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THE EFFECT OF SPECIES ORIGIN OF LIVER ON QUALITY OF LIVER PATE TYPE SAUSAGE

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ABSTRACT

The aim of the study was to determine the effect of species origin of liver in the raw material composition and kind of thermal process (pasteurisation and sterilization) on the physicochemical and sensory quality of liver pate type miscellaneous sausages.

Experimental material consisted of model emulsified liver pate type miscellaneous sausages produced at the P.P.H.U. "W-D" sp. z o.o. processing plant in Skwierzyna. The technological factor, which affected properties of experimental batters and the quality of final products, was the introduction in the formulation of three different species origin types of liver (porcine, poultry and rabbit liver). In this way three variants of experimental sausages liver pate type were produced. The quality of experimental sausages was assessed on the basis of the following characteristics: cooking loss, vitamin A content, sensory analyses.

The following conclusions can be formulated from the presented study. The quality of liver pate is determined both by the method of preparation of liver for production (raw, blanched) and the temperature of heating (pasteurization or sterilization). It was found that the lowest cooking loss occurs in pasteurized products produced with the additions of raw poultry and rabbit liver. Preproduction blanching of liver and higher heating temperature (sterilization) have a negative effect on the analyzed quality attributes of experimental products. Out of the three experimental products the highest scores for sensory quality attributes (apart from aroma) were given to sausages produced with the addition of poultry and rabbit liver.

Key words: liver pate, edible by-products, quality.

INTRODUCTION

Constantly changing consumer requirements and preferences force food producers, including also producers of meat products, to search for new assortments. The dynamic development of various forms of distribution (wholesale chains, etc.) force food producers to search for high quality, safe products at attractive prices. Processed meats in which edible by-products are the main "meat components" (so called miscellaneous sausages), belongs to the group of products with increasing popularity due to relatively low price and availability of the raw materials [17].

The commonly applied formulation of miscellaneous sausages contains considerable amounts of fat, lower class meats trimmings and liver [9, 13, 18, 19]. Such raw material require novel technologies and addition of functional additives in order to obtain final products which will be acceptable by the consumers.

Dietary recommendations publicized in recent years suggest cutting down on the consumption of processed meats containing considerable amounts of animal fat [14, 15, 16, 24].

Emulsified meat products – especially liver pate type due to their formulation contain rather large amounts of animal fat. In spite of this disadvantage, their original taste and certain nutritive value due to the relatively high vitamin A content [2, 8], in combination with the low price of the final product make such product very popular and in high demand among consumers.

A significant factor in the production of the above mentioned processed meats is the development of an appropriate quantitative and qualitative composition of meat, edible by-products and fat [5, 9, 10, 11, 13, 20].

Edible by-products, especially the liver, is an essential raw material in the development of high quality of such product, due to its specific taste and technological function (at least 20% addition to the formulation) [6, 7]. The liver is very good and effective emulsifier [5] mainly due to the residue of bile acids and bile in the bile ducts [13]. Moreover, the liver is a significant source of vitamin A, required for the proper functioning of human and animal organisms. At the same time, as a parenchymatous organ it is characterized by high concentrations of harmful heavy metals and has rather short shelf life caused by the presence of endogenous enzymes [2, 8, 11, 12, 13].

As a rule porcine liver is used in the processing process, with bovine liver being used occasionally. With the growing demand for such products also poultry, veal, rabbit or game liver is being used with increasing frequency.

Liver may be used in the processing process either raw or preliminarily blanched witch influence the properties (due to the state of their proteins) [9] . The use of raw liver facilitates technological control over rheological attributes and makes it possible to obtain a final product with the elastic consistency. In case of liver being pre-blanched, the final products will have rather plastic consistency [13].

The aim of the study was to determine the effect of selected species origin of liver in the raw material composition and kind of thermal process (pasteurization and sterilization) on the physicochemical and sensory quality of liver pate type miscellaneous sausages.

MATERIALS AND METHODS

Experimental material consisted of model emulsified liver pate type miscellaneous sausages produced at the P.P.H.U. “W-D” sp. z o.o. processing plant in Skwierzyna with the following formulation: yowl with skin – 20%; fat – 30%; porcine head meat – 30% and liver – 20%. During chopping 20% broth was added, along with 1.6% NaCl and 0.15% black pepper. The technological factor, which affected properties of experimental batters and the quality of final products, was the introduction in the formulation of three different species origin types of liver (porcine, poultry and rabbit liver). In this way three variants of experimental sausages liver pate type were produced. The sausages were marked as A, B and C (Table 1).

Table 1. Raw material composition of experimental processed edible products (%)

Material		Sausage type		
		A	B	**C**
Porcine head meat		30	30	30
Yowl		20	20	20
Fat		30	30	30
Liver:	Porcine	20	-	-
	Poultry	-	20	-
	Rabbit	-	-	20
Broth		20	20	20

Meat and fat (but not liver) was subjected to preliminary thermal processing at the temperature of 90-95°C until soft. Livers were used in two variants, i.e. raw and blanched (65°C, 20 min.). All materials were mixed, spices and broth were added, after which they were subjected to further comminution in a emulsifier. Batter temperature was 48±1°C.

Cans of 73×55 mm (200g) were filled with homogenous batter and subjected to thermal processing. Thermal processing of caned products (temperature measured at the geometric centre of the can) was performed as follows:

- pasteurization: water temperature of 75°C until 72°C was obtained in the can center;
- sterilization: temperature of 121°C, sterilization value F=3.0 in a WAA6 autoclave equipped with a controller for automatic sterilization process SPAR-41 [3].

After the completion of thermal processing, products were cooled in water to the temperature ≈10°C, after which they were cold-stored at the temperature of 4-6°C.

Due to used raw material composition and methods of thermal processing, these products may be called both sausages and canned meats. We referred to these products as a model sausages.

The quality of experimental sausages was assessed (after 7 days of cold storage) on the basis of the following characteristics:

- cooking loss was determined measuring their weight according to Shut [21],
- vitamin A content – the assay was based on the saponification of fat extracted from the sample, extraction of free fatty matter, purification of the extract and final analyses using high performance liquid chromatography (HPLC) according to the standard, i.e. hexan vitamin A solution [22],
- sensory analyses using 5-point scale according to Baryłko-Pikielna [4].

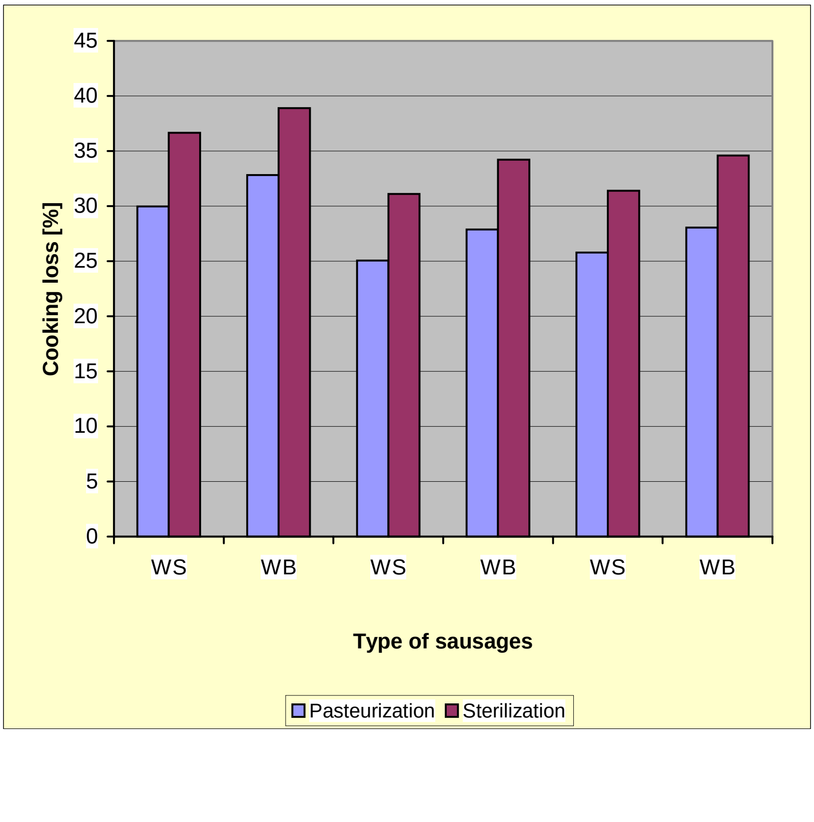
Three series of products were prepared. Statistical analysis of the obtained results consisted in the calculation of the mean value and standard deviation. Moreover, a three-way analysis of variance was performed to assess the effect of variation factors on the investigated attribute. This analysis made it possible to distinguish in the Tukey test groups of mean values differing statistically significantly.

RESULTS AND DISCUSSION

Cooking loss

Finely comminuted model sausages of the liver pate type may be produced maintaining full spatial dispersion of their components, obtained during chopping. At that time there is no or very limited cooking loss. Depending on the selection of the raw material and technology of its production, the amount of cooking loss exuded in the final product after thermal processing may constitute as much as 38.8% weight of sausages (Fig. 1). It is determined by all the investigated factors of technological variability, i.e. the species origin of the used liver (porcine, poultry and rabbit), the method of liver preparation (raw and blanched), parameters of thermal processing of the product (pasteurization and sterilization) and their interaction (Table 2). However, the type of liver has the biggest statistically significant effect on the amount of cooking loss from emulsified model sausages. This is followed by thermal processing of the product and the method of liver preparation.

Fig. 1. Cooking loss of experimental sausages [%]



Relatively high amounts of cooking loss in experimental products results from the raw material composition with a considerable content of adipose tissue. Thus, it made it possible to thoroughly follow the effect of selected technological variability factors on the investigated quality attribute of the final product. Technological utilization of used liver species types (porcine, poultry, rabbit) varies considerably in case of the production of experimental sausages. Poultry and rabbit livers are the most effective stabilizers of chopped batter structure. Model sausages produced with the addition of these liver types exhibited slight differences (0.3-0.7%) in the contents of fat and jelly of the collected cooking loss. It was further shown that cooking loss from sausages produced with the addition of porcine liver was higher by approx. 13-17% in comparison to sausages produced with poultry or rabbit livers. These differences are probably due to the state of proteins in the used livers and some other factors, such as e.g. bile residue content etc.

Table 2. Analysis of variance of amount of cooking loss model sausages (n=9)

<table>
<tr><td colspan="7">Analysis of variance of the effect of technological variability factors on cooking loss</td></tr>
<tr><td colspan="3">Variation factors</td><td colspan="2">F test</td><td colspan="2">significance F</td></tr>
<tr><td colspan="3">Type of sausage (liver) [1]</td><td colspan="2">1720.5</td><td colspan="2">< 0.0001</td></tr>
<tr><td colspan="3">Method of liver preparation [2]</td><td colspan="2">310.12</td><td colspan="2">< 0.0001</td></tr>
<tr><td colspan="3">Type of thermal processing [3]</td><td colspan="2">1289.3</td><td colspan="2">< 0.0001</td></tr>
<tr><td colspan="2"></td><td>[1x2]</td><td colspan="2">6.23</td><td colspan="2">< 0.005</td></tr>
<tr><td colspan="2"></td><td>[1x3]</td><td colspan="2">2.95</td><td colspan="2">< 0.061</td></tr>
<tr><td colspan="2"></td><td>[2x3]</td><td colspan="2">7.12</td><td colspan="2">< 0.015</td></tr>
<tr><td colspan="2"></td><td>[1x2x3]</td><td colspan="2">345.20</td><td colspan="2">< 0.0001</td></tr>
<tr><td colspan="7">Mean values of thermal drip (%)</td></tr>
<tr><td rowspan="3">Type of thermal processing</td><td colspan="6">Type of sausage (liver)</td></tr>
<tr><td colspan="2">A</td><td colspan="2">B</td><td colspan="2">C</td></tr>
<tr><td>W_S</td><td>W_B</td><td>W_S</td><td>W_B</td><td>W_S</td><td>W_B</td></tr>
<tr><td>Pasteurization</td><td>29.98^c</td><td>32.83^c</td><td>25.05^a</td><td>27.87^b</td><td>25.80^a</td><td>28.05^b</td></tr>
<tr><td>Sterilization</td><td>36.65^e</td><td>38.88^e</td><td>31.10^c</td><td>34.20^d</td><td>31.40^c</td><td>34.58^d</td></tr>
</table>

Legend: Sausage A – with the addition of porcine liver, sausage B – with the addition of poultry liver, sausage C with the addition of rabbit liver, W_S – raw liver, W_B – blanched liver.
Different letters at mean values denote statistically significant differences at $\alpha \leq 0.05$.

An essential factor in the production of processed the liver pate or liver sausage type is the adopted technology (method of liver preparation). Liver may be used in the production process both raw and pre-blanched. Long-term technological practice recommends the use of liver only in the raw state, as the blanching process causes irreversible denaturation changes in proteins, which serve as emulsifier during batter preparation.

In our study preliminary thermal liver processing (blanching) results in an increase in cooking loss by 7.8 to 10.5% in comparison to products produced with the addition of raw liver.

The experiment showed that the quality of experimental model sausages is dependent not only on the species origin of the liver and the method of its preparation, but also the temperature of its heating.

The effects of high heating temperature of experimental sausages, measured by the weight of collected cooking loss, show that thermal processing under sterilization conditions in comparison to pasteurization increases the amount of drip by approx. 15.5% to 19.4% (Fig. 1).

In the experimental design applied in this study, the adopted factors of technological variability to a bigger or lesser extent affect the shelf life and spatial stability of material components in the final product. The significance of the adopted factors of technological variability, as well as their interactions show that in order to conduct a proper inference process it is necessary to statistically assess the significance of variation in all the experimental designs used in this experiment. This would make it possible to distinguish groups, which do not differ statistically significantly from one another. For this purpose the LSD (least significant difference) test was applied (Table 3).

Table 3. Cooking loss (%) – statistical variation in technological designs (interaction: type of sausage x method of liver preparation x type of thermal processing)

Type of sausage (liver)	Method of liver preparation	Type of thermal processing	X mean± Standard deviation	Technological category
A	W_S	P	29.98 ± 0.57[c]	I
B	W_S	P	25.05 ± 0.35[a]	I
C	W_S	P	25.80 ± 0.42[a]	I
A	W_S	S	36.65 ± 1.32[e]	III
B	W_S	S	31.10 ± 0.89[c]	II
C	W_S	S	31.40 ± 0.95[c]	II
A	W_B	P	32.83 ± 0.44[c]	II
B	W_B	P	27.87 ± 0.49[b]	I
C	W_B	P	28.05 ± 0.38[b]	I
A	W_B	S	38.88 ± 1.75[e]	III
B	W_B	S	34.20 ± 0.83[d]	II
C	W_B	S	34.58 ± 0.92[d]	II

Legend: P – pasteurization, S – sterilization, other denotations as in Table 2.

From results presented in Table 3 can be assumed, that among the 12 experimental designs a few groups may be distinguished differing statistically significantly at the level of α=0.05. For this reason for the purpose of technological inference differing groups were classified additionally into three categories, i.e. medium drip – up to 30.0% (category I), large drip – 30.1-35.0% (category II) and very large drip – over 35.0% (category III). Limits between the groups were established arbitrarily on the basis of the range of result variation. In this way technological information was obtained, facilitating the selection of such experimental designs, which would exhibit the lowest amount of cooking loss (technological category I) (Table 4). It was shown that such cooking loss was observed in model sausages produced with the addition of porcine, poultry and rabbit livers, used both raw and blanched, but subjected to thermal processing only under pasteurization conditions. Summing up, the differentiation in cooking loss within the distinguished groups (technological classification) is determined by the adopted factors of technological variability, i.e. the species origin of liver, the method of liver preparation and the temperature of thermal processing of experimental products.

Table 4. Cooking loss (%) – optimum technological designs

Type of sausage (liver)	Method of liver preparation	Type of thermal processing	X mean± Standard deviation	Technological category
A	W_S	P	29.98 ± 0.57	I
B	W_S	P	25.05 ± 0.35	I
C	W_S	P	25.80 ± 0.42	I
B	W_B	P	27.87 ± 0.49	I
C	W_B	P	28.05 ± 0.38	I

Denotations as in tables 2 and 3.

Changes in vitamin A contents

The liver from slaughter animals are edible product and contain considerable amounts of vitamin A [2, 6, 8]. Traditional cooking processes cause the degradation of retinol only to a slight degree (up to 10%); however, prolonged heating, even at low temperatures, result in its significant loss [23].

Changes in vitamin A contents in experimental sausages are presented in Table 5. Statistical analysis showed a significant ($\alpha \leq 0.05$) effect of species origin of liver and the method of its preparation and the type of thermal processing on the investigated attribute. Moreover, the interaction of the adopted factors of technological variability turned out to be statistically significant (Table 5).

Table 5. Changes in vitamin A content in experimental sausages [mg retinol/100g product] (n=6)

Type of sausage (liver)	Method of liver preparation	Type of thermal processing	X_{mean} ± Standard deviation
A	W_S	P	9.82 ± 0.41[j]
B	W_S	P	3.95 ± 0.79[ef]
C	W_S	P	4.82 ± 0.68[gh]
A	W_S	S	5.54 ± 0.27[h]
B	W_S	S	2.43 ± 0.31[ab]
C	W_S	S	3.55 ± 0.46[de]
A	W_B	P	6.56 ± 0.33[i]
B	W_B	P	3.19 ± 0.56[cd]
C	W_B	P	3.70 ± 0.37[def]
A	W_B	S	4.33 ± 0.28[fg]
B	W_B	S	1.91 ± 0.16[a]
C	W_B	S	2.71 ± 0.25[bc]
Analysis of variance of the effect of technological variability on the amount of cooking loss			
Factors of variation		Test F	Significant F
Type of sausage (liver) [1]		625.89	< 0.0001
Method of liver preparation [2]		223.86	< 0.0001
Type of cooking loss [3]		442.15	< 0.0001
	[1x2]	27.666	< 0.0001
	[1x3]	61.038	< 0.0001
	[2x3]	22.810	< 0.0001
	[1x2x3]	11.223	< 0.0001

Denotations as in tables 2 and 3.

Results of the investigations showed that experimental sausages produced with the addition of porcine liver had definitely higher vitamin A contents than those produced with use of poultry or rabbit liver. The highest vitamin A content was found in the sausage with the addition of porcine liver either in the raw form or pasteurized at the temperature of 72°C (9.82 mg retinol/100g product). In turn, the smallest vitamin A content in the presented experiment was found in the sausage produced with poultry liver blanched and heated under sterilization conditions Fc=3.0 (1.91 mg retinol/100g product). Differing vitamin A contents in experimental sausages were connected with the species origin of liver used in their production. Vitamin A contents in liver depends primarily on methods of feeding of live animals and their life span [2, 23]. Our results proved that the porcine liver was better source of vitamin A in comparison to poultry or rabbit liver.

The obtained results demonstrate that process of liver blanching has a negative effect on retinol, causing significant losses in vitamin A content in the final product. Liver blanching at the temperature of 65°C resulted in a 19-30% decrease of vitamin A content in sausages. The above findings confirm results of studies by Antilia and Niinivaara [1], who found a 2-14% loss in vitamin A content in porcine liver as a result of blanching, while in the course of the whole process of sausage production it on the level of 22-47%. The variation factor differentiating the experimental processed products in terms of their vitamin A contents was the temperature of their heating (pasteurization or sterilization). These results indicate that along with an increase in the temperature of thermal processing from 72°C to 121°C the content of vitamin A in experimental sausages decreased by 33 to 40% (Table 5).

On the basis of the obtained results on changes in vitamin A contents in experimental sausages a regression equation was calculated:

$$\text{vitamin A} = 9.29 - 0.024\ (\text{T mat})^{*} - 0.041\ (\text{T process})^{**}$$

$$R = 0.550;\ F = 14.974,\ \text{level of significance}\ \alpha = 0.0002;\ n = 6$$

*T mat – temperature of material used to produce experimental sausages. In case of raw liver it was 10°C, while in case of blanched liver it was 65°C,
**T process – temperature of thermal processing; pasteurization – 72°C, sterilization – 121.1°C.

from which it results that both factors, i.e. temperature of liver blanching and temperature of thermal processing of the product, have a significant, negative effect on changes in vitamin A contents. On the basis of the calculated standardized coefficients of regression β for T raw = -0.318 and T processed = -0.448 it was shown that thermal processing of model sausages had bigger effect on vitamin A content than process of liver blanching. In terms of maintaining the highest vitamin A content in the final product, the experimental design in which the product was produced with raw porcine liver and subjected to pasteurization at 72°C turned out to be technologically optimal (Table 5).

However, it needs to be taken into consideration that factors of technological variability adopted in the experiment are not the only ones, which may affect vitamin A content in such products [8]. Thus in further studies it seems advisable to assess the effect of other factors on vitamin A content, such as e.g. liver comminution or batter chopping conditions.

Sensory analyses of experimental sausages

Results of sensory analyses indicate a variation in their final quality. The assumed factors of technological variability, i.e. species origin of liver, method of liver preparation for production and temperature of thermal processing affects taste, aroma, color at cross-section and consistency of experimental products (Table 6).

Out of the three experimental products the highest scores for sensory atributes: taste, color and consistency, were given to sausages B and C, i.e. those produced with the addition of poultry and rabbit liver. These sausages, except for aroma, received higher scores in the appraisal of the analyzed attributes than the other sausages. In turn, the use of porcine liver, both raw and subjected to preliminary thermal processing (blanching) rather considerably improved the aroma (0.3-0.5 points in a 5-point scale) of the final products (Table 6).

The technological reasons for the use of liver of different species origin in the production of the liver pate or liver sausage type are connected not only with their improved sensory desirability, but also results from better water binding, and emulsifying capacity of fat and it effective binding with the structure of the final product. Mainly these two phenomena are responsible for reduction of the volume of cooking loss and at the same time increase the final yield of emulsified sausages produced in semi-permeable casings.

The quality of liver sausages is dependent not only on the species origin of liver, but also on the physical state of the used liver (raw or blanched) and the temperature of their heating (Table 6).

Table 6. Appraisal of sensory quality of experimental sausages in a 5-point scale (n=15)

Type of sausage	Method of liver preparation	taste		aroma		colour		Consistency	
		X_{mean}	Sd	X_{mean}	Sd	X_{mean}	Sd	X_{mean}	Sd
Thermal processing – Pasteurization									
A	W_S	4.30	0.32	4.77	0.26	3.51	0.32	4.17	0.24
	W_B	4.17	0.41	4.67	0.41	3.47	0.30	4.03	0.40
B	W_S	4.53	0.35	4.30	0.25	3.83	0.24	4.43	0.37
	W_B	4.47	0.30	4.13	0.30	3.70	0.25	4.30	0.25
C	W_S	4.41	0.28	4.45	0.33	3.80	0.27	4.40	0.29
	W_B	4.35	0.36	4.30	0.40	3.70	0.31	4.30	0.35
Thermal processing – Sterilization									
A	W_S	4.07	0.32	4.37	0.35	3.57	0.37	4.07	0.32
	W_B	3.90	0.34	4.33	0.41	3.45	0.35	4.03	0.40
B	W_S	4.27	0.32	3.87	0.30	3.80	0.25	4.30	0.25
	W_B	4.13	0.35	3.80	0.25	3.73	0.26	4.20	0.32
C	W_S	4.00	0.31	4.05	0.28	3.75	0.25	4.35	0.31
	W_B	3.90	0.34	4.00	0.32	3.70	0.30	4.30	0.27

Denotations as in tables 2 and 3.

The use of raw liver caused a situation, in which the taste, aroma, consistency and color of the final products received much better notes in comparison to identical sausages produced with the addition of blanched liver.
The final thermal process in the production of experimental sausages had significant effect on its taste attributes. All experimental sausages subjected to pasteurization received much higher scores than the products subjected to thermal processing at the temperature of 121°C.

CONCLUSIONS

1. The species origin of liver is one of the technological factors determining the quality of emulsified sausage of the liver pate type. The quality of these sausages is determined both by the method of preparation of liver for production (raw, blanched) and the temperature of heating (pasteurization and sterilization).
2. It was shown that the lowest cooking loss occurs in pasteurized products produced with the additions of raw poultry and rabbit liver.
3. The use of porcine liver considerably increases vitamin A content in final products in comparison to that of poultry or rabbit liver.
4. Out of the three experimental products the highest scores for sensory quality attributes (apart from aroma) were given to sausages B and C, i.e. those produced with the addition of poultry and rabbit liver.
5. Preproduction blanching of liver and higher heating temperature (sterilization) have a negative effect on the analyzed quality attributes of experimental products.

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