Influence of the Brown Marine Algae on the Physicochemical and Sensory Characteristics of the Sausages

Claudiu-Dan SĂLĂGEAN, Carmen POP*, Mihai CATRINOI, Melinda NAGY

Faculty of Food Science and Technology, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca
*Corresponding author, e-mail: carmen-rodica.pop@usamvcluj.ro

Bulletin USVM Food Science and Technology 72(2) / 2015
ISSN-L 2344-2344; Print ISSN 2344-2344; Electronic ISSN 2344-5300
DOI: 10.15835/buasvmcn-fst:11558

ABSTRACT
The aim of this study was to assess the influence of the brown algae on the quality in manufacturing of a certain halfsmoked sausages assortment. Exploiting the natural plant resources as well as reducing the animal fat in the finished product by replacing it with proteins, fibres and minerals (provided by the brown marine algae) were also intended. Two technological variants with different ratios of algae (V1-10% respectively V2-15%) from those 25% of fat (the remaining of 75% being represented, in each case, by beef) were experienced and compared with the control sample (VM, without algae, 75% beef and 25% fat). The finished products were analyzed in terms of organoleptic and physicochemical, in different stages of storage, at 24 hours after obtaining and seven days of storage at 10 to 12 degrees. The correlations between investigated quality parameters and the ratios of algae were also established. The physicochemical analysis highlighted the highest values regarding the protein, moisture, sodium chloride and the lowest fat content values in the case of the V2 variant compared to the V1 and VM variants. Furthermore, an increase in protein, fat, sodium chloride and a decrease of the moisture content have been found in all variants observed during the storage. The shelf life of the product was not negatively affected by the addition of algae due to their antimicrobial activity. The addition of algae in combination with beef components led to obtaining a higher quality product with functional characteristics.

Keywords: algae, beef, physicochemical analyses, sausage assortment, sensory analyses.

INTRODUCTION
As we know, the marine algae such as the brown ones are an important renewable source of protein containing all essential amino acids, easily assimilated minerals such as iodine, essential in the proper functioning of the thyroid gland, soluble fibres and antioxidants such as fucoxantina (Burtin, 2003; Simionescu et al., 1974).

The protein content of brown algae is small (5-15% of dry matter) compared to that of red and green ones, 10-30% of dry matter. The lipids content is 1-5% of the dry matter, but has a composition of specific unsaturated fatty acids such as the omega 3 and omega 6 acids. Marine algae contain polysaccharides, 30-50% of dry matter. The fraction of soluble fibre is between 51 and 56% of total fibers in green and red algae and 67-87% in brown algae. Macrophytes contain considerable amounts of polysaccharide: alginates in brown algae, carrageenan and agar in red algae (Burtin, 2003).

The carbohydrates from algae are not digestible by the human gastrointestinal tract, therefore are considered and act as fiber (Dawczynski et al., 2007).

Some studies have shown a reduction at about 50% of the total content of phenols and flavonoids in the dried algae at temperatures above 25 °C, compared to the green ones. At the same time, the antiradical effect against DPPH was higher in
the case of the fresh algae compared to the dried ones at 35-40 °C, the antioxidant activity being reduced at about 50%. Therefore, by increasing the drying temperature, there was a more pronounced decrease in antioxidant activity, flavonoids and phenols. Fucoxantin is the main bio-functional pigment in brown algae and some specialized studies revealed a good antioxidant and antitumor capacity (Gupta et al., 2011).

Various technological rules allow substitution of equivalent raw materials with others in large comparative limits. The equivalence means that from a wide range of raw materials must be manufactured finished products with similar nutritional values and sensorial properties. The composition in the finished product of the main nutrients (proteins and lipids) is directly correlated with the raw material quality used in the manufacturing, by their origin (beef, pork), tissue ration (fatty/connective/muscle), their nature (animal/vegetable), chemical composition (protein and fat content) of the raw materials and last but not least, their proportion in the manufacturing technology (Sălăgean et al., 2012).

The advantages of the usage of the vegetal protein derivatives in the processing of the meat products (as raw materials, exclusively vegetal) consist in elimination of the variation in the quality of animal raw materials, a lower content in cholesterol, calories, fats of the finished products therefore being recommended as dietetic food (hypoglucidic and hypocaloric), with a good impact over the human health (Sălăgean and Țibulcă, 2014).

It is well known that edible seaweeds have been used as foods since ancient times, largely in Asian countries. In addition to the considerable interest they represent from the standpoint of nutrition and technology, they contain various bioactive compounds (dietary fibre, good quality protein, large amounts of minerals and vitamins, higher proportions of essential unsaturated fatty acids, particularly n-3 polyunsaturated fatty acids PUFA, polyphenols, carotenoids, tocopherols, etc.) with potential health benefits.

Because seaweeds contain various bioactive compounds with potential health-beneficial properties, their use as functional ingredients opens up new possibilities in food processing, including meat products (Cofrades et al., 2008; López-López and Cofrades, 2007; Fleurence, 1999).

Despite their benefits, very little attention has been paid to the use of edible seaweeds as ingredients in meat products. López-López et al. (2009) demonstrated that the addition of seaweed considerably influenced the properties of low-fat frankfurters enriched with n-3 PUFA (polyunsaturated fatty acids), favouring the formation of harder and chewier structures with better water and fat binding properties. They mentioned that this fact opens up interesting prospects for the use of seaweeds in the formulation of healthier meat products to overcome technological problems associated with low-salt products, including those relating to water/fat binding properties and texture. Replacing pork back-fat with olive oil in frankfurters produced acceptable sensory characteristics, similar to control, while addition of seaweed resulted in less acceptable products, due mainly to the special flavour of the seaweed. Shelf life stability did not appear to be affected by the presence of seaweed.

López-López et al. (2009) analyzed the nutritional composition (fatty acid profile, cholesterol, mineral and amino acid content) of low-fat frankfurters enriched with n-3 polyunsaturated fatty acids (PUFA) as affected by the addition of seaweed (5.5%) and the partial substitution (50%) of animal fat by olive oil (as a source of monounsaturated fatty acids – MUFA) or combinations of olive oil and seaweed. They found that although adding seaweed had little effect on the lipid and amino acid profiles of frankfurters, it does constitute a means to produce low-sodium products with important dietary fibre content, with better Na/K ratios and rich in Ca.

Our country has quite significant amounts of brown and red algae, mainly Phyllophora nervosa and Cystoseira barbata species, but today are little exploited and still are an important natural plant resource. In Western countries algae are still not well accepted in human nutrition, both due to their less attractive appearance and their content in polysaccharides that require special microflora to be digested (Simionescu et al., 1974).

MATERIALS AND METHODS

The raw materials have been represented by the first quality beef (veal calf), animal fat and brown algae. Two technological variants obtained into a micro scale production have been experienced and compared with the control sample (VM) without algae, containing 75% beef.
and 25\% fat: the first one (V1) containing 10\% algae and 15\% animal fat and the second one (V2) containing 15\% algae and 10\% animal fat, the remaining of 75\% being represented, in each case, by beef (Tab. 1).

The finished products were analyzed in terms of organoleptic (taste, odour, colour, external appearance and section aspect) and physicochemical (fat, protein, salt, moisture and easily hydrolyzed nitrogen content) in different stages of storage, at 24 hours after obtaining and 7 days of storage at 10 to 12 degrees (Tab. 2).

Tab. 1. The two experimental variants with different ratios of algae and the control sample

<table>
<thead>
<tr>
<th>Component</th>
<th>Variant VM</th>
<th>Variants V1</th>
<th>Variants V2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (1st quality veal calf), %</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Brown algae (hydrated), %</td>
<td>-</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Animal fat (bacon), %</td>
<td>25</td>
<td>15</td>
<td>10</td>
</tr>
</tbody>
</table>

In addition, the correlations between investigated quality parameters and the ratios of algae have been established.

For sensory evaluation of the algae influence on the finished products Hedonic scale and Likert scale were used.

The sensory analyses of the samples have been evaluated by 26 untrained panelists using a 9 point hedonic scale.

By Likert scale, consumers have expressed disagreement/agreement on the use of brown algae and the correlation between their and beef benefits. Axis Likert scale ranges between -2 (that means a total disagreement of the consumers) and +2 (that means a total agreement).

**RESULTS AND DISCUSSION**

The results of the physicochemical exam of the raw materials used in manufacturing revealed values in accordance with those mentioned by other researchers (Burtin, 2003; Sălăgean and Țibulcă, 2012; Simionescu, 1974) (Tab. 3)

Tab. 2. The sensory and physicochemical quality indicators of the algae and finished products samples

<table>
<thead>
<tr>
<th>No.</th>
<th>Sensory and physicochemical indicator</th>
<th>Method of examination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensory assessment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(section aspect, taste, odour, colour, consistency)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water, g%</td>
<td>Drying-oven at 105 Celsius degrees</td>
</tr>
<tr>
<td></td>
<td>Protein substances, g%</td>
<td>Kjeldahl method (N X 6.25)</td>
</tr>
<tr>
<td></td>
<td>Ammonia nitrogen, mg%</td>
<td>Titration with NaOH</td>
</tr>
<tr>
<td></td>
<td>Fatty substances, g%</td>
<td>Soxhlet extraction</td>
</tr>
<tr>
<td></td>
<td>Sodium chloride, %</td>
<td>Mohr method</td>
</tr>
<tr>
<td></td>
<td>Antioxidant capacity, % RSA</td>
<td>DPPH method</td>
</tr>
<tr>
<td></td>
<td>Polifenoli, mg EAG/g</td>
<td>Folin-Ciocalteu method</td>
</tr>
<tr>
<td></td>
<td>Antimicrobial activity</td>
<td>Diffusimetrical method</td>
</tr>
</tbody>
</table>

Tab. 3. The results of the physicochemical examination of the raw materials

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Physicochemically quality indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Proteins substances, g%</td>
</tr>
<tr>
<td></td>
<td>Fatty substances, g%</td>
</tr>
<tr>
<td></td>
<td>Water, g%</td>
</tr>
<tr>
<td></td>
<td>Minimum value</td>
</tr>
<tr>
<td>Beef (1st quality), %</td>
<td>17.7</td>
</tr>
<tr>
<td>Brown algae (dehydrated), %</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Note: Minimum and maximum values are mentioned by others researchers; medium values are those obtained by physicochemical determination
The results of the organoleptic examination of the finished products revealed, as can be seen analyzing each characteristic, there are no significant differences between the two experimental variants. The most appreciated by consumers of all analyzed characteristics and that made a major difference between V1 and V2, were the smell and taste followed by the flavor that emerged from them (Fig. 1).

The results show the mean and standard deviations for each feature and a note of general appreciation of the products.

As a note of general appreciation, it has been observed that V1 was more appreciated by consumers, achieving an average of 7.53, compared to V2 that obtained an average of 7.11. It can therefore be seen that the differences of appreciation between V1 and V2 are not significant, obtaining similar values.

**Fig. 1.** Sensory characteristics evaluation of the finished products by hedonic test

**Fig. 2.** Likert Scale assessment concerning the agreement and disagreement of some tasters regarding product information
According to the Likert scale, the most appreciated among respondents was the fact that in the processing of the new product (beef sausages with the addition of brown algae) were no toxicological substances added and the fact that algae have replaced some of the fat content, the product being more healthy and nutritious (Fig. 2).

The results of the finished products physicochemical exam are shown in the table 4.

The protein content (g%) at 24 hours of storage ranged between 15.11 (in case of the V1 variant) and 18.04 (V2 variant) compared to 14.19 (in case of the VM variant). These values have increased during a 7 day storage at values of 24.38 (V1 variant) and 30.09 (V2 variant) compared to 22.46 (VM variant).

The fat content (g%), during 7 day storage, has increased from the average value of 20.20 to 28.84 (in case of the VM variant), from 16.72 to 23.48 (in case of the V1 variant) and from 9.98 to 15.62 (in case of the V2 variant), the lowest values being obtained in case of the V2 variant compared to V1 and VM variant.

The salt content (g%), during 7 day storage, has increased from the average value of 1.05 to 1.81 (in case of the VM variant), from 1.17 to 1.96 (in case of the V1 variant) and from 1.21 to 2.10 (in case of the V2 variant), the highest values being determined in case of the V2 variant compared to V1 and VM variant.

The moisture content (g%), during 7 day storage, has decreased from the average value of 52.20 to 38.51 (in case of the VM variant), from 56.87 to 39.81 (in case of the V1 variant) and from 64.83 to 42.09 (in case of the V2 variant), the highest values being determined in case of the V2 variant compared to V1 and VM variant.

Concerning the easily hydrolyzed nitrogen content (mg/100 g) at 7 days of storage it has not exceeded, in all cases, the maximum limit provided by STAS (45) namely average values of 29.91 in case of the VM variant, 31.98 in case of the V1 variant and 33.25 in case of the V2 variant.

The physicochemical analysis highlighted the highest values regarding the protein, moisture, sodium chloride content and the lowest fat content values in case of the V2 variant compared to the V1 and VM variants. Furthermore, an increase in protein, fat, sodium chloride content and a decrease of the moisture content in all variants have been observed during the storage.

Regarding the sensory analysis, according to the hedonic test consumers preferred the V1 variant (with 10% brown algae addition) with the following physicochemical quality parameters (average values determined after 24 hour storage): 15.11% protein, 16.72% fat, 56.87% moisture, 1.17% sodium chloride content and 31.98 mg/100 g easy hydrolyzed nitrogen (determined after seven days of storage).

Concerning the antioxidant activity (antiradical capacity on DPPH radical, % RSA) of the compounds from dried brown algae and their content of polyphenols (gallic acid equivalent, mg EAG/g), the values obtained were not high: 3.39% RSA (the results compared to the positive control, however above the lower limit, 2.80%, established by the negative control) respectively 1.79 mg EAG/g (compared with the positive control represented by gallic acid). This is due to the light and temperature instability (at temperatures higher than 45 °C) of phenolic compounds in the process of obtaining dehydrated algae.

Determination of the antimicrobial activity of the brown algae extracts revealed an antimicrobial activity against Gram-positive (Staphylococcus
aureus) and Gram-negative (Escherichia coli) bacteria evidenced by a 8.5 mm diameter zone of inhibition on the strain of Staphylococcus aureus and a 10 mm diameter zone of inhibition on the strain of Escherichia coli (Fig. 3, Fig. 4).

**CONCLUSION**

Following this study, an improvement of the new product quality regarding the organoleptic characteristics (such as smell and taste and therefore flavor, texture and slice aspect) as well as the physicochemical and nutritional ones (by reducing the saturated fat and cholesterol therefore, increasing of the protein content, fibers and minerals) has been observed.

By the organoleptic point of view, according to the 9-point hedonic scale, as based on overall assessment, the two experimental variants were ranked by the consumers between pleasure and very pleasant. The V1 variant (containing 10% algae) was better appreciated concerning the taste and flavor than the V2 variant (containing 15% algae), while the V2 variant had the greatest impact on the physicochemical properties (protein and fat). An improvement in the appearance and texture of the finished products it has also been observed.

According to the Likert scale, tasters mainly appreciated the improving of the nutritional value and ensuring product harmlessness. Following these results, it should be noted that the promotion of the new product it is important to take into account and highlight these consumer preferences.

Concerning the correlations between investigated quality parameters and the ratios of algae, the highest values in the protein, moisture, salt content and the lowest fat content values were observed when compared V2 to V1 and VM (the lowest values of protein, moisture and sodium chloride content and the highest values of fats being determined in the VM variant). Furthermore, an increase in protein, fat, sodium chloride and a decrease of the moisture content in all variants have been observed during the storage.

The shelf life of the product was not negatively affected by the addition of algae due to their antimicrobial activity, the highest of it being against gram-negative bacteria (Escherichia coli).

The addition of algae in combination with beef components led to obtaining a higher quality product with functional characteristics and within the quality limits imposed by STAS.

**Acknowledgements.** This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

**REFERENCES**


