Fatty Acid Composition and Cholesterol Levels of Set Type Yoghurts Produced from Camel (*Camelus Dramedarius)* Milk Enriched with Native Rice Flour

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ABSTRACT---- ***Three different types of set type yoghurt were produced from camel (Camelus dramedarius) milk (CaM). The 1st yoghurt type (Y_{SMP}) was produced by adding 9% (w/v) skim milk powder (SMP) to camel milk, the 2nd yoghurt type (Y_{NRF}) was produced by adding 9% (w/v) native rice flour (NRF) (from Oryza sativa L. ssp. japonica) to the camel milk and the 3rd yoghurt type ($Y_{SMP+NRF}$) was produced by adding a 50/50 (w/v) SMP+NRF mixture to the camel milk. Samples were stored for 10 days at 4°C±1. Fatty acid composition and cholesterol levels analyses were conducted at the 12th hour and 10th days of storage. Throughout the storage, short and medium chain fatty acids (SFA) decreased. Long chain fatty acids decreased in YSMP, but increased in other samples. MUFA and PUFA increased in YSMP+NRF, but decreased in YNRF. In YSMP, PUFA decreased, while MUFA increased. DHA, oleic acid, linoleic acid, MUFA, PUFA ratios increased in YSMP+NRF throughout the storage period. Cholesterol levels decreased in all samples throughout storage; the highest decrease was determined in YSMP+NRF (7.60%).***

Keywords--- Camel milk, yoghurt, Native Rice Flour, Fatty acid,

1. INTRODUCTION

Yoghurt is a fermented dairy product produced from the lactic acid fermentation of milk by *Lactobacillus delbrueckii subsp. bulgaricus (Lb.bulgaricus)* and *Streptococcus thermophilus (Str. thermophilus)* bacteria. Starter cultures used in the production grow better in the presence of glucose and some other sugars (sucrose, maltose)[1]. Yoghurt has several industrial types including set type, stirred type, drinking type, frozen type and concentrated type. In order to improve consistency and viscosity in the yoghurt, dry matter should be increased in the processed milk. Skim milk powder is the most frequently used ingredient for this purpose. This process, however, is not adequate for the prevention of physical deteriorations in the yoghurt[2]. Accordingly, animal colloids (skimmed milk powder, whey powder, caseinate, gelatin) and vegetable colloids (locust bean flour, pectin, various vegetable gums, agar, cereal starches including barley, oatmeal, corn and rice) can be added as stabilizers individually or as mixtures in certain ratios to milk which will be used for yoghurt production[3,4].

Camel milk can be consumed by lactose intolerant individuals[5], it is hypoallergenic[6] and its immunoglobulin G ratio (1.64 $mg.mL^{-1}$) is higher than that of cow's, ewe's, buffalo's and human milk[7]. Camel milk is anti-diabetic [8], antimicrobial, antiviral [9], anti-carcinogenic, anti-hypertensive[8] and renoprotective[10], it enhances immune function, increases metabolic rate, improves bone formation and muscle mass, it has therapeutic effects against certain diseases including hepatitis B and autism[11] and tuberculosis[12].There have been studies on the production of yoghurt supplemented with skimmed milk powder[13], probiotic yoghurt[9,14], stabilizer-supplemented yoghurt[15,16], yoghurt supplemented with different spices[17] and flavored yoghurt[18]from camel milk.

Most of the rice (*Oryza sativa*) produced is directly as food, although some is also consumed as native rice flour (NRF) obtained via trituration. The quality of NRF varies depending on its physicochemical properties[19,20,21]. Starch, which is the main component of NRF, consists of two glucose polymers called amylose and amylopectin. These polymers affect the functional, adhesion, gelatinization and retrogradation properties of NRF[22,23].

In this study, NRF obtained from rice (*Oryza sativa* L. ssp. *japonica*) was examined in terms of its usability for the enrichment of camel milk used for yoghurt production. Its effects on Fatty Acid Composition and Cholesterol levels of yogurt after different storage periods were compared with skim milk powder.

2. MATERIAL AND METHODS

2.1.Raw camel, Native rice flour, freeze-dried yogurt culture and Skim milk powder

Raw camel (*Camelusdramedarius)* milk (CaM) used in the study was obtained from a local camel farm in Sarayköy, Denizli (Turkey). Native rice flour (NRF)(content data according to the producer: fat 0.70%; protein 6.79%; starch 85.42%; amylose %18.22, amylopectin 65.20%; moisture 6.12% and ash 0.35%) produced from *Oryza sativa* L. ssp. *japonica* was obtained from a local company in Turkey. JOINTEC VB530 freeze-dried yogurt culture was obtained from CSL laboratories (Strade per Merlino, 3,26839, Italy). Skim milk powder(content data according to the producer: fat 0.48%; protein 35.12%; lactose 51.14%) was obtained from Pınar Sut Inc. (Kemalpaşa, Izmir, Turkey). Yoghurt samples were produced in pilot plants in Ege University, Faculty of Agriculture, Department of Dairy Technology.

2.2.Set Type Yoghurt Production

Set type yoghurts were produced from camel milk enriched with skimmed milk powder (SMP), natural rice flour (NRF) and SMP + NRF with starter cultures (*Lb. bulgaricus*and *Str. thermophilus)*. Camel milk was divided into three parts. 9% (w/v) SMP (Y_{SMP}) was added to the 1st part, 9% (w/v) NRF (Y_{NRF}) was added to the 2nd part and 4.5% (w/v) NRF + 4.5% (w/v) SMP ($Y_{SMP+NRF}$) was added to the 3rd part. The SMP ratio added to the milk was higher than the reference value reported by Salih and Hamid[13] (7% skim milk powder). NRF ratio was determined based on the results of preliminary trials. In the preliminary trials, 4% (w/v), 5% (w/v), 7% (w/v) and 9% (w/v) NRF were added. The best results regarding appearance, structure-consistancy, and flavor-aroma was achieved with the 9% (w/v) treatment. Rice flour, as recommended by Schmidt et al.[24], was added not modified but in natural form. Milks were pasteurized considering the maximum gelatinization temperature [25]of low amylose (18.22%) at 85°C for 20 minutes and cooled to 42-43°C. Each treatment was inoculated with 3% starter cultures and left to incubate. Incubation was stopped at pH 4.60 (approximately 12 hours) and stored at 4°C±1 for 10 days. On the 12^{th} hour, 1^{st}, 5^{th}, 7^{th} and 10^{th} days, physicochemical, rheological, microbiological and sensory analyses were carried out.

2.3.Determination of Fatty Acid Composition of Samples

2.3.1.Oil extraction and preparation of fatty acid methyl ester

Each sample was homogenized and fat was obtained by extraction[26]. Fatty acid methyl esters were prepared according to[27] and analyzed by gas chromatography (GC) (Chromatography: Supelco SP-2380 fused silica capillary column, 60m0.25mm i.d., 0.2 mm film thickness; Supelco Inc., Bellefonte, PA, USA) with a flame ionizing detector (Hewlett-Packard GC model 6890). Injection volume was 1µL. GC oven temperature was programmed as increasing from 100 °C to 220 °C at 4°C/min. Injector and detector temperature were 300°C, carrier gas was helium and the flow rate was 1 mL/min.

2.3.2.Determination of Cholesterol in the Samples

Cholesterol levels of the samples were analyzed according to Ossa et al.[28] and then examined by gas chromatography (GC) (Chromatography;HP 5-silica capillary column (25mx0.32mmi.d., 0.52 mm film thickness, Hewlett-Packard, USA) with a flame ionizing detector (Hewlett-Packard GC model 6890). Injection volume was 1µL. GC detector temperature was 300°C, injector temperature was 280°C and column temperature was 270°C for 15 minutes. Carrier gas was helium and flow rate was 1.5 mL/min.

3. RESULT AND DISCUSSION

Fatty acid compositions of yoghurts produced from camel milk on the 12th hour (X) and the 10th day are given in Table 1 and the cholesterol levels are given in Table 2.

Table 1.*Fatty acid composition in Y_{SMP}, Y_{NRF} and $Y_{SMP+NRF}$ samples at the 12th hour (X) and the 10th day (Y) (g/100g).*

Name of Fatty Acid Methyl Ester and Formula of Molecule	Y_{SMP}		Y_{NRF}		$Y_{SMP+NRF}$	
	X	**Y**	**X**	**Y**	**X**	**Y**
Butyric Acid Methyl Ester (C4:0)	ND	ND	ND	ND	ND	ND
Caproic Acid Methyl Ester (C6:0)	0.0134	0.0128	0.0229	0.0161	0.0278	0.0149
Caprylic Acid Methyl Ester (C8:0)	ND	ND	ND	ND	ND	ND
Capric Acid Methyl Ester (C10:0)	0.0052	0.0052	0.0053	0.0036	0.0060	0.0052
Undecanoic Acid Methyl Ester (C11:0)	ND	ND	ND	ND	ND	ND
Lauric Acid Methyl Ester (C12:0)	0.0414	0.0412	0.0335	0.0319	0.0349	0.0339
Tridecanoic Acid Methyl Ester (C13:0)	0.0104	0.0107	0.0071	0.0086	0.0105	0.0112
Myristic Acid Methyl Ester (C14:0)	0.3439	0.3365	0.3320	0.3158	0.3514	0.3476
Myristoleic Acid Methyl Ester (C14:1)	0.0412	0.0377	0.0353	0.0354	0.0480	0.0474
Pentadecanoic Acid Methyl Ester (C15:0)	0.0317	0.0289	0.0263	0.0261	0.0326	0.0313
cis-10- Pentadecanoic Acid Methyl Ester (C15:1)	0.0630	0.0612	0.0534	0.0530	0.0611	0.0593
Palmitic Acid Methyl Ester (C16:0)	0.9918	0.9535	1.0167	0.9630	0.9825	0.9620
Palmitoleic Acid Methyl Ester (C16:1)	0.2521	0.2667	0.2801	0.2635	0.2906	0.3010
Heptadecanoic (Margaric) Acid Methyl Ester C17:0)	0.0283	0.0289	0.0271	0.0251	0.0281	0.0283
cis-10-Heptadecanoic Acid Methyl Ester (C17:1)	0.0179	0.0204	0.0218	0.0193	0.0188	0.0198
Stearic Acid Methyl Ester (C18:0)	0.6751	0.6407	0.5854	0.5642	0.6011	0.6005
Oleic Acid Methyl Ester (C18:1n9c)	1.0116	1.0269	0.0174	1.0165	1.0309	1.0366
Linoleic Acid Methyl Ester (C18:2 n6c)	0.0787	0.0783	0.0945	0.0923	0.1188	0.1192
γ-Linolenic Acid Methyl Ester (C18:3 n6)	0.0063	0.0056	0.0068	0.0061	0.0071	0.0067
Arachidic Acid Methyl Ester (C20:0)	0.0037	0.0041	0.0090	0.0090	0.0071	0.0078
cis-11- Eicosenoic Acid Methyl Ester (C20:1)	0.0224	0.0364	0.0380	0.0372	0.0330	0.0339
cis-11,14-Eicosadienoic Acid Methyl Ester (C20:2)	0.0100	0.0183	0.0094	0.0093	0.0120	0.0123
Arachidonic Acid Methyl Ester (C20:4n6)	0.0310	0.0237	0.0128	0.0118	0.0086	0.0056
Behenic Acid Methyl Ester (C22:0)	0.0060	0.0070	0.0060	0.0068	0.0060	0.0075
Erucic Acid Methyl Ester (C22:1 n9)	ND	0.0037	0.0086	0.0064	ND	ND
Lignoceric Acid Methyl Ester (C24:0)	ND	ND	ND	ND	ND	ND
DokosahekzaenoikAcid Methyl Ester (DHA) (C22:6n3)	0.0038	0.0041	0.0064	0.0039	0.0038	0.0048
Other fatty acids	0.0313	0.0479	0.0320	0.0329	0.0536	0.0448
Short-chain fatty acids (4-6C)	0.0183	0.0178	0.0229	0.0161	0.0278	0.0149
Medium-chain fatty acids (8-12C)	0.0504	0.0464	0.0387	0.0354	0.0409	0.0392
Long-chain fatty acids (>12C)	3.5894	3.5516	3.4955	3.6664	3.6274	3.6278
Saturated fatty acids (SFA)	2.1597	2.0739	2.0714	1.9701	2.0880	2.0541
Monounsaturated fatty acids (MUFA)	1.4047	1.4666	1.5048	1.4324	1.4824	1.4980
Polyunsaturated fatty acids (PUFA)	0.1343	0.1217	0.1519	0.1446	0.1260	0.1294

ND:Non-detected

$Y_{SMP:}$ Yoghurt with skim milk powder
Y_{NRF} : Yoghurt with native rice flour

Camel milk fatty acid composition varies depending on type of camel, regional, seasonal and nutritional differences; the milk fatty acid composition in turn is a determinant for the fatty acid composition of the product[29, 30]. In this study, between the 12th hour and the 10th day of the storage, short [4-6C), medium [8-12C) and saturated fatty acids (SFA) decreased in all samples and long chain fatty acids (>12C) increased in $Y_{NRF}$and $Y_{SMP+NRF}$. Also, mono-unsaturated fatty acids (MUFA) increased in Y_{SMP} (4.73%)and $Y_{SMP+NRF}$ (1.56%) while poly-unsaturated fatty acids (PUFA) decreased by 9.38% in Y_{SMP} andincreased by 2.69% in $Y_{SMP+NRF}$ throughout the storage. Regarding Y_{NRF}, it was also found that the amount of MUFA and PUFA ratios decreased during storage.

DHA levels increased in $Y_{SMP+NRF}$ and Y_{SMP} throughout the storage; the highest increase was determined in $Y_{SMP+NRF}$ (23.07%). DHA levels decreased in Y_{NRF}. In yoghurt samples, palmitic acid, γ-linolenic acid and arachidonic acid levels decreased throughout the storage.Oleic acid levels increased in Y_{SMP} and $Y_{SMP+NRF}$, while they decreased in Y_{NRF}. Linoleic acid levels increased in $Y_{SMP+NRF}$ but decreased in other samples. As a result, in yoghurt samples produced from camel milk, especially in $Y_{SMP+NRF}$, fatty acids which have beneficial effects(DHA (C22: 6n3), oleic acid (C18:1n9c), linoleic acid (C18:2 n6c), MUFA, PUFA) levels increased throughout the storage, while SFA, which has deleterious effects, decreased. In Y_{SMP}, MUFA, DHA and oleic acid levels increased while SFA and PUFA levels decreased.

Table 2. *Cholesterol levels in Y_{SMP}, Y_{NRF} and $Y_{SMP+NRF}$ samples at the 12th hour (X) and the 10th day (Y) (g/100g).*

Y_{SMP}		Y_{NRF}		$Y_{SMP+NRF}$	
X	**Y**	**X**	**Y**	**X**	**Y**
11.83	11.46	9.58	9.21	8.81	8.14

It was determined that cholesterol levels decreased in yoghurt samples throughout the storage. Accordingly, the highest decrease from the 12th hour to the 10th day was 7.60% in $Y_{SMP+NRF}$, 3.86% in Y_{NRF}, and 3.12% in Y_{SMP}, respectively. The relationship between colloid type/ratio and cholesterol levels and the relationship between colloid type/ratio and storage were both found to be significant ($p<0.05$) (Table 2). Cholestrol level of camel milk has been reported to be higher than that of cow's milk by some researchers[30,31], while others have reported it to be lower[12,32].

Yoghurt is described as a functional food[33]. The increase in beneficial fatty acids, decrease in deleterious fatty acids, and the highest decrease in cholesterol levels throughout the storage period in $Y_{SMP+NRF}$ show that using NRF and SMP together improves the functional properties of the yoghurt. The results demonstrated that solitary use of SMP and especially NRF did not have such an effect.

Cholesterol levels decreased significantly in YSMP+NRF and beneficial fatty acids increased whereas deleterious fatty acids decreased. In this study, unaccompanied use of rice flour in yoghurt production was not possible. However, it was concluded that it is possible to produce yoghurt from camel milk with the addition of 4.5% SMP and 4.5% NRF containing low levels of amylose (18.22%).

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