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Utilization of plant proteins for solid fat substitutes (#522)

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Introduction

The rising interest in meat analog products is based on four major trends: growing world population, an increasing interest in nutritional and environmental aspects, as well as an increase in the vegetarian diet [1]. Unfortunately, due to lack of solid fat alternatives, palm oil is used in many vegan products (e. g. VEGGYNESS Vegan Chorizo from TOPAZ GmbH or CHEATIN Chicken Style Slices from V-Bites Foods Limited). Palm oil is known to have a negative environmental impact as deforestation, in order to make way for oil palm plantations, destroys the habitat of many species [2]. For people that pay attention to environmental aspects, these products are unsuitable. In the past years, organogels – dispersed vegetable oils, mineral oils or organic solvents that are structured by an organogelator – became of interest of industry. They provide solid-like properties and high nutritional quality, as use of saturated fatty acids can be avoided. Oleogels can be induced directly, e. g. by heat, causing reorganization of gelators or indirectly by emulsification or solvent exchange technique [3]. Based on the indirect induction by emulsification, the eligibility of plant protein isolates (1x soy, 2x pea and 1x potato) to form solid fat emulsions from canola oil was analyzed and respective emulsion properties evaluated, aiming a fat substitute for vegan sausages.

Methods

Canola oil and protein suspensions (8.0 – 11.5 % (w/w) protein) from pea 1, pea 2, soy and potato protein isolate were emulsified with different ratios (o/w 65:35 – 75:25) using Ultra Turrax® T25 with dispersion tool S25N 25G (IKA Labortechnik, Germany) at 16,000 rpm until solid. After heating to 65 °C and subsequent cooling (4 °C), the optimal ratio of protein and oil was determined visually by emulsion appearance (homogenous, non-emulsified oil, instable) and instrumental by firmness using texture analyzer TA-XT2 (Stable Micro Systems, UK). The effect of protein concentration on emulsion structure and stability was analyzed via CLSM (Eclipse E600, Nikon, JP), oscillation rheometer (TA Instruments, DE), droplet-size distribution in cream (Mastersizer 2000, Malvern Instuments, UK), and amount in extractable fat (petroleum ether extraction), using 70 % o/w emulsions.

Results

First, different amounts of oil and 8.0 – 11.5 % (w/w) protein suspension were dispersed to analyze the effect of oil-to-protein ratio on emulsion-gel firmness. Maximum pressure and thus firmness of the emulsions increased with increasing protein and oil content. In case of pea 1 the emulsifying capacity was reached at o/w ratio 75:25 with 11.5 % protein in suspension, indicated by emulsion instability and phase separation. Also soy emulsions with o/w ratio 75:25 and 11.5 % protein in suspension decreased in firmness. Generally, firmness was in ascending order pea 1 < pea 2 ≤ potato < soy, whereat at o/w ratio 70:25 and 11.5 % protein in suspension potato formed by far the firmest emulsions. To allow comparison of all proteins, an o/w ratio of 70:30 was chosen to analyze the effect of protein concentration on emulsion-gel structure and stability. Particle size distribution with 8, 10, and 11.5 % protein in the continuous phase indicated macro emulsions. Smallest volumetric mean diameters (D[4,3]) of oil droplets in cream were obtained with 8 % pea 1 and 10 % pea 2 protein, 18 and 13 µm, respectively, while potato (10 % optimum) and soy (8 % optimum) revealed mean diameters of 47 and 70 µm (Tab 1). The amount of extractable fat reflected these results with lowest percentage for pea 1 and 2 emulsions (< 2 % and < 0.5 %), followed by soy with a slightly higher percentage (5 – 7 %). Potato emulsions emerged to be instable as extractable fat was > 25 %. A closer view by CLSM revealed that potato protein formed a fine gel-network instead of forming an interphase between oil and water droplets. Thus, it did not function as emulsifier, pointed up by non-emulsified oil explaining the high amount of extractable fat and the high firmness (Fig. 1). By contrast, leguminous proteins formed an interphase between oil and water. For them, it is known that protein gelling only occurs upon heating [4, 5] allowing the action as emulsifiers prior to heat-induced gel formation. All leguminous proteins microscopically showed insufficient emulsification when 8 % protein suspension was used. These results are reflected in the droplet size distribution, as besides many small also many big droplets are present. Consequently, D[4,3] values alone cannot be used to make a statement about how finely dispersed oil is. Increasing protein concentration reduced droplet size and enhanced dispersion matching the increasing firmness. For soy, saturation of the system was shown using 11.5 % protein suspension. Optimum protein amount for pea 2 and soy can be assumed between 10 and 11.5 % and needs to be further examined.

Conclusion

We conclude that potato protein is an improper emulsifier due to its ability to form polymeric gel networks after solubilization. Leguminous proteins, which form aggregated dispersions, suit better to incorporate emulsified oil in the gel network.

Notes

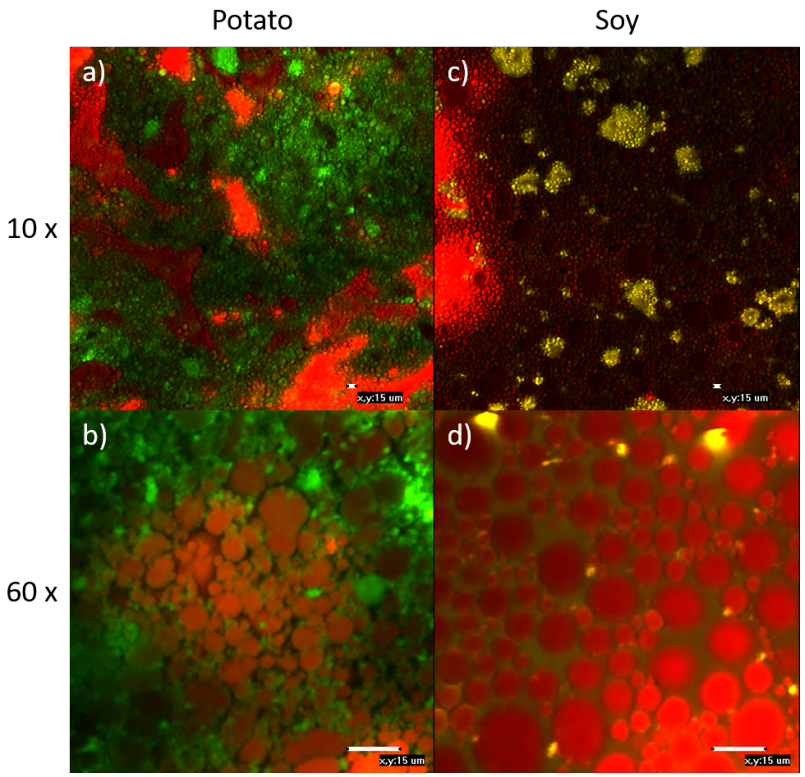

Figure 1. CLSM images of potato (a, b) and soy protein emulsions (c, d). Emulsions were made with o/w ratio 70:30 and 8 % protein in suspension. Protein was stained with Fluorescein (green signals) and canola oil with Nile red (red signals). Enlargement: 10x (a, c) and 60x (b, d). Bars: 15 µm.

	Volume mean diameter D[4,3] in µm		
Protein Concentration	**8 %**	**10 %**	**11.5 %**
Pea 1	18.18±5.27	19.82±0.87	21.30±7.27
Pea 2	18.85±5.44	13.23±0.47	16.89±1.74
Potato	65.03±29.13	46.56±0.42	69.39±5.62
Soy	69.54±10.29	91.41±0.76	76.65±6.43

Table 1, Volume mean diameter D[4,3] (µm) values of Pea 1, Pea 2, Potato and Soy-based Emulsions. Emulsions were prepared with canola oil and o/w ratio 70:30 using 8, 10 or 11.5 % protein in suspension.

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