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Structure of a new functional walnut oil-enriched mayonnaise

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The aim of this work was to study the structure of a walnut oil-enriched mayonnaise, characterized by a high content of polyunsatured n-3 and n-6 fatty acids.
Close packing structure of spherical and uniform oil droplets are observed in the control sample. When walnut oil is added, the droplets are polydisperse and the samples present a less close packing structure. The structure stability increases by increasing the rotation speed. Viscoelastic behaviour of the dressing sauce samples is affected by oil type, rotation speed and storage time. The increase in walnut oil content leads to the diameter dimensions oil droplets increase and consequently viscoelastic properties decrease. For each walnut oil content, the viscoelastic properties increase with increasing of rotational speed. Sensory profiles were affected only by oil type: at higher walnut oil content correspond more intense colour, bitterness, walnut odour and flavour; texture attributes change as a consequence of a different structure.

1. Introduction

Today, strong interest in functional food market is growing as result of consumer demand in obtaining foods that contain some health-promoting components beyond traditional nutrients. Of major interest are dietary fats and current research is to a large extent focused on effects of individual fatty acids related to health. This includes the essential n-3 and n-6 fatty acids of plant origin (Torstensen et al., 2004; Jacobsen et al., 1999). The actual nutritional trend towards functional foods has increased the interest in fat type utilized without altering the consistency of the product. In fact, fats type have many important functions, they contribute to the flavour, appearance, texture and shelf life of a food emulsion (Worrasinchai et al., 2006). In this work the structure of a walnut oil-enriched mayonnaise, characterized by a high content of polyunsatured n-3 and n-6 fatty acids, was studied. Mayonnaise is a semi-solid oil in water emulsion, consisting of closely packed foam of oil droplets (Depree and Savage, 2001). Emulsion structure affects rheological properties and sensory characteristics of mayonnaise such as flavour, mouthfeel and texture (Batista et al., 2006; Ma and Barbosa-Canovas, 1995; Paredes et al, 1989; Peressini et al., 1998; Wendin et al.,1999, Yilmazer and Kokini, 1992).
The aim of this work was to study the effect of the cutter rotational speeds, walnut oil substitution levels and storage time on microstructure, rheological and sensory properties of mayonnaise samples.

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2. Materials and methods

The ingredients used to prepare mayonnaises samples were: sunflower oil (78,2%), egg yolk (16,7%), wine vinegar (3,4%), lemon juice (1,1%) and salt (0,7%). All the ingredients were purchased from a local supermarket. All samples were prepared at 20°C, by using a knife blender (UMC 5 electronic, Stephan, Germany) at 600 and 1200 rpm, for 23 min. To obtain functional samples 25, 50, 75 and 100% of sunflower oil was replaced by walnut oil (Organic Oils S.p.a., Perugia Italy). Mayonnaise samples (table 1)were stored in lidded glass beakers, covered with aluminium paper, at 2-5°C for 90 days.

Table 1 Mayonnaise samples

Walnut oil (%)	600rpm	1200 rpm
0	A	A’
25	B	B’
50	C	C’
75	D	D’
100	E	E’

Microscopy investigation and rheological measurements were conducted on samples stored for 2, 8, 18, 31, 45, 60 and 90 days. Digital images were collected by using a LEO EVO 40 scanning electron microscope (Zeiss, Germany) with a 20kV acceleration voltage. Sample preparation was according to the procedure of Worrasinchai et al. (2006). Rheological measurements were performed by means of a controlled strain rheometer (ARES-LS, Rheometric Scientific, Inc. Piscaloway, NY, USA) equipped with a plate and plate geometry (50 mm diameter, 2 mm gap). Frequency sweep tests were conducted by applying an oscillation amplitude of 0.5% over a frequency range between 10^{-2} and 10^{2} rad/s, at 20°C. The elastic and dissipative moduli, G' and G”, were collected. Sensory profiles of two days stored samples were determined. Descriptive quantitative analysis was conducted by a trained panel, consisting of eight judges. Appearance, odour, taste, flavour and texture attributes were scored by using a 100 mm continuous line-scale, anchored with low intensity at 0 mm and high intensity at 100 mm. Data were acquired and analysed by FIZZ Acquisition, Biosystemes Couternon, France. Samples were served at room temperature, in plastic cup. All products were served in triplicate in individual randomised order. One-way analysis of variance (ANOVA) and Duncan’s test were used to evaluate if significant differences ($p \leq 0.05$) in sensory data exist among the samples (SPSS v. 13.0 for Windows program, Spss Inc.).

3. Results and discussion

3.1 Microstructure

The microstructure of mayonnaise samples is illustrated in Figure 1. In particular, in the plots 1-3 is shown the effect of the content of walnut oil: the emulsions are characterized by droplets with different size and dispersion. Close packing structure of spherical and uniform (monodisperse) oil droplets are observed in the sample A, moreover the droplets have the smallest diameters.

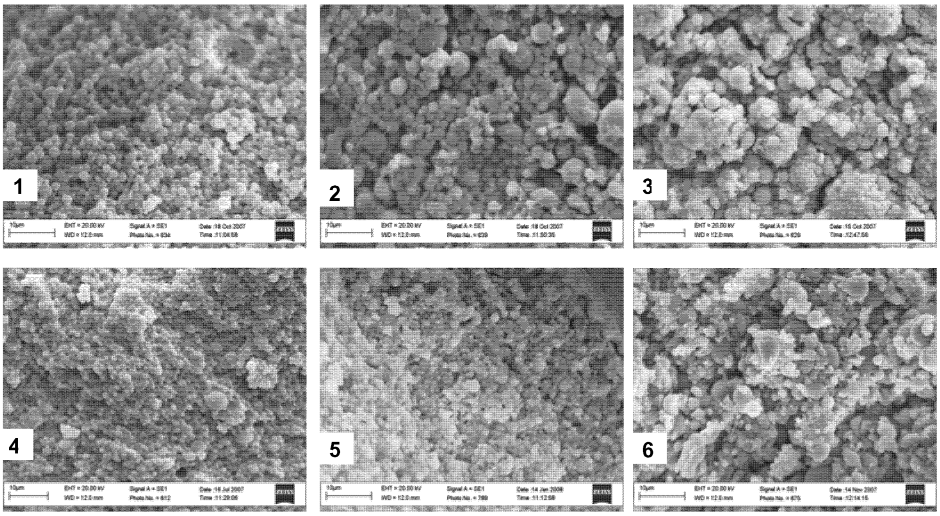
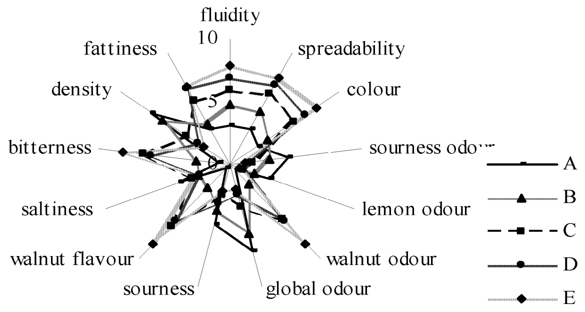


Figure1 SEM micrographs of mayonnaise samples: 1) A two storage days, 2) C two storage days, 3) E two storage days, 4) A' two storage days, 5) A' sixty storage days, 6) A' ninety storage days. Magnification is 4000X

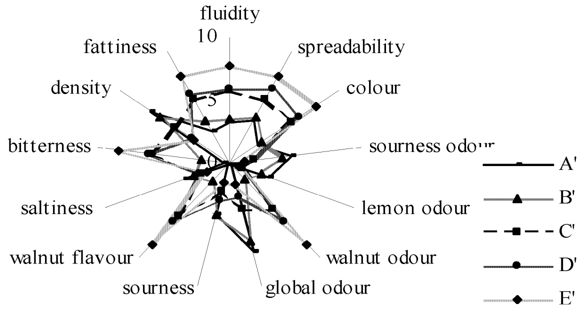
The emulsion C (plot 2) is polydisperse and has a less close packing structure. Sample E, plot 3, is characterized by a relatively open loose structure, by a polydisperse emulsion in which the small droplets are trapped between the large ones forming aggregates. In the plots 4-6 is shown the effect of the storage time: the emulsions were characterized by droplets with a diameter that increases as the storage time increases. Close packing structure of spherical and monodisperse oil droplets are observed in plot 4; after 60 and 90 days the droplets have a larger diameters (plots 5-6) and consequently emulsions have a less close structure; the stability of the emulsions is compromised by a coalescence phenomena. The effect of the cutter rotational speed on the microstructure is evident by comparing plots 1 and 4: samples A and A' are both characterized by a closed structure, but sample A is constituted by droplets with a larger diameter. In fact, it is known that the droplets size can be reduced by increasing the amount of energy supplied during homogenization; in a high-speed blender, the energy input can be enhanced by increasing the rotation speed or the length of the time that the sample is blended (Mc Clements, 1999).

3.2 Sensory profile

Sensory profiles of all mayonnaise samples investigated are shown in Figure 2. It's evident that samples with higher walnut oil content present a more intense colour, bitterness, walnut odour and flavour. Instead, walnut oil reduces sourness odour and taste, typical mayonnaise odour. With the walnut oil percentage increase texture attributes increase, with exception for density as a consequence of the less closed structure characterized by lager droplets. Rotational speed of the cutter has no effect on sensory perception.



(1)



(2)

Figure 2 Sensory profiles of mayonnaise samples produced at 600 (1) and 1200 (2) rpm

3.3 Rheological properties

As reported in the literature (Peressini et al., 1998), the mayonnaise exhibits viscoelastic behaviour due to the network formed by the lipoproteins, which are adsorbed around the oil droplets. Figure 3 shows the storage and viscous moduli, G' and G", versus frequency of mayonnaise samples with different walnut oil content, at different storage times, prepared at 600 and 1200 rpm. With increasing walnut oil level substitution dynamic moduli decrease suggesting that the samples behaviour became more liquid-like. The results are in agreement with the micrographs reported in Figure 1, in fact the presence of walnut oil determines the formation of aggregates of droplets so the rheological properties diminish. Storage time influences in a different way the various samples. For the samples with no walnut oil added, both dynamic moduli decrease with time, if the emulsion is prepared at 600 rpm, (Figure 3, plot 1). This effect can be attributed to the greater extend of destabilization of the three-dimensional network structure of the emulsion. When the emulsion is prepared at 1200 rpm they remain almost constant (Figure 3, plot 4). These observations could be explained with the greater compactness of the structure due to the smaller size of oil droplets, according to Worrasinchai et al. (2006). For the remaining samples, the moduli increase about up to forty five days of storage then diminish; this phenomena is more pronounced for samples prepared at the lowest rotational speed cutter and with the highest walnut oil content. This behaviour is related to the microstructure of the samples: the diameter of the droplets first diminish, because of a phenomenon of solubilisation, then it increases for a phenomenon of coalescence.

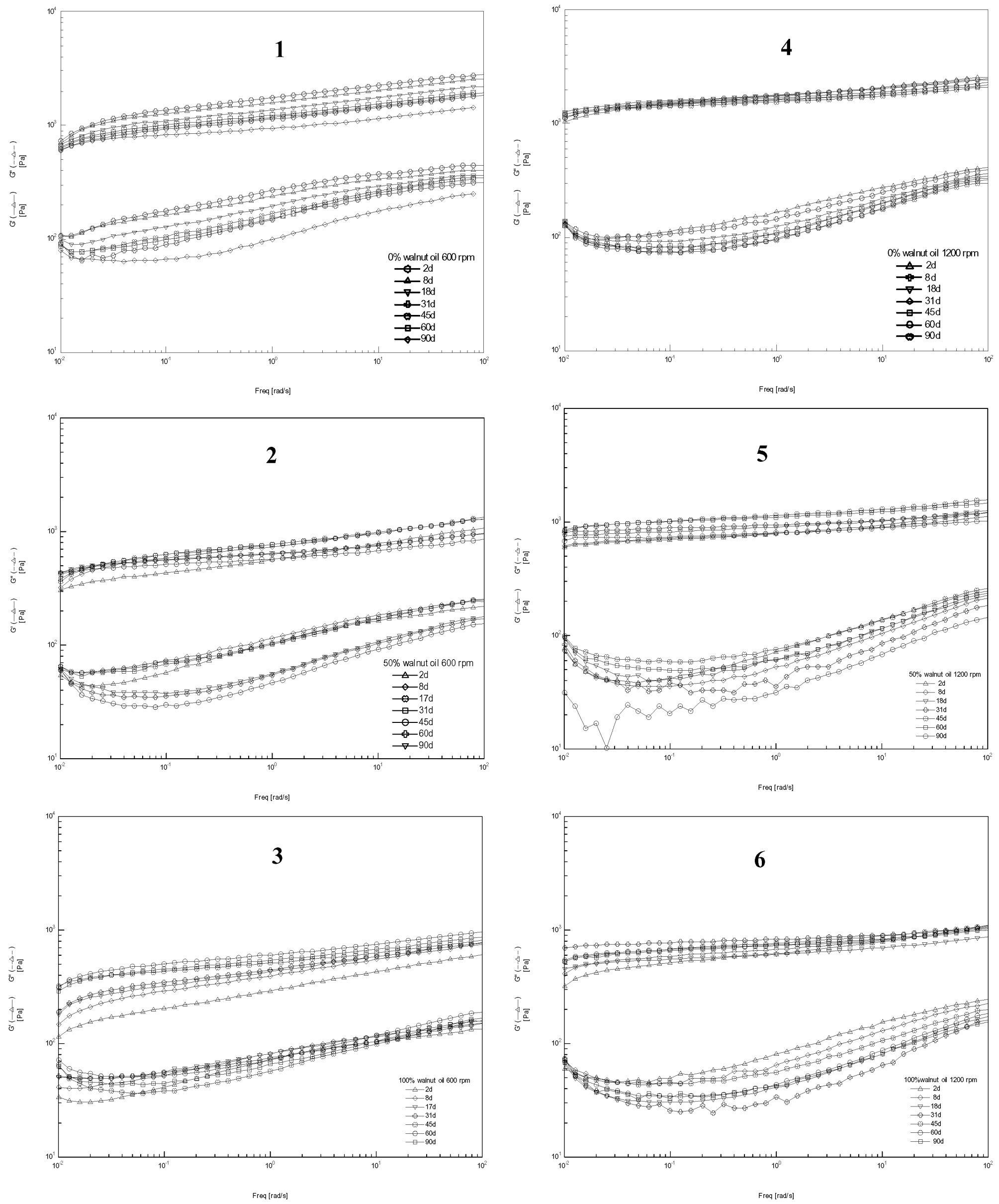


Figure 3 Storage (G') and loss (G") moduli vs. frequency of samples A (1), C (2), D (3), A' (4), C' (5) and E' (6)

3.4 Conclusions

Close packing structure of spherical and uniform oil droplets are observed in the control sample. When walnut oil is added, the droplets are polydisperse and the samples present a less close packing structure. The structure stability increases by increasing the rotation speed. Viscoelastic behaviour of the dressing sauce samples is affected by oil type, rotation speed and storage time. The increase in walnut oil content leads to the diameter dimensions oil droplets increase and consequently viscoelastic properties decrease. For each walnut oil content, the viscoelastic properties increase with increasing of rotational speed. Sensory profiles were affected only by oil type: at higher walnut oil content correspond more intense color, bitterness, walnut odor and flavor; texture attributes change as a consequence of a different structure.

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