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The Technological Research Outcomes of Boiled Sausages Fortified with Sea Buckthorn Peels

Erkigul Bukyei[1]*, Buyanchimeg Baasanjargal[1], Enkhbat Tumurbaatar[1], Altanzul Ragchaa[1] and Solongo Ganbold[2]

[1]School of Engineering and Technology, Mongolian University of Life Sciences, Ulaanbaatar, Mongolia; erkigul@muls.edu.mn
[2]Mongolian University of Science and Technology, Ulaanbaatar, Mongolia

Abstract

The article presents the evaluation of dried peels from sea-buckthorn fruit pomace obtained after juice production in Tes Sum, Uvs province and its use in producing boiled sausages. The boiled sausages were enriched with four different amounts of sea buckthorn peels which are as follows: 0.2%, 0.3%, 0.4% and 0.5%. According to the experimental research compared to the reference, the amount of oil increased by 1.9%, fiber by 0.4%, flavonoids by 0.2 mg%, calcium and magnesium by 2 mg% and iron by 0.2% in boiled sausages that were enriched with 0.4% sea buckthorn peels. Moreover, the moisture and nitrite content decreased by 3.3% and 2.2 mg%, respectively.

Keywords: Fortifier, Meat Products, Sea Buckthorn Peels, Technology

1. Introduction

Within the framework of the "Sea buckthorn" program implemented by the Government of Mongolia, projects including increasing fruit cultivation, improving harvesting technology, refining industrial processing technology, increasing the types of products that are produced from sea buckthorn fruit and conducting clinical studies on the biochemical composition of the product and its effects on human health have been developed and carried out through the collaboration of enterprises, organizations and academic centers[1].

Although the result of the program reflects the increase in enterprises that plant sea buckthorn and produce products in Mongolia, these enterprises only separate the juice and oil mechanically and the soft tissue and seeds and peels are wasted or used as animal feed. Sea buckthorn pomace, which is considered waste matter, contains a significant amount of biologically active compounds. There is a focus on processing and using it as a fortification in production[2].

In our country, imported peas and red and green sweet peppers mainly play the part of fortifier in the production of sausages and meat product. There is a reason to believe that almost no variety of sausages with plant additions, except for the boiled sausages called "Pepper" and "Pea Sausage," which are produced by German technology and supplied to the market[3,4].

Enriching food items with substances that are extremely important to the human body should be treated carefully and not by common principles, but by taking into account several factors such as the conditions of the country, the customs, and traditions of the people, the nature and climate.

Therefore, in the research work, an experimental study was conducted to develop boiled sausage technology enriched with sea buckthorn peels grown in

*Author for correspondence

an ecologically clean environment that has its natural appearance and increased the biological value of sausages.

2. Objectives of the Research

The aim of the research is to develop a new technology that improves the structure and quality of boiled sausages by using dried sea buckthorn peels in the sausage production process. To achieve this, we set the following goals. It includes:

- Study of the chemical composition of dried sea buckthorn peel.
- Optimize the amount of sea buckthorn peel added to making boiled sausages.
- Determine and evaluate the physical and chemical parameters of enriched sausages.

2.1 Innovative Aspects of the Research Work

It consists in developing the technology of boiled sausage products enriched with sea buckthorn peel, an unused raw material of production at present in Mongolia.

2.2 The Practical Significance of the Research Work

It is determined by improving the biological value of boiled sausages by reducing the amount of nitrite salt and increasing the variety of products.

3. Materials and Methods

Dried Sea buckthorn peels from the fruit pomace obtained after juice production in Tes Sum, Uvs province,

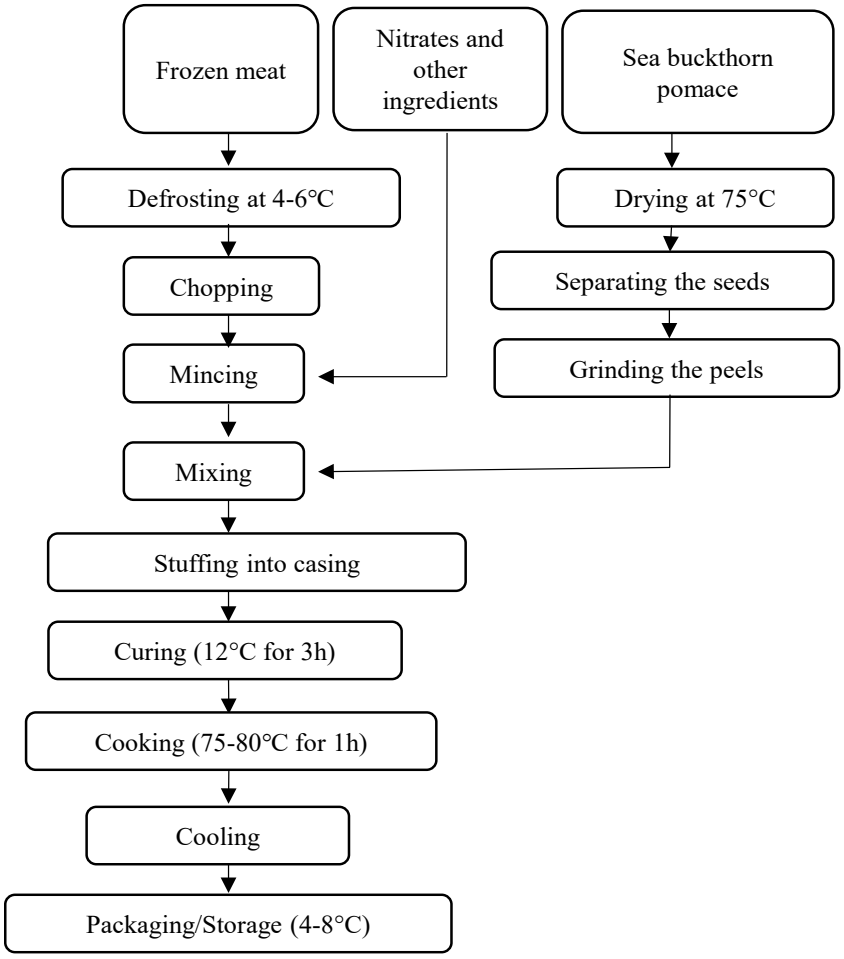

Figure 1. Flow chart for sausage processing.

have been used to prepare the sausages. The sausage has been made according to the procedure depicted in Figure 1.

Determinations of moisture, fat, protein and ash contents in the sausage samples were performed according to MNS ISO 6477:2014, 1444:1984, 937:1984 and 9376:2003 respectively. The microbiological analyses were performed following the MNS 6308:2012, MNS ISO 6579-1:2020, 4833:1995 as well as 6579:1995. The analysis of the mineral composition of sausages was performed by atom spectrophotometry. The crude fiber of sausage was determined according to AOAC 978.10.

The rotatable central composite design was used in the experiment design and the obtained experimental data were processed using the STATISTICA 12 software package.

The research was carried out at the Food Research Laboratory of Mongolian University of Life Science (MULS), the Food biochemistry laboratory of the Institute of Technology and the accredited food testing laboratory of the "CAMO" Institute using standard methods of instrumental analysis. The sausage-making experiments were performed at the meat processing center and plant of the MULS and Khan Brand LLC. The sensory properties of the fortified sausages (appearance, color, and flavor) were estimated using a quantitative-descriptive test with a grading scale from 2 to 14 by 28 untrained panelists.

4. Results and Discussion

4.1 Characterization of Sea Buckthorn Peels

Sea buckthorn peels were separated from the fruit pomace and were dried in a drying chamber until their moisture content reached 6% to evaluate their chemical

Table 1. Chemical Characteristics of Dried Sea Buck Thorn Peels, %

No	Chemical characteristics	Dried sea buckthorn peels	G Nanjid[4]	MN Volgarev[5]
1	Moisture	6.2±0.2	6.2	5.8
2	Lipid	30.0±0.4	15.0	8
3	Protein	24.4±0.3	25.49	26
4	Fiber	14.0±0.3	12.3	24
5	Ash	1.7±0.2	0.74	2.9

Table 2. The content of some minerals and flavonoids of dried sea buck thorn peels, mg/%

Minerals	Dried sea buckthorn peels	Dried sea buckthorn peels[5]	Dried apple[5]	Dried raisins[5]
Calcium	21.0±0.6	22±1.0	11.0±0.6	8.0±0.8
Magnesium	11.0±0.05	9.0±1.5	7.0±1	10.0±1.5
Iron	6.6±0.2	7.0±0.5	6.0±0.9	3.0±1
Chloride	34.5±0.8	32.0±1	47.0±0.7	59.0±0.5
Flavonoids	4.1±0.3	ND	ND	ND

ND - Not Determined

composition. Table 1 depicts the chemical composition of sea buckthorn peels.

From the experimental data presented in Table 1, it is apparent that the fiber, ash, moisture and protein content of the dried sea buckthorn peels are comparable to the results of G Nanjid, *et al*[4]. However, fiber content and ash levels were less than 10% and 1.2%, respectively, than the results of Volgarev, *et al*[5], which directly relates to its oil content.

In addition, the oil content of the peels was 2 and 4 times higher than the result of Volgarev, *et al.,* and Nanjid *et al.,*respectively[4,5]. This discrepant result may be due to the oil separation technology. In particular, there is a lack of efficient methods for separating oil from sea buckthorn peels in domestic industry.

The mineral contents and the total flavonoid content in sea buckthorn peels are depicted in Table 2.

According to the results, the amount of calcium, magnesium, iron and chloride contents of the sausage were comparable with that of the sausages reported by Volgarev *et al*[5]. However, no significant differences have been observed in the magnesium, iron and chloride contents of the sausage. The calcium content was twice as much higher than the other dried fruit peels[5]. Furthermore, in the experimental dried peel, 4.1-4.4 mg/% flavonoids were determined.

Based on the results of this research, sea buckthorn peels are highly valued for their essential nutrients for the human body.

4.2 Characterization of the Boiled Sausages Fortified with Sea Buckthorn Peels

The preparation of sausage in this study used fortification level treatment of sea buckthorn fruit peels: 0.2%, 0.3%, 0.4%, and 0.5% per 100 g of meat. The technological processing of the boiled sausages took place in compliance with general technical requirements of sausage products and nitrite levels in the prepared boiled sausages were aimed to be two times lower than in the control samples.

On the one hand, the quality of sausages directly depends on consumer appreciation. On the other hand, one of the tasks of this work is finding optimal sea buckthorn peel fortification of the boiled sausages. Therefore, sensory analysis was performed by 28 untrained panelists, including lecturers and students. The results of sensory tests by panelists on boiled sausage fortified with sea buckthorn peels are presented in Table 3.

The study results convey, the sea buckthorn peel fortification level of 0.4%, was given the highest score of 31.1, while the fortification of 0.2% was given the lowest score of 27.1 by panelists. In addition, eighty percent of

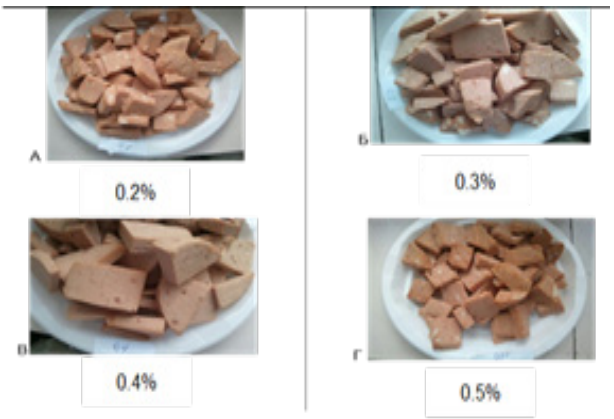

Figure 2. Experimental design.

Table 3. Results of the Sensory evaluation of the boiled sausages fortified with sea buckthorn peels

No	Fortification level, %	Variable			Total score
		Appearance 12-14 score	Colour 2-4 score	Flavor 11-14 score	
1	0.2%	13.2	2.1	11.8	27.1
2	0.3%	13.3	2.9	12.1	28.3
3	0.4%	13.8	3.8	13.5	31.1
4	0.5%	13.6	2.1	12.2	27.9

Table 4. Recipe optimization of sausages with sea buckthorn peels (criteria for regression model reliability)

Criteria	Results			
	y_1	y_2	y_3	y_4
R	0.907	0.912	0.897	0.879
R^2	0.822	0.833	0.791	0.812
$F_{experiment}$	3.385	5.551	2.562	4.345
$F_{theory}(0,05; 9; 10)$	0.035	0.006	0.033	0.008

all panelists stated that the fortification of boiled sausage through a level of 0.4% met the consumer-consumption characteristics of taste, texture, and color. The boiled sausage enriched with 0.5% of sea buckthorn peels is marked as having a bright yellow color (Figure 2).

In the technological experiment, input value (peel amount -x_1, nitrate salt-x_2, ice amount-x_3) and output value (fiber-y_1, flavonoid- y_2, nitrate amount- y_3, physical condition- y_4) have been chosen to optimize the peel ingredient. Also, the experimental reliability has been established by a rotatable central composite design of 3 factors (n=20) in numerical data. After that, the curvilinear regression equation was defined.

$$y_1 = 0.58 + 0.159 * x_1 + 0.045 * x_1^2 + 0.018 * x_2 - 0.131 * x_2^2 - 0.044 * x_3 - 0.165 * x_3^2 + 0.075 * x_1x_2 + 0.025 * x_1x_3 - 0.075 * x_2x_3$$

$$y_2 = 0.212 + 0.058 * x_1 + 0.103 * x_1^2 - 0.071 * x_2 + 0.148 * x_2^2 + 0.036 * x_3^2 + 0.1 * x_1x_3$$

$$y_3 = 2.142 - 0.132 * x_1 - 0.331 * x_1^2 - 0.131 * x_2 + 0.092 * x_2^2 + 0.113 * x_3 + 0.088 * x_3^2 - 0.1 * x_1x_2 - 0.05 * x_1x_3 - 0.15 * x_2x_3$$

$$y_4 = 5.017 - 0.573 * x_1 - 0.312 * x_1^2 + 0.004 * x_2 - 0.321 * x_2^2 + 0.179 * x_3 + 0.214 * x_3^2 + 0.333 * x_1x_2 - 0.583x_1x_3 - 0.083 * x_2x_3$$

The significance of Regression coefficients and Student t -tests has been determined by using program software. Additionally, the Fisher F-test has been used to determine whether the model form matched or not (Table 4).

As can be seen in Table 4, the regression determination coefficient is = 0.791-0.833. On the other hand, assuming the factors influencing y_1, y_2, y_3, and y_4 are 100%, the dependence of x_1, x_2, and x_3 on factors is 79-83%, while uncounted factors or external influence is low and around 17-21%.

The main influence factors on the technology of boiled sausage with sea buckthorn peel production recipes are displayed on three-dimensional surfaces (Figure 3).

The main factors that influence the technology of boiled sausage with sea buckthorn peel were estimated based on the results of the mathematical-statistical

Table 5. Result of a microbiological study on the enriched sausage with sea buckthorn peels

No	Characteristics	Record	Requirements	Enriched sausage
1	Total number of microorganisms per gram	MNS 6308:2012 ND ND	$2*10^3$	$<1*10^2$
2	*Escherichia coli* per gram		ND	Undetected
3	*Salmonella* per 25 grams		Undetected	Undetected

ND - Not Determined

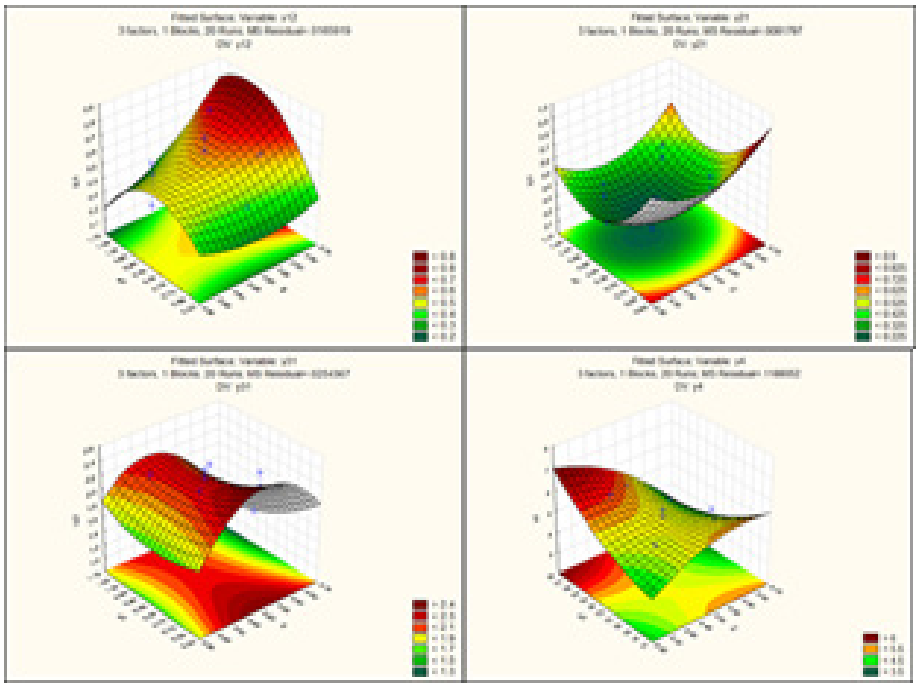

Figure 3. Three-dimensional surface of the main influence factors.

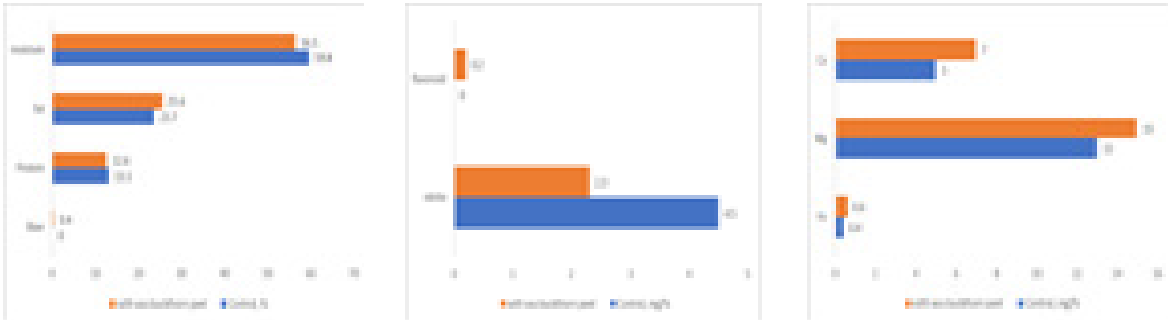

Figure 4. Chemical composition of boiled sausage enriched with sea buckthorn peel and control sample.

analysis. The results reveal that amount of dried sea buckthorn peel (x_1) is 0.42%, nitrate salt (x_2) is 0.87%, the amount of ice (x_3) is 22.3%, sausage fiber (y_1) is 0.48%, flavonoid (y_2) is 0.2%, nitrate (y_3) is 2.12 mg, physical condition (y_4) is 5 points, respectively.

Based on the research results above, we compared the chemical composition of the sausage enriched with 0.4% sea buckthorn peel with the control sample (without sea buckthorn peels) (Figure 4).

Compared to the control sample, the sausage enriched with sea buckthorn peel had a higher fat content; the total increase in fat was (1.9%), and the lower moisture content; the total decrease in moisture was (3.3%). The moisture change increases the fat content and hence the fiber content of the sea buckthorn peel increases its water-binding capacity. The amount of nitrite compared to the controls' was determined to be 2.2 mg/% lower.

Furthermore, the calcium, magnesium and iron contents of the enriched sausage with sea buckthorn peels increased by 2 mg/%, 2 mg/%, and 0.2 mg/%, separately, compared to the control sample.

It should also be notable that after three days of storage at 10°C, the enriched sausage in relation to reduced nitrite met the standard requirements for the number of bacteria and some pathogenic microorganisms (Table 5).

5. Conclusions

Based on the results obtained from the experimental investigation on the technology of boiled sausage with sea buckthorn peel, the following conclusions were made:

The sea buckthorn peel sample contains 30.0% oil, 14.0% fiber and 1.7% ash (including iron 6.6 mg/%, calcium 21.0 mg/%, chloride 34.5 mg/%) and flavonoid 4.1 mg/% shows that it is a raw material with high biological value.

Based on the results of mathematical modeling of sensory evaluation, chemical composition and technological parameters optimization of the enriched boiled sausage, it was determined that it is suitable to enhance the boiled sausages with 0.4% sea buckthorn peel.

When the boiled sausage was enriched with 0.4% sea buckthorn peel, the average oil content increased by 1.9%, fiber by 0.4%, flavonoids by 0.2 mg/%, calcium and magnesium by 2 mg/% and iron by 0.2 mg/%, clear evidence of biological value increase.

Sea buckthorn peels used as a fortifier in boiled sausages lead to reduced nitrite by 2.2 m/% and moisture content by an average of 3.3%.

6. Acknowledgments

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