelli G, Carta G, Cordeddu L, Melis MP, et al. Metabolism of c9,t11-
542 conjugated linoleic acid (CLA) in humans. Prostaglandins Leukot. Essent. Fatty
543 Acids. 2013; 89: 115–119.
544 42. Razzaghia A, Naseriana AA, Valizadeha R, Ebrahimia SH.; Khorramia B, et al.
545 Pomegranate seed pulp, pistachio hulls, and tomato pomace as replacement of wheat
546 bran increased milk conjugated linoleic acid concentrations without adverse effects on
547 ruminal fermentation and performance of Saanen dairy goats. Anim Feed Sci Technol.
548 2015; 210: 46-55.
549 43. Piclin N, Pintore M, Lanza CM, Scacco A, Guccione S, et al. Sensory analysis of red
550 wines: discrimination by adaptive fuzzy partition. J Sens Stud. 2008; 23: 58-569.
551 44. Nurgel C, Pickering GJ, Inglis DL. Sensory and chemical characteristics of Canadian
552 ice wines. J Sci Agric. 2004; 84: 1675- 1684.
553

554 Supporting information

555 **S1 Table. Fatty acid profile present in fats in percentage.** [a] VF: vegetable fat; [b] B: butter, [c]
556 G: goat cream; [d] GCLA: goat cream with CLA, expressed as a percentage.

557 **S2 Table. Ingredients used in the formulations of cookies for 100 g of fresh dough.** [a] CVF
558 - vegetable fat; [b] CB - butter; [c] CG - goat cream; [d] CGCLA - goat cream with CLA.

559 **S3 Table. Physical parameters of cookies with different lipid sources.** Means ± standard
560 deviation with different letters on the same line differed by Tukey's test ($p < 0.05$). CVF - vegetable
561 fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.
562 **S4 Table. Physico-chemical parameters of cookies made with different lipid sources.** Averages
563 ± standard deviation with different letters on the same line differed by Tukey's test ($p<0.05$). CVF
564 - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.
565 **S5 Table. Mean values of sensory acceptance and purchase intention tests.** Averages ±
566 standard deviation with different letters on the same line differed by Tukey's test ($p<0.05$). CVF
567 - vegetable fat; CB - butter; CG - goat cream; CGCLA - goat cream with CLA.
568 **S6 Table. Distribution of the scores according to the order of general preference by the**
569 **tasters (n = 123) in the sensory analysis of cookies.** * 1 = least preferred, 4 = most
570 preferred.
571 ** Sum of the orders of each sample = (1 x number of tasters) + (2 x number of tasters) + (3
572 x number of tasters) + (4 x number of tasters).
573 CGV - Vegetable fat; CM - Butter; Caprine CNCLA - Goat cream enriched with CLA).
574 **S7 Table. Profile of fatty acids present in cookies in percentage.** [a] CGV (cookie with
575 vegetable fat); [b] CB (cookie with butter); [c] CG (cookie with goat cream); [d] CGCLA (cookie
576 with goat cream enriched with CLA).
577 **S1 Fig. PCA of the data for physical-chemical, physical, sensory and chromatographic of**
578 **the cookies**. CVF (cookie with vegetable fat), CB (cookie with butter), CG (cookie with goat
579 cream) and CGCLA (cookie with enriched goat cream with CLA).
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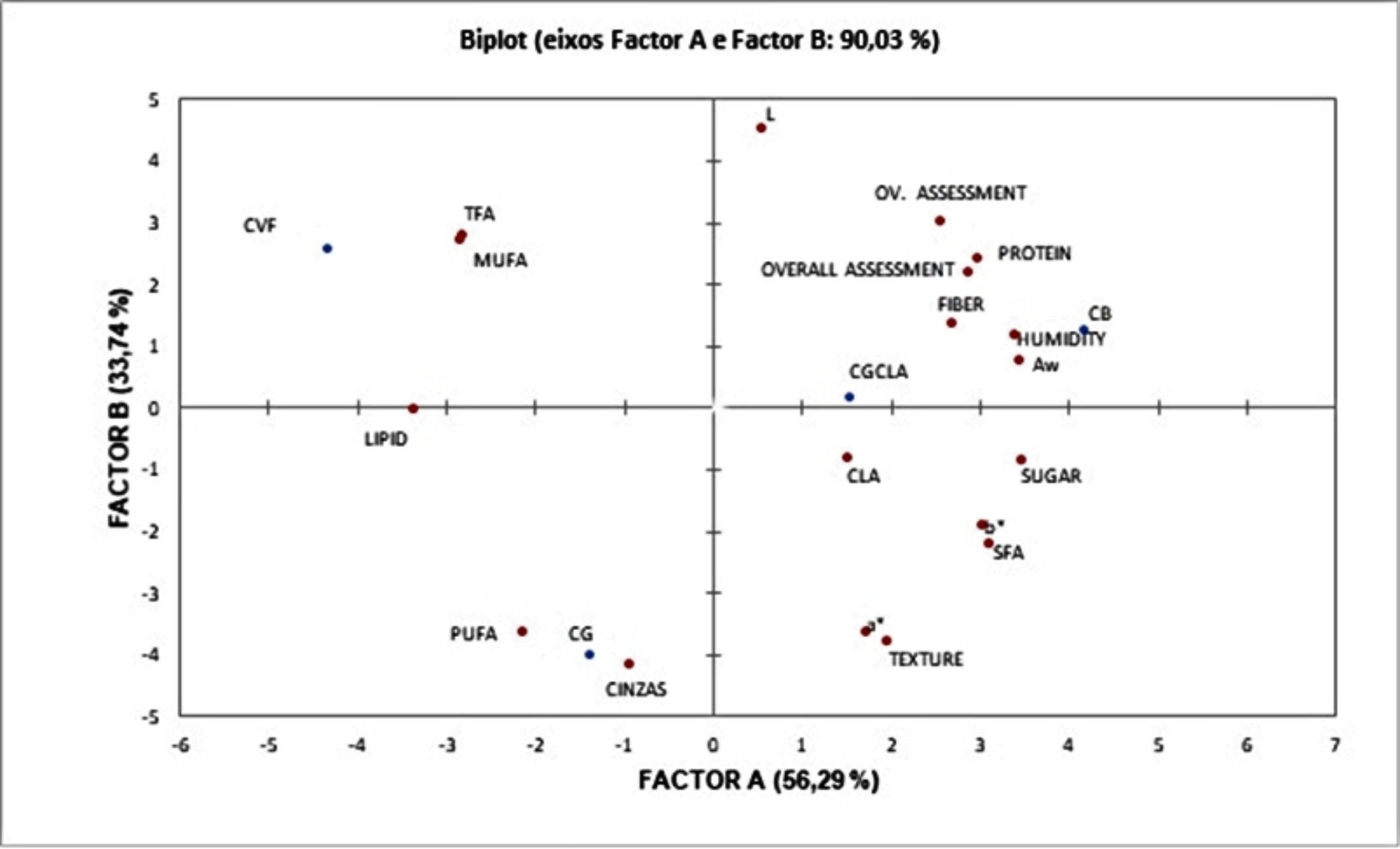
Biplot (eixos Factor A e Factor B: 90,03 %)
FACTOR B (33,74 %)
FACTOR A (56,29 %)
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TEXTURE
PUFA
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Figure