Valorization of edible red seaweeds by the recovery of bioactive compounds optimized in traditional and novel extraction techniques

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INTRODUCTION

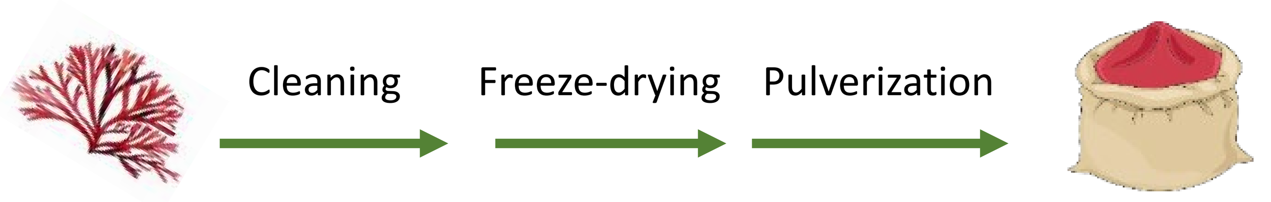
Seaweeds have been consumed since ancient times in different cultures, especially in Asian regions [1]. Currently, there are several scientific studies that, in addition to highlighting the nutritional content of seaweeds, also highlight their bioactive properties, normally associated with the presence of different compounds, namely phenolic compounds [2]. In the last years, red seaweeds have also proved their potential due to their bioactive properties mostly associated with the presence of pigments and phenolic compounds.

The present work aimed to determine the nutritional composition (ash, protein, fat, and carbohydrate content and energy value), the organic acids content and the antioxidant activity of three typical red algae from Galicia: *Chondrus crispus, Mastocarpus stellatus* and *Gigartina pistillata*. Moreover, the extraction conditions for these species were optimized for two techniques: traditional heat assisted extraction (HEA) and novel high pressure assisted extraction (HPAE) in order to improve the extract yield enriched in the target compounds.

MATERIALS AND METHODS

1. Preparation of the samples

Wild samples of *Chondrus crispus* (Irish mosh), *Mastocarpus stellatus* ("cats' puff"false Irish mosh) and *Gigartina pistillata* were collected from the natural environment in Galician coasts (Spain).

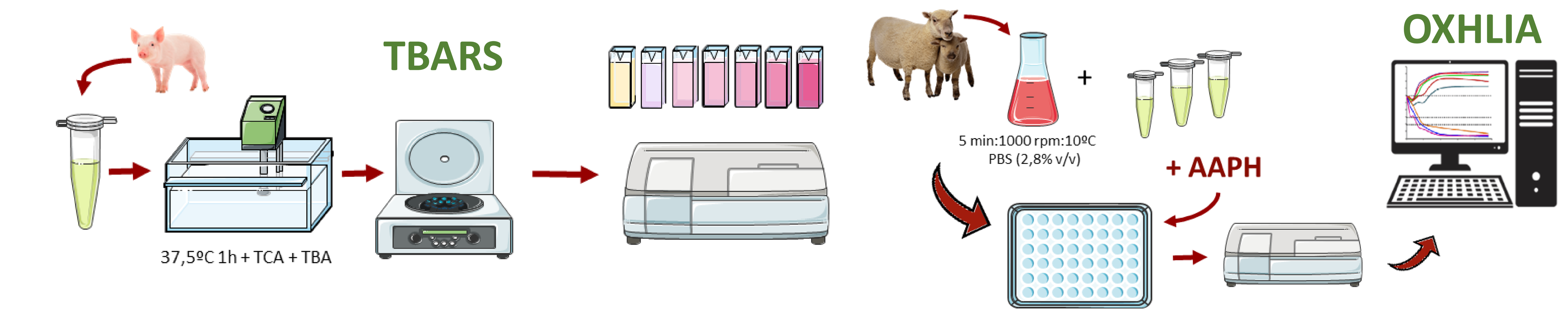


2. Nutritional characterization and chemical composition

For the protein, fat, carbohydrates and ash content, AOAC methods were employed [3]. Energy was calculated following the next formula: Energy (kcal) = 4 × (g protein + g carbohydrates) + 9 × (g fat) whereas total carbohydrates were calculated by difference. Organic acids were measured following the methodology described by [4] and identified and quantified by UFLC/PAD.

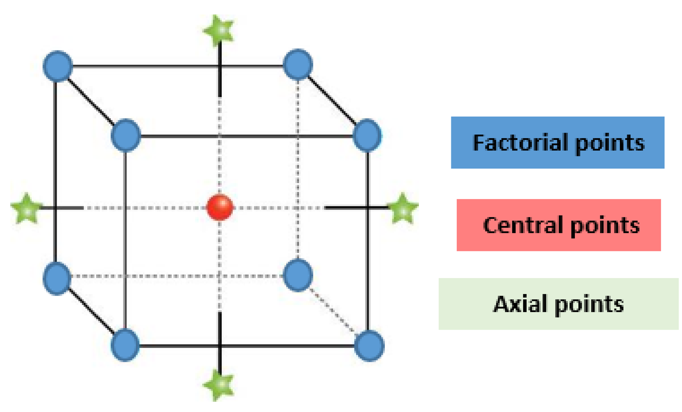
3. Evaluation of antioxidant activity

In compliance with the methodology described by [4] the inhibition of lipid peroxidation in porcine (*Sus scrofa*) brain homogenates is showed by the decrease in thiobarbituric acid reactive substances (TBARS). The oxidative haemolysis inhibition assay (OxHLIA) was performed using sheep blood samples, following the procedure described by [5].



4. Evaluation of antimicrobial activity

The antibacterial potential was evaluated against *Escherichia coli, Enterobacter cloacae* and two Gram-positive bacteria strains: *Listeria monocytogenes* and *Bacillus cereus.* The minimum inhibitory (MIC) and minimum bactericidal (MBC) concentrations were determined using streptomycin and ampicillin as positive controls. Four fungal strains were used: *Aspergillus niger*, *Aspergillus versicolor, Aspergillus ochraceus* and *Penicillium funiculosum*. In this case, ketoconazole was used as positive control.

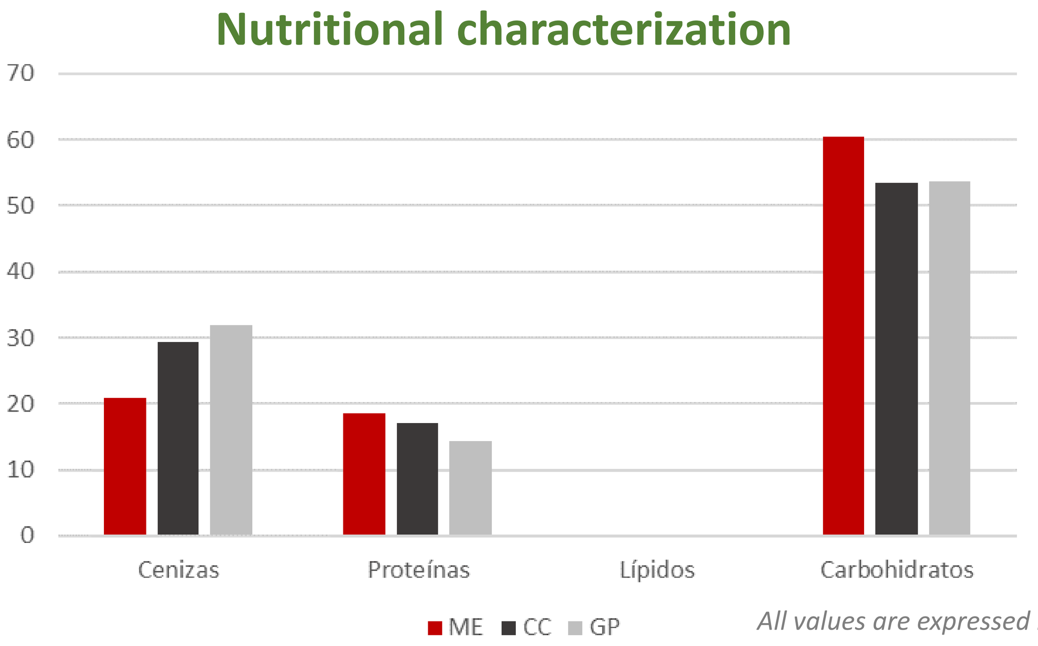


5. Extraction optimization

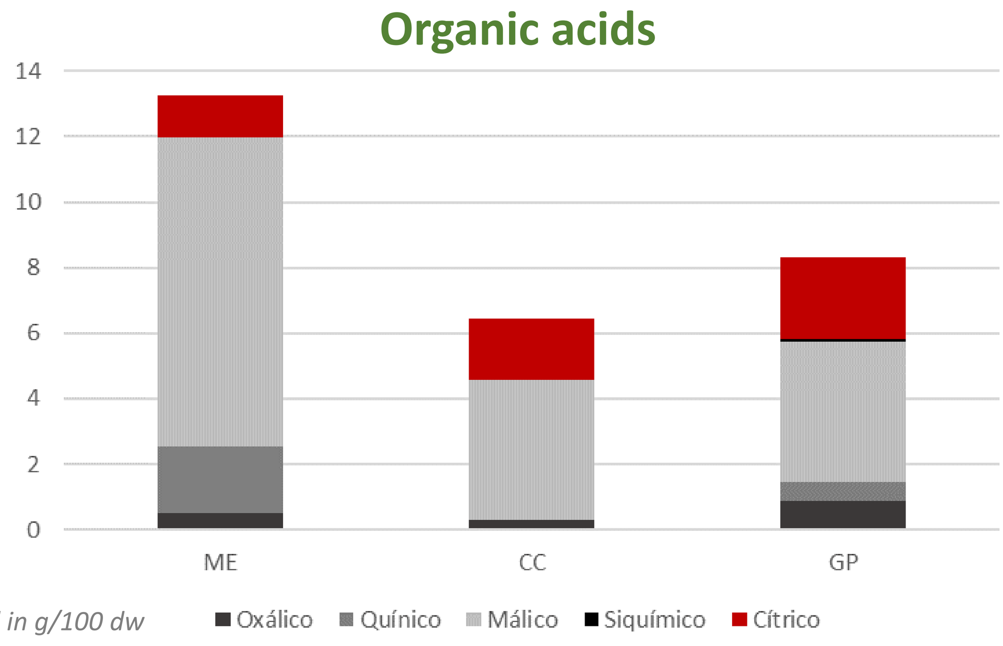
The experiments were designed following a *response surface methodology (RSM)* and models were developed. In the optimization process, different independent variables were considered: for HEA, time (*t*, 19.5-120.5 min), temperature (*T*, 21.4-88.6°C) and solvent as hydroalcoholic mixtures of water-ethanol (*S*, 0-100%); and for HPAE, *t* (10-110 min), *pressure* (*P*, 100-600 MPa) and *S* (0-100%). Extraction yield efficiency was measured in terms of dry weight variation to figure out which method and experimental conditions maximize the extraction efficiency.

RESULTS AND DISCUSSION

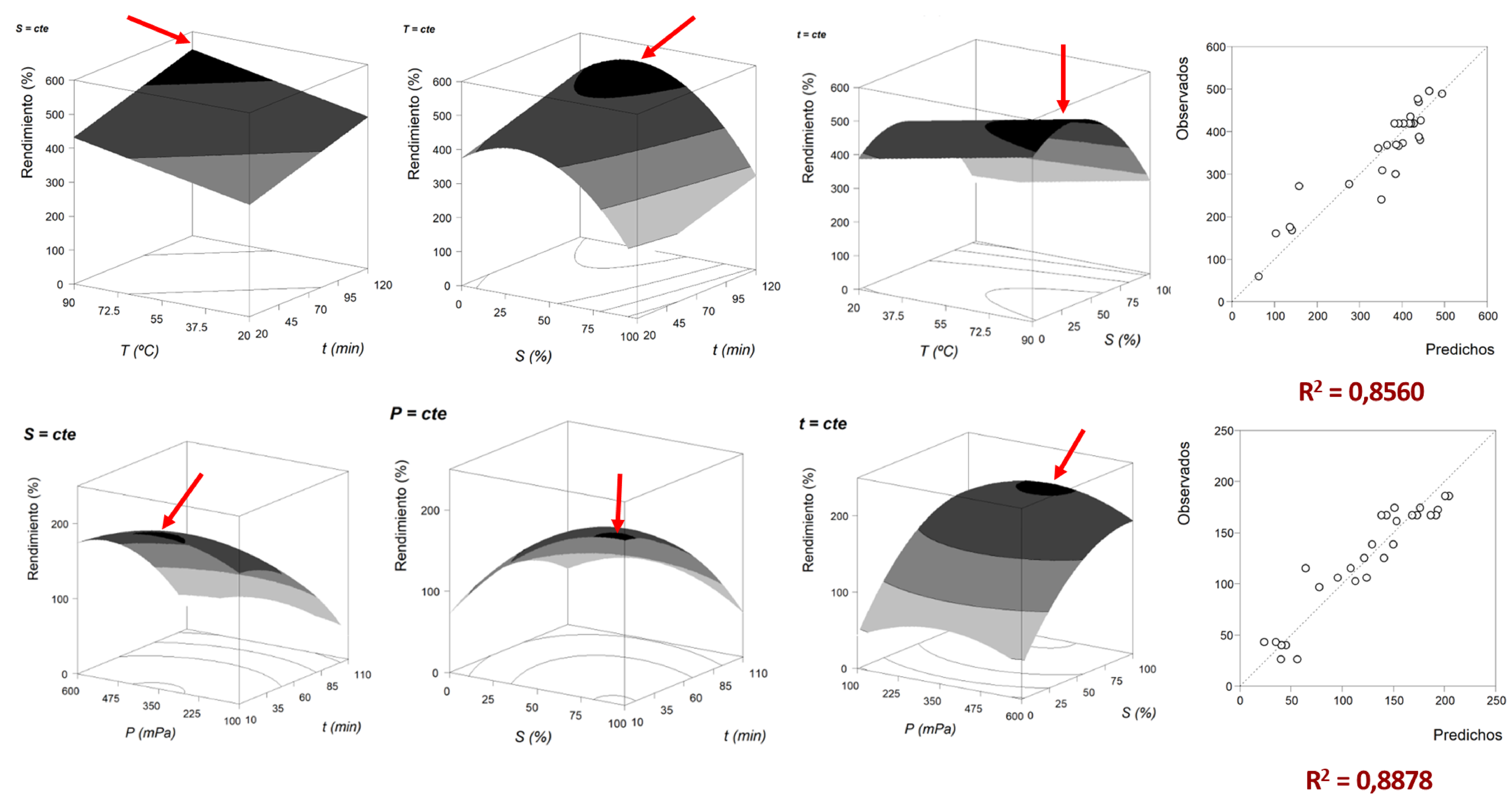
Nutritional characterization



Organic acids



All values are expressed in g/100 dw



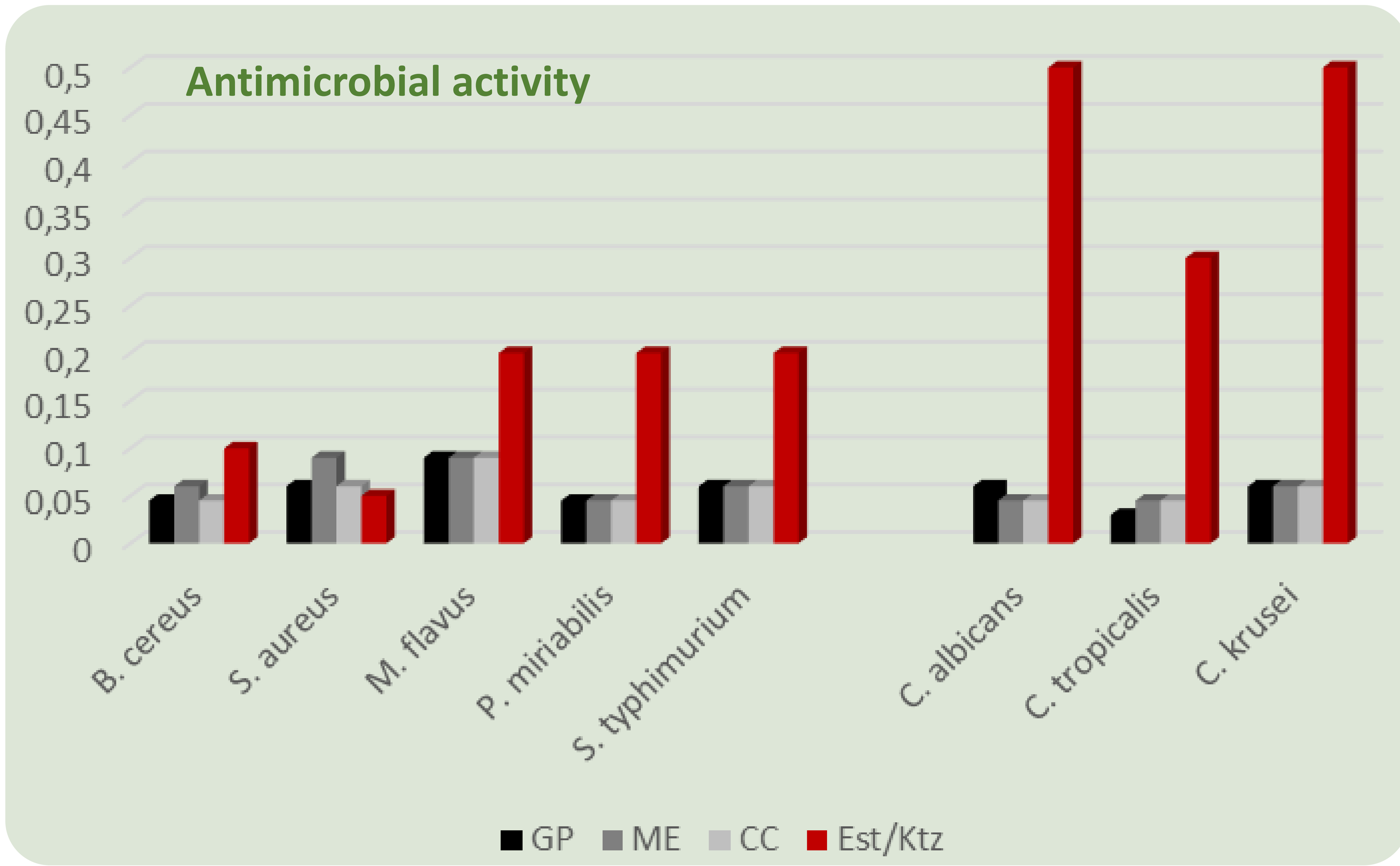
EAC	*ME:*				405,0±12,2	mg/g
	CC:	36,6±10,8	*88,6±2,4	50,0±2,4	373,2±22,4	mg/g
	GP:				375,0±3,8	mg/g
EAAP	*ME:*				292,2±14,6	mg/g
	CC:	49,0±3,4	51,9±2,6	50,0±5,0	94,4±4,7	mg/g
	GP:				441,1±4,4	mg/g

Acknowledgments: To MICINN supporting the Ramón&Cajal grant for M.A. Prieto (RYC-2017-22891); by Xunta de Galicia and University of Vigo supporting the post-doctoral grant for M. Fraga-Corral (ED481B-2019/096), and the pre-doctoral grant for of P. García-Oliveira (ED481A-2019/295); by EcoChestnut Project (Erasmus+ KA202) supporting the work of M. Carpena; by Ibero-American Program on Science and Technology (CYTED - AQUA-CIBUS, P317RT0003); by UP4HEALTH Project (H2020-BBI-JTI-2019); by Axudas Conecta Peme (Xunta de Galicia) supporting the IN852A 2018/58 NeuroFood Project and by AlgaMar (www.algamar.com). The authors are also grateful to FCT and FEDER under the PT2020 Program for financial support to CIMO (UIDB/00690/2020) and for the research contract of L. Barros through the institutional scientific employment program-contract. This communication was funded by Xunta de Galicia, Spain (CITACA Strategic Partnership, Reference: ED431E 2018/07).

Antioxidant activity

	ME	CC	GP	Trolox
TBARS	209± 27	160± 18	285± 41	23
OXHLIA	1,0± 0,1	1,4± 0,2	1,5± 0,3	85

Antimicrobial activity



CONCLUSIONS

This study proposes red algae as a suitable alternative to be incorporated to the diet, without significant differences in their composition. Most effective technique was EAC in the following conditions: *36.6 min, 88.6ºC and 50,0% of ethanol*. The three species showed potential as natural antioxidants and thus, potential applications in the food and cosmetic industry.

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