SUSTAINABLE APPROACH FOR FOOD SHELF LIFE PROLONGATION TROUGH BY-PRODUCTS RECYCLING

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INTRODUCTION

Food research is greatly focusing on the potential of recycling fruit and vegetable by-products to reduce food waste. The by-products contain valuable compounds, especially phenolic substances, and therefore can be used to fortify food or to prolong their shelf life. In the perspective of food sustainability, several researches have been conducted with the aim to valorize industrial by-products. However, further efforts need to be made to promote by-products recycle at industrial level.

The aim of the study was to develop ready-to-cook breaded cod sticks by implementing new and effective combinations of by-products and fish, being the by-products adopted as breading of fresh fish sticks.

Two case studies:

- **cod sticks breaded with dried olive paste as by-products of the oil production process**
- **cod sticks breaded with pomegranate peel powder as pomegranate by-products**

MATERIAL AND METHODS

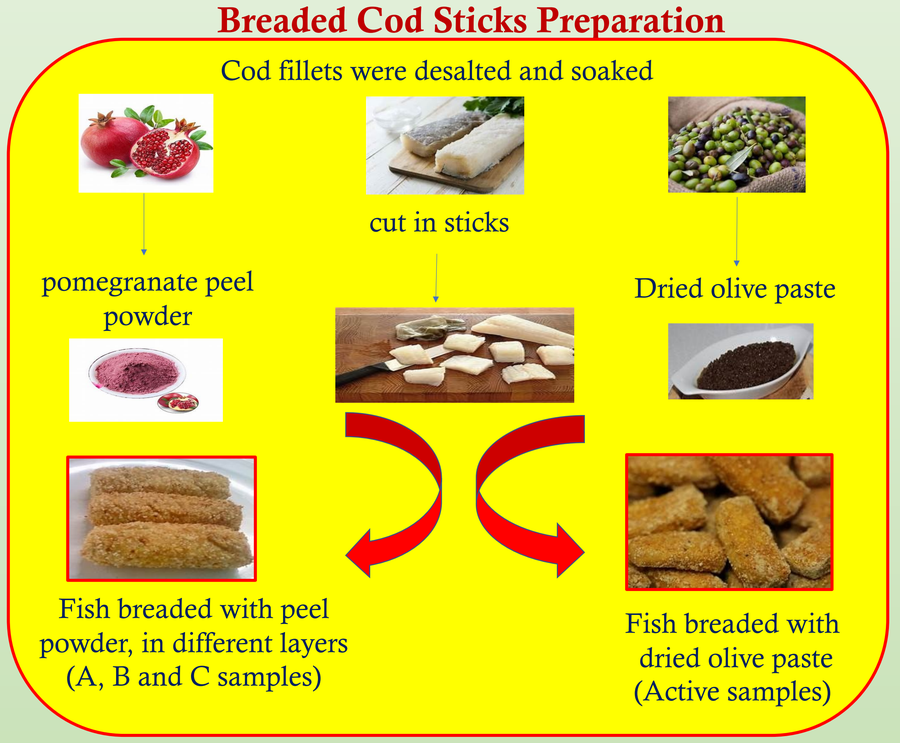
Microbiological analyses and pH determination

Serial dilutions of control and breaded fish samples were plated onto specific media in Petri dishes to enumerate *Pseudomonas* spp., hydrogen sulfide-producing bacteria (HSPB), psychrotolerant and heat labile aerobic bacteria (PHAB), mesophilic and psychrotrophic bacteria, *Enterobacteriaceae* and lactic acid bacteria, during proper storage period under refrigerated conditions (4 °C). The measurement of pH was performed on the first homogenized dilution of samples. Analyses were carried out in duplicate on two different samples.

Chemical analyses

Chemical analysis were conducted to determinate Total Phenol content, Total Flavonoids and Antioxidant Activity, according to standard methods. All analyses were carried out the day after sample preparation, in triplicate.

Breaded Cod Sticks Preparation



Sensory analysis

Five trained panelists were asked to give judge on odor, color, appearance, texture and overall quality using a nine-point scale. In the scale, 9 = excellent, 8 = very good, 7 = good, 6 = reasonable, 5 = not good (acceptable limit), 4 = disliked, 3 = bad, 2 = very bad and 1 = completely unacceptable.

Statistical analysis

Experimental data of cod sticks breaded with dried olive paste were fitted by the modified version of the Gompertz equation. The experimental data of cod sticks breaded with pomegranate peel powder were compared by a one-way analysis of variance (ANOVA). A Duncan's multiple range test, with the option of homogeneous groups ($P < 0.05$), was carried out to determine significant differences among samples. STATISTICA 7.1 for Windows (StatSoft, Inc, Tulsa, OK, USA) was used.

RESULTS AND DISCUSSION

Table 1. Nutritional quality of od sticks with dried olive paste

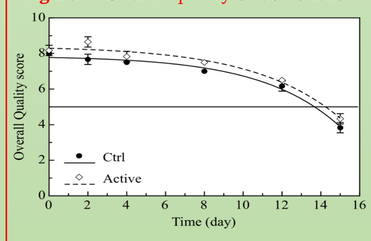
Samples	Total phenols (mg GAE/g dw) ± SD	Total flavonoids (mg QE/g dw) ± SD	Antioxidant Activity (mg Trolox/g dw) ± SD
R-Ctrl	$2.70 \pm 0.15^{a,A}$	$1.69 \pm 0.09^{a,A}$	$5.88 \pm 0.18^{a,A}$
R-Active	$12.63 \pm 0.18^{b,A}$	$13.68 \pm 0.90^{b,A}$	$20.02 \pm 0.43^{b,A}$
C-Ctrl	$2.82 \pm 0.13^{a,A}$	$1.38 \pm 0.13^{a,B}$	$4.40 \pm 0.15^{a,B}$
C-Active	$12.46 \pm 0.26^{b,A}$	$10.61 \pm 0.53^{b,B}$	$12.55 \pm 0.75^{b,B}$

Table 2. Nutritional quality of sticks with pomegranate peel powder

Samples	Total Phenols (mg GAE/g dw) ± SD	Total Flavonoids (mg QE/g dw) ± SD	Antioxidant Activity (mg Trolox/g dw) ± SD
R- Ctrl	$1,17 \pm 0,03^{a,A}$	$0,54 \pm 0,16^{a,A}$	$1,05 \pm 0.34^{a,A}$
R-A	$8,13 \pm 0,74^{b,A}$	$5,43 \pm 0,55^{b,A}$	$5,15 \pm 0,12^{b,A}$
R-B	$8,44 \pm 2,05^{b,A}$	$5,80 \pm 1,53^{b,A}$	$5,47 \pm 0,49^{b,c,A}$
R-C	$10,59 \pm 2,89^{b,A}$	$7,19 \pm 2,11^{b,A}$	$7,46 \pm 2.18^{c,A}$
C-Ctrl	$1,24 \pm 0,12^{a,A}$	$0,74 \pm 0,35^{a,A}$	$1,08 \pm 0,19^{a,A}$
C-A	$5,08 \pm 2,31^{a,b,A}$	$2,87 \pm 0,77^{a,b,B}$	$2,89 \pm 0,67^{a,b,B}$
C-B	$4,19 \pm 0,72^{b,B}$	$1,66 \pm 0,58^{b,B}$	$2,19 \pm 0,94^{b,B}$
C-C	$6.19 \pm 2.18^{b,A}$	$5.8 \pm 0.81^{c,A}$	$4.54 \pm 0.96^{c,A}$

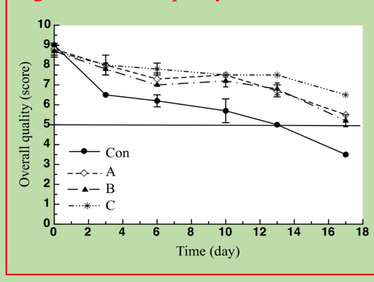
Improved nutritional quality of both raw [R] and cooked [C] fresh breaded cod sticks. Ctrl = control fish; Active = fish breaded with dried olive paste; A, B and C = fish breaded with pomegranate peel powder.

Figure 1. Overall quality of cod sticks with dried olive paste



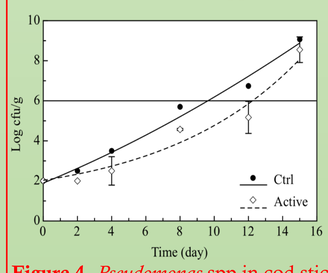
The addition of olive paste to the breading contributes to the maintenance of sensory quality.

Figure 2. Overall quality of cod sticks with pomegranate peel powder



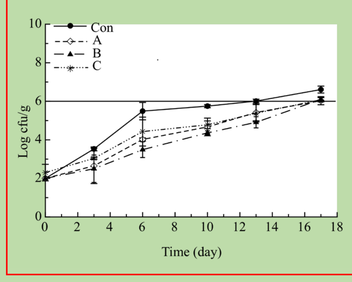
The control (Con) sample reached the threshold after 11 days, while the overall quality of all active samples (A, B and C) remained acceptable.

Figure 3. *Pseudomonas* spp.in cod sticks with dried olive paste



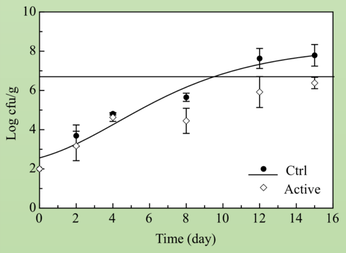
Pseudomonas spp. growth was slower in the active sample than in the control (Ctrl) fish, due to the active olive paste used as fish breading.

Figure 4. *Pseudomonas* spp in cod sticks with pomegranate peel powder



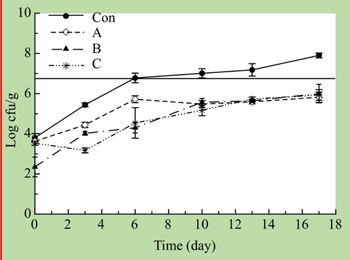
Fruit peel exerted antimicrobial properties, thus maintaining better microbial stability in active (A, B and C) breaded cod sticks.

Figure 5. *Psycrhrotrophic* bacteria in cod sticks with olive paste



The active samples maintained the microbial concentration below the limit until the end of the observation period.

Figure 6. *Psycrhrotrophic* bacteria in cod sticks with peel powder



The active samples (A; B; and C) maintained the microbial concentration below the limit until the end of the observation period.

CONCLUSIONS

Results obtained in these two case-studies showed a significant improvement in the nutritional quality of breaded samples. In fact, the cod sticks breaded with both dried olive paste and pomegranate peel powder increased their phenol and flavonoid contents and, consequently, their antioxidant activity. Furthermore, the results on fish quality during storage showed that adding by-products also microbial stability was improved, without affecting the sensory characteristics. Therefore, it can be concluded that the recycle of by-products could be a sustainable way to reduce the environmental impact and costs associated with by-products disposal, with great advantages for the quality of ready-to-cook fresh fish products.

REFERENCES

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