

Determination of physical stability of nanoemulsions loaded algal carotenoids

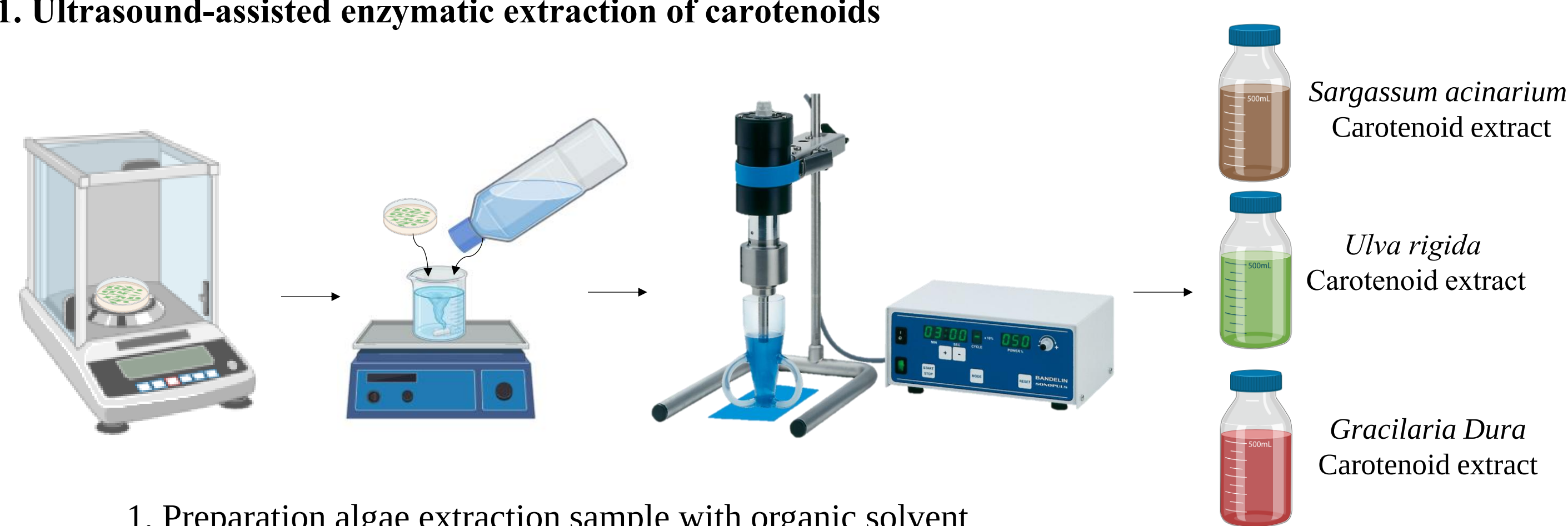
Maide Koşar , Mustafa Enes Arslan, Aziz Mohammed, Gamze Sarıbaş, Gökhan Durmaz, Emine Şükran Okudan, Beraat Özçelik, Sibel Uluata, Aysun Yüçetepe

Introduction

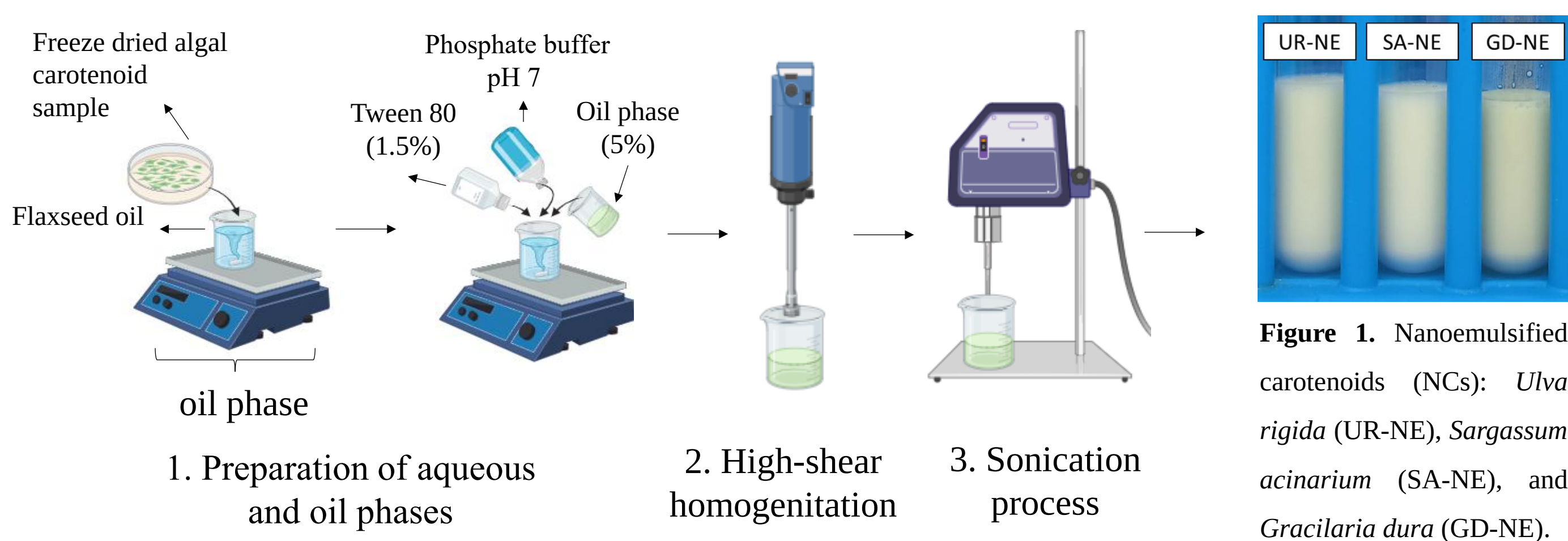
Macroalgae perform photosynthesis and create vast underwater forests in the oceans [1]. In this regard, they hold a significant advantage over terrestrial plants. For instance, they grow approximately 3 to 10 times faster than terrestrial plants such as corn and sugarcane [1, 2]. In recent years, the increasing of interest in clean-label and functional foods, the food industry is moving towards more naturally sourced and sustainable ingredients. Marine algae continue to become interesting candidates as they can yield products with active bioactive compounds, including pigments (e.g., fucoxanthin, β -carotene, phycobiliproteins), which provide not only a natural color in food products, but also antioxidant, anti-inflammatory, and health-promoting effects [3–6]. The best of our knowledge, there is no study investigating nanoemulsions of macroalgal carotenoids from the coastal waters of Türkiye. Therefore, this study aims to develop the potential use of macroalgae based carotenoid pigments-loaded emulsions and add to developing sustainable health formulations in the food industry. In this study, carotenoid-loaded nanoemulsions were prepared after extracting carotenoids from *Gracilaria dura*, *Sargassum acinarium* and *Ulva rigida* macroalgae collected from Türkiye seas by ultrasound-assisted enzymatic extraction for the first time.

Material-Method

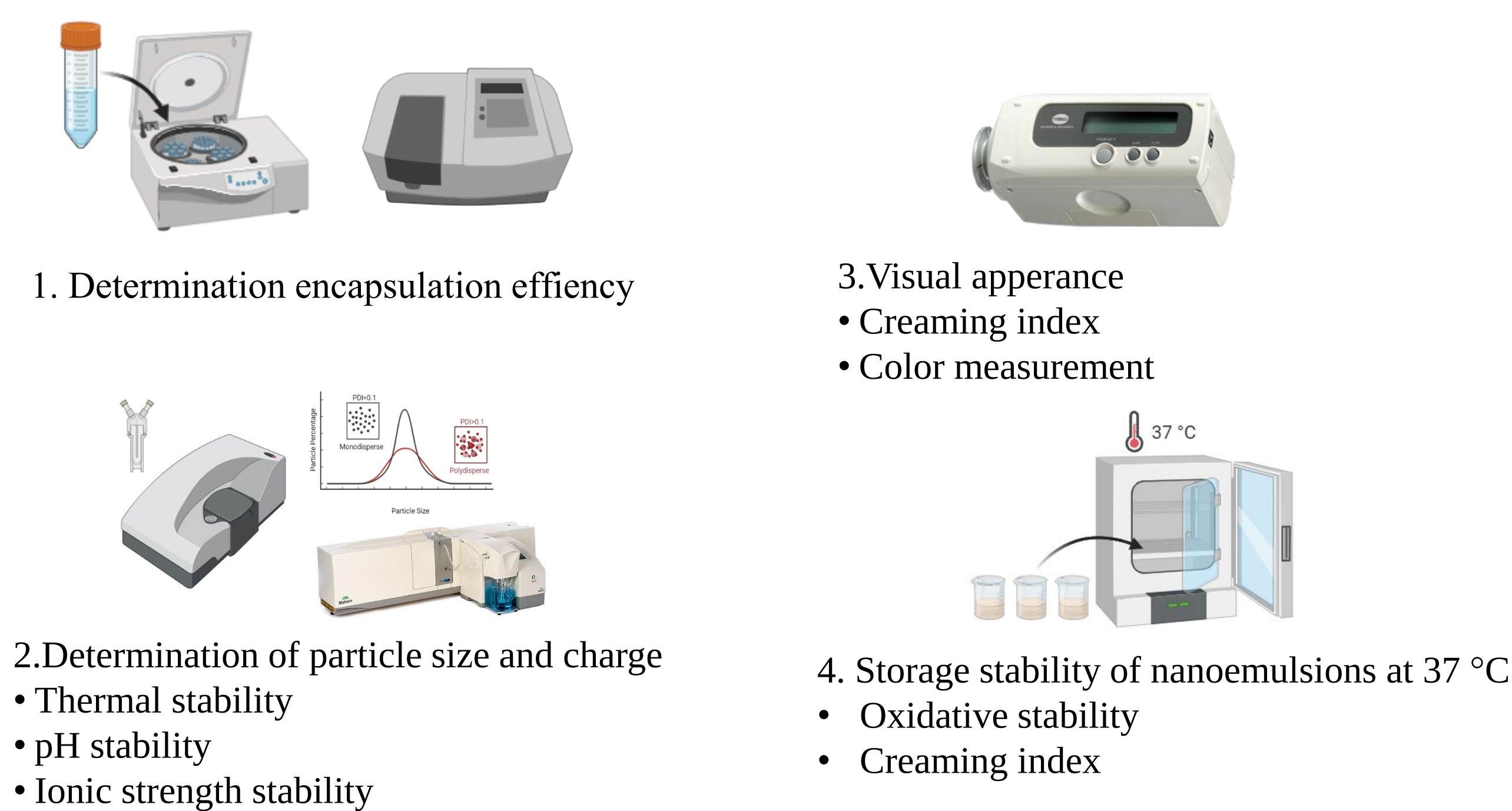
1. Ultrasound-assisted enzymatic extraction of carotenoids



2. Preparation of nanoemulsions



3. Determination some characterization, physical stability and storage stability of nanoemulsions



Conclusion

In this study, algal carotenoid nanoemulsions exhibited enhanced oxidative stability compared to the control. Utilizing carotenoids extracted from algae in nanoemulsion formulations can enhance the absorption of bioactive compounds by cells. In future studies, the potential use of algal carotenoid emulsions in food products can be investigated by incorporating them into various food items to assess their impact on the physicochemical, sensory and biological properties of the food products.

Acknowledgments

This study was supported by The Scientific and Technological Research Council of Türkiye (TUBITAK) (Project no: 2210673).

References

- [1] Figueroa V, Farfán M, Aguilera JM (2023). Seaweeds as Novel Foods and Source of Culinary Flavors. Food Rev Int, 39:1–26.
- [2] Konda NVSNM, Singh S, Simmons BA, Klein-Marcuschamer D (2015). An Investigation on the Economic Feasibility of Macroalgae as a Potential Feedstock for Biorefineries. BioEnergy Res, 8:1046–1056.
- [3] Amlani M, Yetgin S (2022). Seaweeds: Bioactive Components and Properties, Potential Risk Factors, Uses, Extraction and Purification Methods. Mar Sci Technol Bull, 11:9–31.
- [4] Generalić Mekinić I, Šimat V (2024). Marine Algae Bioactives: Isolation, Characterization, and Potential Application. Foods, 13:1736.
- [5] Holdt SL, Kraan S (2011). Bioactive compounds in seaweed: functional food applications and legislation. J Appl Phycol, 23:543–597.
- [6] Plaza M, Cifuentes A, Ibáñez E (2008). In the search of new functional food ingredients from algae. Trends Food Sci Technol, 19:31–39.

Results

According to the results of the study, the mean particle diameter of NCs (Fig. 1) ranged from 0.176 ± 0.01 to 0.189 ± 0.01 nm and the particle charges varied between -17.6 ± 1.18 and -24.35 ± 0.92 mV (Table 1). All NCs were stable between 30–80 °C (Fig. 2a-b). NCs remained stable against coalescence over a wide pH values ranged from 3 to 7 (Fig. 2c-d). Among NCs, the concentration of NaCl at which the net charge decreased (Fig. 2e-f) the most was the emulsion containing 200 mM NaCl. Color discoloration of NCs occurred during the storage period of 28-days. NCs of *S. acinarium* with the smallest particle size showed minimal creaming and an anticipated lower creaming index because smaller oil droplet size was linked to a lower creaming index (Fig. 3a). On the other hand, NCs of *U. rigida* continuously had the lowest zeta potential of all the nanoemulsions during the storage period, suggesting an early creaming trend. On the 5th day of storage, the lipid hydroperoxides (Fig. 3b) production of NCs increased significantly and this increase continued throughout the storage period ($p < 0.05$).

Table 1. Encapsulation efficiency, average particle size and zeta potential of emulsions.

Sample	Encapsulation efficiency (%)	Particle size (µm)	Zeta potential (mV)
Control	-	0.189 ± 0.01^a	-17.60 ± 1.18^c
UR-NE	91.36 ± 0.95^a	0.178 ± 0.01^c	-23.01 ± 1.70^a
GD-NE	94.13 ± 1.08^a	0.176 ± 0.01^d	-20.55 ± 1.46^b
SA-NE	87.29 ± 2.48^b	0.181 ± 0.01^b	-24.35 ± 0.92^a

*UR-NE: Nanoemulsion of carotenoids from *Ulva rigida*, GD-NE: Nanoemulsion of carotenoids from *Gracilaria dura*, SA-NE: Nanoemulsion of carotenoids from *Sargassum acinarium*. The results represent the average of three repetitions (n:3). Averages indicated by different letters (a, b) in the same column are significantly different from each other at the $p < 0.05$ level among the samples.

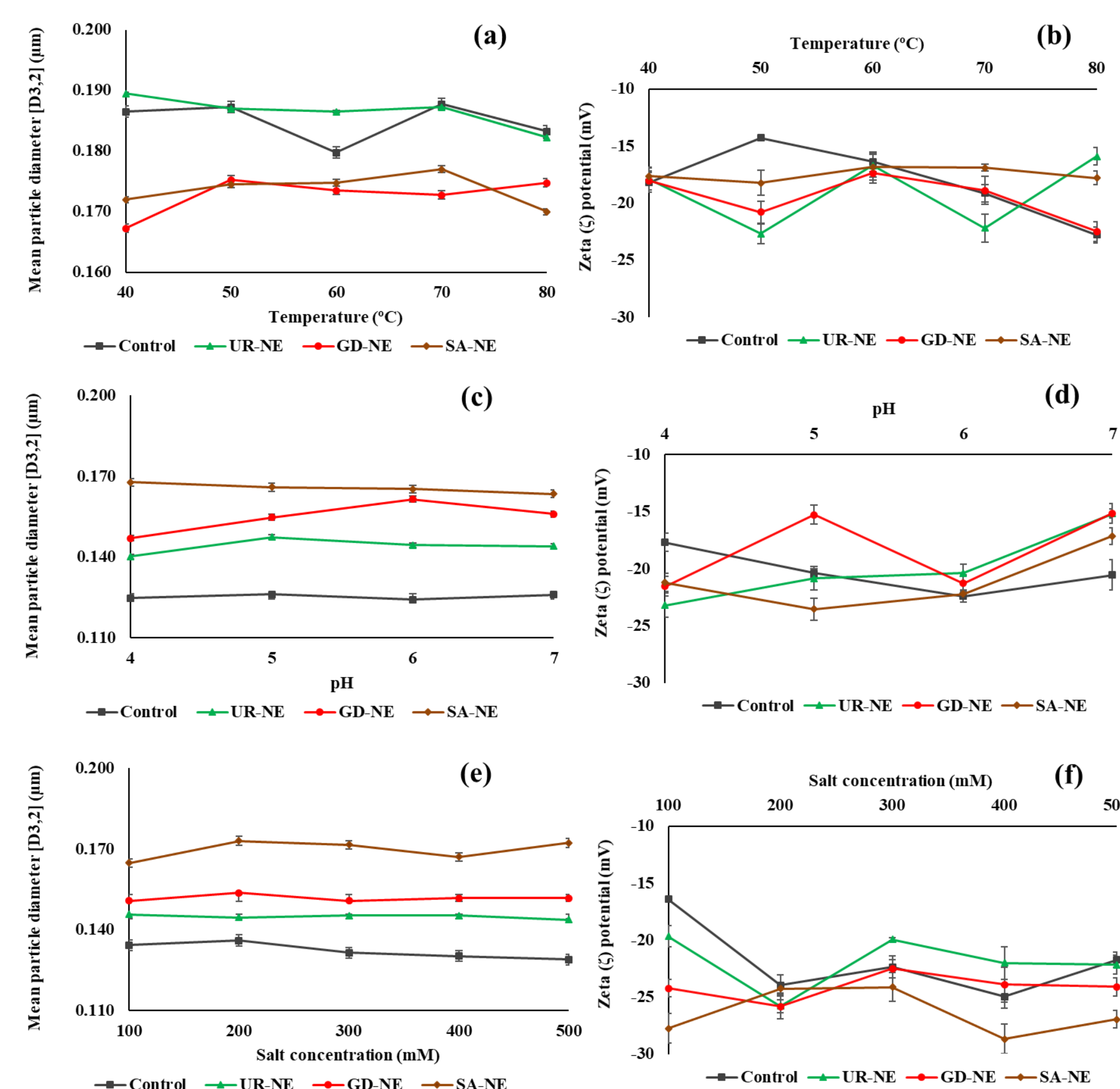


Figure 2. The graphs illustrate the changes in mean particle diameter and zeta potential of nanoemulsions in response to environmental influences.

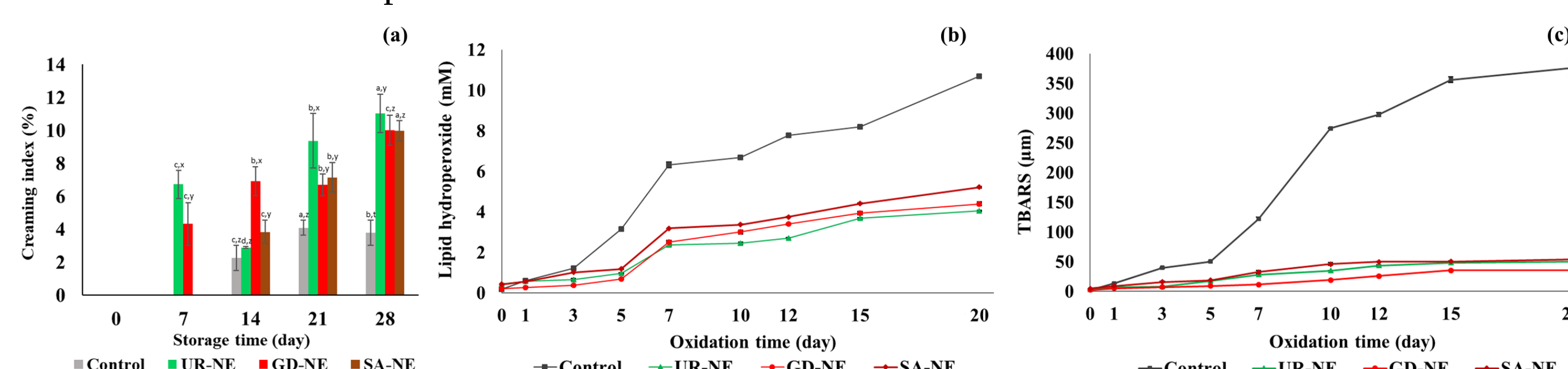


Figure 3. Creaming indices measured over 28-day storage period for nanoemulsions (a), the changes in lipid hydroperoxide levels (b) and TBARS (c) during the storage period of nanoemulsions.