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Emulsion characteristics, chemical and textural properties of meat systems produced with double emulsions as beef fat replacers

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ABSTRACT

In recent years, double emulsions are stated to have a promising potential in low-fat food production, however, there are very few studies on their possible applications in meat matrices. We aimed to investigate the quality of beef emulsion systems in which beef fat was totally replaced by double emulsions ($W_1/O/W_2$) prepared with olive oil and sodium caseinate (SC) by two-step emulsification procedure. Incorporation of $W_1/O/W_2$ emulsion resulted in reduced lipid, increased protein content, and modified fatty acid composition. $W_1/O/W_2$ emulsion treatments had lower jelly and fat separation, higher water-holding capacity and higher emulsion stability than control samples with beef fat. Increased concentrations of $W_1/O/W_2$ emulsions resulted in significant changes in texture parameters. TBA values were lower in $W_1/O/W_2$ emulsion treatments than control treatment after 60 days of storage. In conclusion, our study confirms that double emulsions had promising impacts on modifying fatty acid composition and developing both technologically and oxidatively stable beef emulsion systems.

1. Introduction

A double emulsion is a multi-layered dispersion system described as "emulsion of an emulsion", in which oil-in-water (O/W) and water-in-oil (W/O) morphologies coexist together (Benichou, Aserin, & Garti, 2004, 2007; Dickinson, 2011; Garti, 1997; Muschiolik, 2007). In a $W_1/O/W_2$ double emulsion, W_1 and W_2 constitute internal and external water phases, respectively, while two different interface layers are present as: W_1–O surrounding internal water droplets and O–W_2 surrounding oil droplets (McClements, Decker, & Weiss, 2007).

Today double emulsions are believed to have noticeable application opportunities in the food industry. Utilization of double emulsions in food matrices is mainly based on two strategic purposes: The first purpose is to encapsulate various aromas, bioactive compounds or sensitive food components, by this way keeping them at a controlled level during consumption and digestion, and masking off-flavor, developing taste, controlling the release or protection of labile ingredients and preventing oxidative deterioration (Bou, Cofrades, & Jiménez-Colmenero, 2013; Choi, Decker, & McClements, 2009; de Cindio, Grasso, & Cacace, 1991; Dickinson, 2011; Garti, 1997; McClements et al., 2007; O'Regan & Mulvihill, 2010). The second strategy of $W_1/O/W_2$ double emulsion applications is to allow the production of healthier and low-fat food products (Bou et al., 2013; Choi et al., 2009; de Cindio et al., 1991; Dickinson, 2011; Garti, 1997; Jiménez-Colmenero, 2013; Jiménez-Colmenero et al., 2015; McClements et al., 2007). As is known, in recent years there has been a rising demand for consumption of healthier meat products all over the world, due to high and saturated fat content of these products. Therefore, utilization of double emulsions as fat replacers presents a novel alternative for reduction of total fat and modification of fatty acid composition, meanwhile protecting functional quality. Although there have been some studies regarding production of different low-fat milk products with double emulsions (Lobato-Calleros et al., 2008; Lobato-Calleros, Recillas-Mota, Espinosa-Solares, Alvarez-Ramirez, & Vernon-Carter, 2009; Lobato-Calleros, Rodriguez, Sandoval-Castilla, Vernon-Carter, & Alvarez-Ramirez, 2006; Márquez & Wagner, 2010; Xu, Liu, Ma, & Yan, 2011), there has been very little research reported on the possible applications of double emulsions in meat systems. Bou

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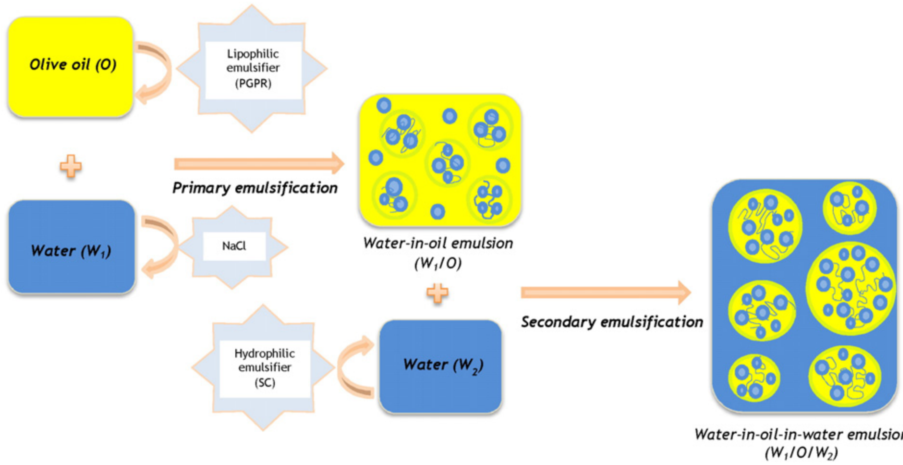

Fig. 1. Preparation of $W_1/O/W_2$ double emulsions by two-step emulsification procedure.

et al. (2013) stated that it could be possible to produce double emulsions as low-fat food ingredients for the meat industry. The researches targeted to evaluate the utility of double emulsions as pork backfat replacers in meat systems showed that double emulsions had promising effects on major fat reduction and functional properties (Cofrades, Antoniou, Solas, Herrero, & Jiménez-Colmenero, 2013; Freire, Bou, Cofrades, Solas, & Jiménez-Colmenero, 2016). To the best of our knowledge, there have been no reports concerning beef fat replacement with $W_1/O/W_2$ double emulsions in beef model systems.

The objectives of this study were: (1) production of $W_1/O/W_2$ double emulsions consisting of olive oil and sodium caseinate to be incorporated in a model beef emulsion system as beef fat replacers, (2) investigating the physical and chemical characteristics of model system meat emulsions produced with different amounts of $W_1/O/W_2$ double emulsions, and (3) developing functional and healthier meat emulsion systems with low-fat content and modified fatty acid composition, meanwhile providing equivalent stability parameters of full-fat meat systems.

2. Material and methods

2.1. Raw material

The study was performed in Ege University Food Engineering Department (İzmir, Turkey). Fresh boneless post-rigor lean beef (M. semitendinosus) and beef fat were purchased from Tesco Kipa Co. (İzmir, Turkey), extra virgin olive oil was supplied from Tariş Co. (İzmir, Turkey) (according to the specifications of the supplier, it was consisted of 70.98% oleic acid (C18:1), 12.46% palmitic acid (C16:0), 11.4% linoleic acid (C18:2), 2.66% stearic acid (C18:0), 0.5% linolenic acid (C18:3) and 2243 ppm total sterol), oil phase emulsifier polyglyserol polyricinoleate (PGPR) was obtained from Çağdaş Chemicals Co. (İstanbul, Turkey) and sodium caseinate (SC) as lyophilized powder (min. 90.0% protein on a dry basis) was kindly donated by Hasal Tarım Co. (İzmir, Turkey).

2.2. Preparation of $W_1/O/W_2$ double emulsions

$W_1/O/W_2$ double emulsions were prepared at room temperature (25 ± 2 °C) according to the two-step emulsification procedure previously described by Dickinson and McClements (1996) and modified by Cofrades et al. (2013) and Lobato-Calleros et al. (2006). The procedure diagram is illustrated in Fig. 1. The ratios of W_1:O and W_1/O:W_2 phases were applied as 1:1 and 7:3, respectively. The inner water phase (W_1) was consisted of distilled water with 0.6% NaCl (w/w). Oil phase (O) was prepared by mixing olive oil and 6.4% (w/w) PGPR in a shaking water bath (NÜVE, Turkey) at 50 °C for 20 min. The primary emulsion (W_1/O) was prepared by pipetting W_1 into O at a constant speed (25 ml/min) and simultaneously emulsifying the phases by a high shear homogenizer (IKA ULTRA-TURRAX® T25, Germany) at 4400 rpm. Outer water phase (W_2) was prepared by mixing 10% SC and 0.6% NaCl on a hot plate stirrer (Stuart, Bibby Scientific, UK) at 50 °C and 600 rpm for 5 min. After that, W_2 was held in a 50 °C water bath for 1 h to improve the solubility. W_1/O and W_2 were kept at 4 °C refrigerator for 12 h for fixation of the phases before secondary emulsification.

In the second step, W_1/O and W_2 were placed in a 50 °C water bath until their temperatures reached to room temperature. After that, W_2 was placed into ice bath to avoid destabilization, and W_1/O was pipetted onto W_2 while emulsifying by a homogenizer at 5200 rpm. After the pipetting operation had finished, $W_1/O/W_2$ emulsion was further emulsified for 10 min. The produced $W_1/O/W_2$ emulsion was used directly as fat replacer in formulation of model system meat emulsions.

2.3. Experimental design

Model system meat emulsions (MSMEs) were prepared either with beef fat (control) or $W_1/O/W_2$ double emulsions as fat replacers. Treatment combinations consisted of 4 different formulations were as follows: (1) MSME prepared with 10% beef fat (control-**C**), (2) MSME prepared with 10% $W_1/O/W_2$ double emulsion (**DE-10**), (3) MSME

Table 1
Formulation of model system meat emulsion (MSME) treatments.

Treatment groups[1]	Beef (g)	Beef fat (g)	$W_1/O/W_2$ (g)	Ice (g)	NaCl (g)	STPP (g)	Sodium nitrite (g)	Total (g)
C	325.00	50.00	0.00	114.175	10.00	0.75	0.075	500.00
DE-10	325.00	0.00	50.00	114.37	9.805	0.75	0.075	500.00
DE-20	325.00	0.00	100.00	64.565	9.61	0.75	0.075	500.00
DE-30	325.00	0.00	150.00	14.76	9.415	0.75	0.075	500.00

[1] **C:** MSME prepared with 10% beef fat (control), **DE-10:** MSME prepared with 10% $W_1/O/W_2$ double emulsion, **DE-20:** MSME prepared with 20% $W_1/O/W_2$ double emulsion, **DE-30:** MSME prepared with 30% $W_1/O/W_2$ double emulsion.