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STUDY OF CHEMICAL COMPOSITION INFLUENCE ON THE RHEOLOGICAL AND TEXTURAL PROPERTIES OF VARIOUS TYPES OF ANIMAL AND VEGETAL PÂTÉ

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Abstract: *The aim of the study was to establish the influence of chemical composition of animal and vegetal pâtés on the rheological and textural properties.The analysis and methods utilized in the present study were the following: determination of dry substance content, moisture content, starch, protein and fat using chemical methods and rheological and textural properties utilizing TPA method. The main chemical parameter to be determined was starch content from wheat flour or starch from corn used as raw materials. The results obtained confirm the fact that starch added in animal and vegetal pâtés could have a strong influence on their rheological and textural properties. For TPA determination the samples were cut as cubes with 20X20 mm sides, displacement of 10 mm/min. and the result interpretation was made using the Mesur Gauge software of Mark 10 texturometer. The main functions of the starch in food products are the following: thickness agent, coloidal stabilizer, agent for moisture retention, gelling agent, binding agent and covering agent. The main role of starch added in pâtés is of thickness agent or agent for moisture retention.*

Keywords: animal and vegetal pâtés, TPA, texturometer, viscosity, hardness, adhesivity, cohesivity, elasticity, gumminess, chewingness, starch, moisture, protein, fat.

1. Introduction

Pâté is one of the dishes with creamy consistency, homemade or industrial obtained, of various ingredients such as: pork meat, beef, fish (tuna), ham, liver, butter, cream, spices, salt, food additives, flavours. The most appreciated is foie gras pâté, made from goose or duck liver, grown especially for this purpose.
The industrial manufactured pates are very different from foie gras made from goose or duck liver. The typical composition of an industrial pâté includes: 20% liver, water, meat, non-hydrogenated vegetable oil, soybean protein, starch from corn, iodized salt, condiments, starch from wheat, condiment extract, mustard, flavours, stabilizers, glucose syrup, emulsifiers, thickness agents, antioxidants, dye, preservatives.
On the market there are also vegetal pâtés which reproduces the composition of pâtés made from liver-meat, containing the following: water, non or hydrogenated vegetable oil (margarine), soybean protein, starch from corn, iodized salt, condiments, starch from wheat, condiment extract, mustard, flavours, stabilizers, glucose syrup, emulsifiers, thickness agents, antioxidants, dye, sugars, dehydrated vegetables, acidifier, carob flour, paprika extract. Several studies regarding the composition of different types of pates and its influence on the textural properties of pates were conducted worldwide. The

effect of fat content (30%, 35% and 40%) on physical, microbial, lipid and protein changes, during chill storage, of foal liver pâté [2], represents one of the studies regarding the composition of pates. The antioxidant effect of two plant essential oils (sage and rosemary) and one synthetic antioxidant (BHT) on refrigerated stored porcine liver pâté (4 °C/90 days) was also evaluated [1]. Another study is regarding the effect of fat content on physico-chemical properties and lipid and protein stability of foal liver pâté. For this purpose, two batches (10 units per batch) of foal liver pâté with different pork back fat content [30% (30F) and 40% (40F)] were manufactured [3]. All physicochemical parameters were affected by the storage time, especially instrumental texture, which indicated emulsion instability during storage due to increased hardness, elasticity and gumminess [4]. Other researchers have studied the physico-chemical characteristics and oxidative stability of liver pâtés with different fat content. Pâtés with high-fat contents presented a smaller cooking yield than pâtés with medium and low fat contents, mainly due to a higher loss of lipids. Fat content was closely related to the calorific value of pâtés, these being more calorific in those with higher fat contents [5].

2. Matherials and methods

The aim of the study was to establish the correlation between chemical composition (starch content and moisture, dry substance, proteins and fat of nine pâtés samples: three pork pâtés, three chicken pâtés and three vegetal pâtés having different chemical compositions. Physico-chemical determinations were made such as: moisture, starch, heavy metals and they were correlated with the textural parameters by using TPA (Texture Profile Analysis) as determination method. For TPA determination the samples were cut as cubes with 20X20 mm sides, displacement of 10 mm/min., and data interpretation using Mesur Gauge software of Mark 10 texturometer.

2.1. Determination of physico-chemical properties. Physico-chemical analysis.

Quality control includes physico-chemical analysis of canned vegetal and animal origin patees and has the following physico-chemical parameters:

- Moisture content determination(dry substance) in pâtés or water content SR ISO 1442: 2010, [6]
- Method of drying in the oven.

The principle of the method is water evaporation from the sample by heating in the oven at 120 ± 2° C until a constant mass is reached [6].

- Determination of protein content (KJELDAHL METHOD) SR ISO 937: 2007, [10]

Represents the nitrogen content of meat and other meat products and consists in determination of nitrogen quantity corresponding to nitrogen produced from the decomposition of proteins.

Principle of method:

A sample digestion of concentrated sulphuric acid which transforms organic nitrogen in ammonium ions under the catalytic action of copper sulphate (II); alkalinization, distillation of ammonia released in excess of boric acid solution, titration with hydrochloric acid of ammonia combined with the boric acid and calculation of nitrogen content from the samples, starting from the produced ammonia.

$$0{,}0014\ x\ (V_1 - V_0)\ x\ \frac{100}{m}$$

Where:

V0- volume of hydrochloric acid solution 0,1 N used as blank, expressed in ml;

V1-volume of hydrochloric acid solution 0,1 N used for determination, expressed in ml;

m-mass of the sample, expressed in g.

- Determination of fat content (SOXHLET METHOD) SR ISO 1444: 2008, [11]

Principle of method:

Fat extraction using an adequate solvent in a closed system through repeated jets, solvent removal by drying in the oven, dosing the fat extracted by weighting. The extraction can be made directly from the food or product or dry residue.

The fat content of the sample it follows from the formula:

$$Fat\,\% = \frac{m}{m_1} \times 100$$

Where:

m-quantity of fat extracted expressed in g (difference between the weight of the balloon with fat extracted after the balloon has dried);

m1-quantity of product

Results obtained:

Qualitative identification of starch from meat products is realized when it comes to products without starch addition and quantitative identification reffers to products made from recipes in which auxiliary materials based on starch are included. The identification could be made on a sample extracted from product or directly on the section of the product.

- Determination of starch content (ELSER METHOD) SR ISO 9297: 2001 [7]

Principle of method: The starch is converted by acid hydrolysis into direct reducing sugar (glucose), using Fehling solution as oxidizing solution and iodometric titration. Results are expressed in % starch.

Expression of results:

Starch content is calculated with the following formula:

$$\%\ starch = \frac{m_1 \cdot 250 \cdot 100}{m \cdot V \cdot 1000} \cdot 0,9 \qquad (1)$$

Where:

mı- the inverted sugar mass, expressed in mg, corresponding to the volume of the iodine used for titration (cm^3);

m- mass of product for determination, in g;

V- volume of solution for determination from the flask, in cm^3;

1000- flask volume;

0.9- starch conversion factor from invert sugar.

2.2 Texture parameters determination

For TPA determination the samples were cut as cubes with 20X20 mm sides, displacement of 10 mm/min. and the results interpretation was made using the Mesur Gauge software of Mark 10 texturometer.

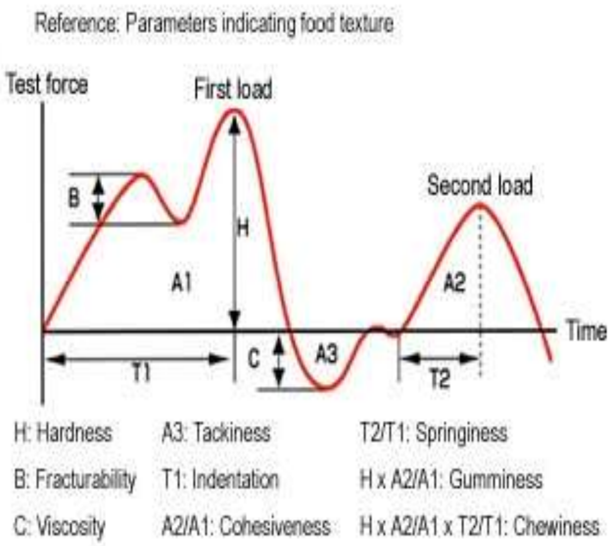

Fig. 1 Load diagram in two cycles used for texture profile analysis (TPA).

Mechanical textural properties: Hardness, Cohesivity, Viscosity, Elasticity, Adhesivity, Fracturability, Chewingness, Gumminess [8], [9].

Table 1

Primary and secondary texture parameters defined according to ISO 11036/2007 [9]

The primary parameters of texture		
Parameter texture	Popular adjectives	Notation (Figure1)

Hardness	Soft, firm, hard	H
Cohesivity	Brittle, crisp, friable, chewable, hard, soft, short and firanaceous, pasta gummy	A2/A1
Viscosity	Fluid, thin, viscous	C
Elasticity	Plastic, malleable, elastic	D2/D1
Adhesiveness	Sticky, gummy, greasy	A3
Secondary parameters of texture		
Fracturability (Fragility)	It is related to the primary parameters of hardness and cohesion	B
Gumminess	It is related to the primary parameters of hardness and cohesion of semisolid foods when cohesion is reduced	HxA2/A1
Chewiness	It is related to the primary parameters of hardness, cohesion and elasticity	HxA2/A1xD2/D1

3. Results and discussion

To study the influence of the chemical composition of pâtés samples on their texture parameters it was used the statistical analysis of experimental data. In order to identify and quantify the relations between the variables studied, the calculation of Pearson correlation coefficient (*r*) was used, as well as the Principal Component Analysis (PCA). These methods are widely utilized in statistic analysis for measuring linear relationships, positive or negative between variables. The experimental data were processed using the software component *Analyze-It* for Microsoft Office Excel (v. 4.10 – the evaluation version)
Pearson correlation matrix only between the dependent variables (texture parameters) is shown in table 3.

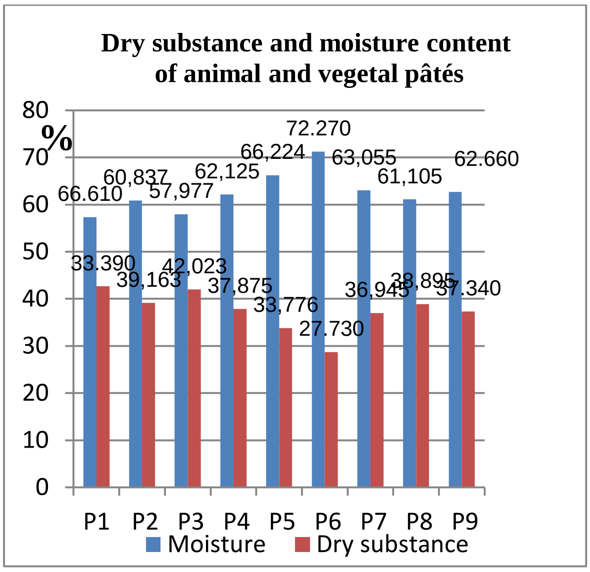

Fig. 2 Dry substance and moisture content of animal and vegetal pâtés

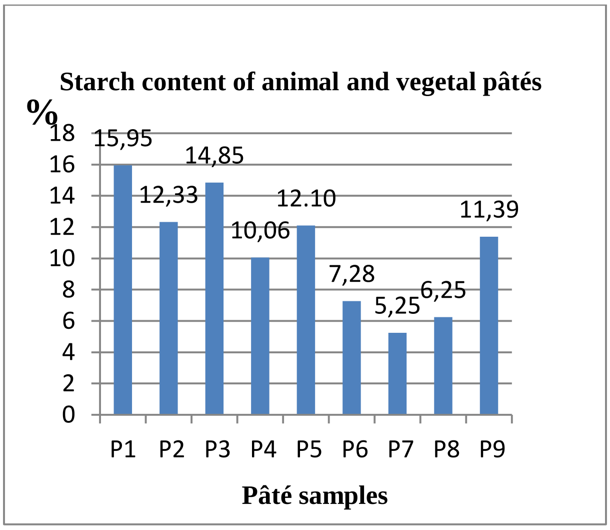

Fig. 3 Starch content of animal and vegetal pâtés

2.3. Stereomicroscope images of animal and vegetal pâté samples

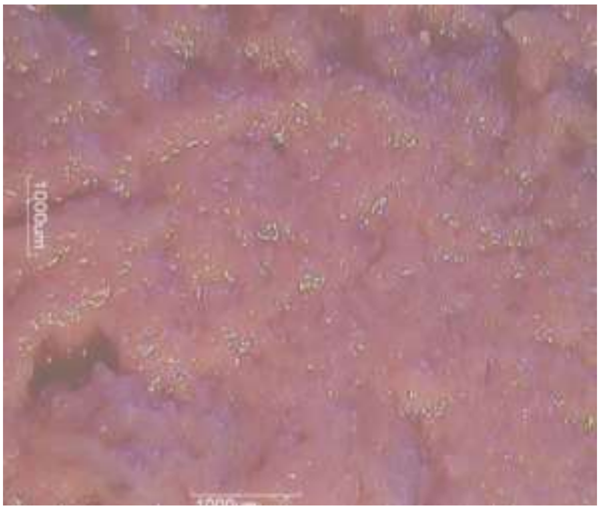

Fig. 4 Pork pâté P1

Fig. 5 Pork pâté P2

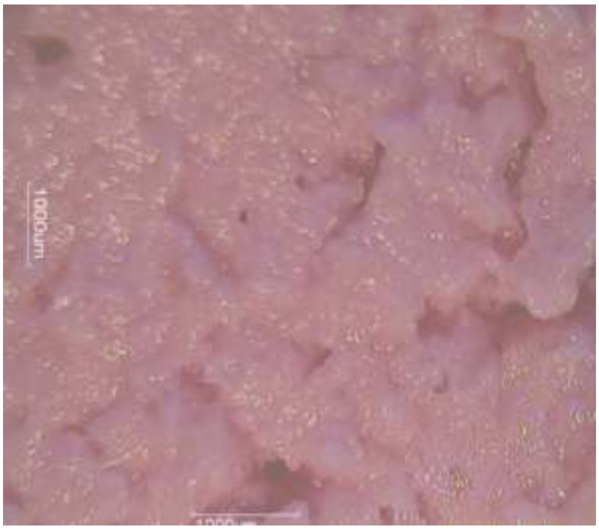

Fig. 6 Pork pâté P3

Fig. 7 Chicken pâté P4

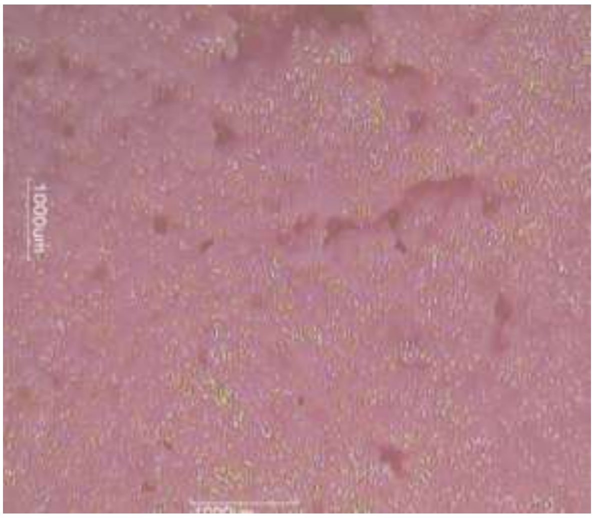

Fig. 8 Chicken pâté P5

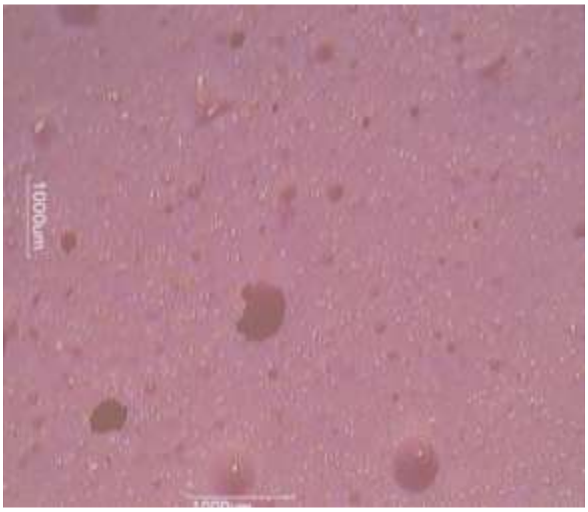

Fig. 9 Chicken pâté P6

Fig. 10 Vegetal pâté P7

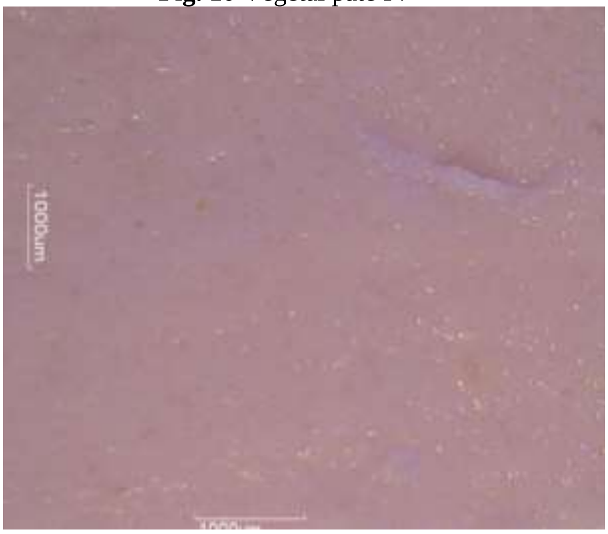

Fig. 11 Vegetal pâté P9

Fig. 12 Vegetal pâté P8

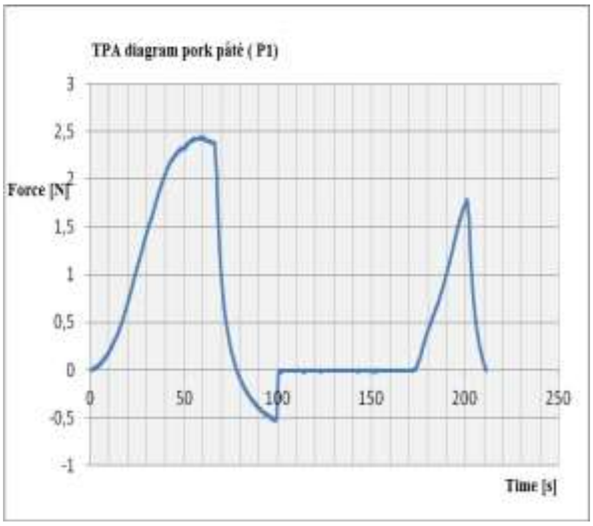

Fig. 13 TPA diagram pork pâté P1

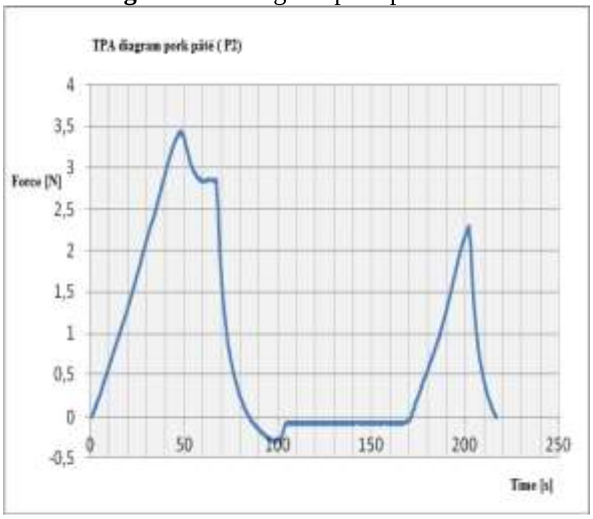

Fig. 14 TPA diagram pork pâté P2

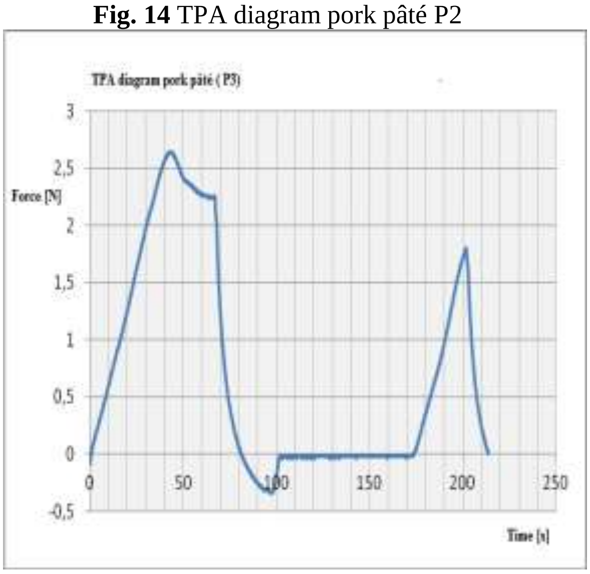

Fig. 15 TPA diagram pork pâté P3

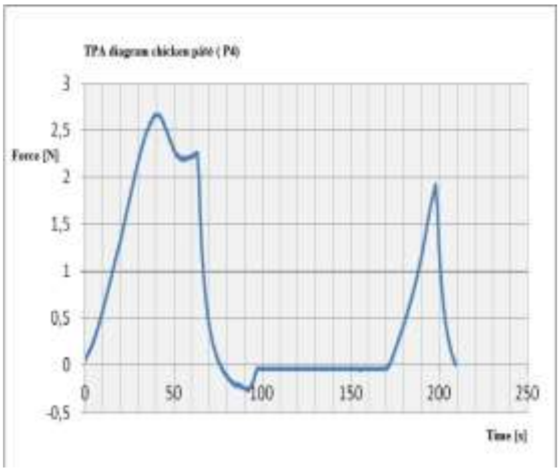

Fig. 16 TPA diagram chicken pâté P4

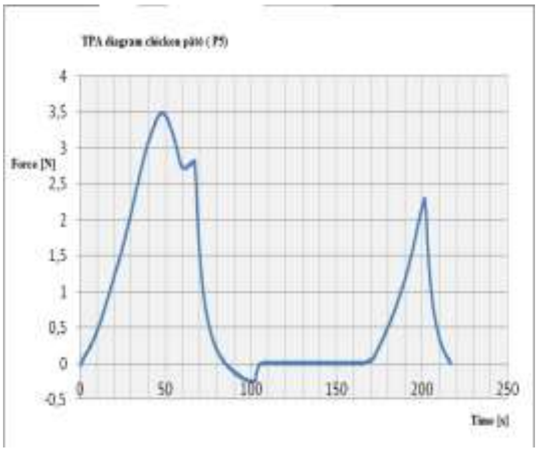

Fig. 17 TPA diagram chicken pâté P5

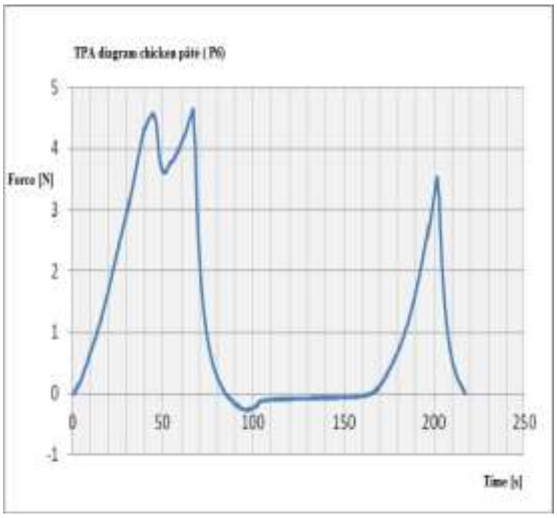

Fig. 18 TPA diagram chicken pâté (P6)

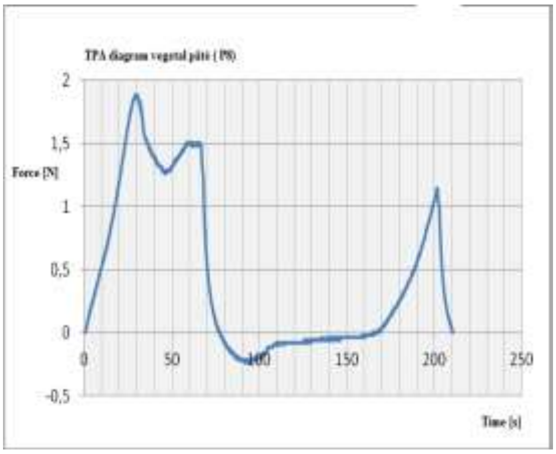

Fig. 20 TPA diagram vegetal pâté P8

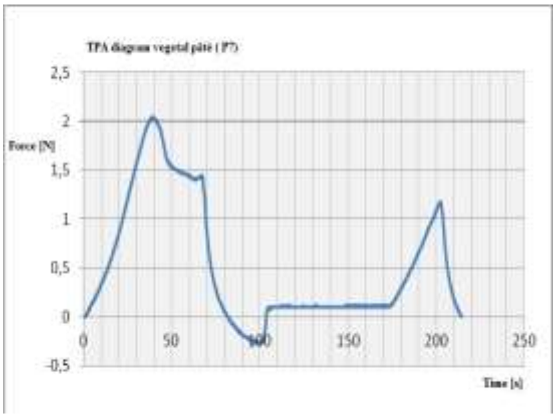

Fig. 19 TPA diagram vegetal pâté P7

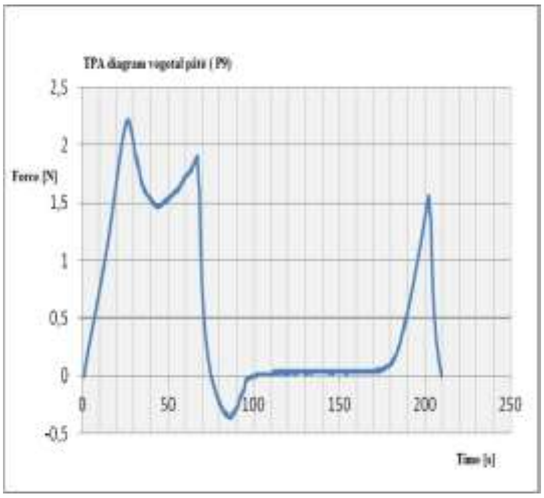

Fig. 21 TPA diagram vegetal pâté P9

Table 2

Texture properties and chemical composition of animal and vegetal pâtés

Nr. Crt.	Sample type	Viscosity [N]	Hardness [N]	Adhesivity [N·mm]	Cohesivity	Elasticity	Gumminess [N]	Chewingness [N·mm]	Starch [%]	Dry substance [%]	Moisture [%]	Protein [%]	Fat [%]
1.	Pork pâté (P1)	0.520	2.440	7.337	0.299	0.472	0.731	0.345	15.950	42.650	57.350	9.000	16.000
2.	Pork pâté (P2)	0.300	3.440	3.786	0.286	0.671	0.986	0.662	12.330	39.163	60.837	11.000	13.900
3.	Pork pâté (P3)	0.340	2.640	4.494	0.246	0.678	0.651	0.441	14.850	29.023	57.977	10.600	14.700
4.	Chicken pâté (P4)	0.260	2.660	3.531	0.247	0.688	0.659	0.453	10.060	37.875	62.125	9.000	17.000
5.	Chicken pâté (P5)	0.240	3.500	3.048	0.275	0.747	0.965	0.721	12.100	33.776	66.224	9.100	10.800
6.	Chicken pâté (P6)	0.280	4.640	3.891	0.304	0.767	1.413	1.084	7.280	28.730	71.270	9.100	10.400
7.	Vegetal pâté (P7)	0.260	2.040	3.649	0.264	0.793	0.539	0.427	5.250	36.945	63.055	2.000	26.000
8.	Vegetal pâté (P8)	0.240	1.880	8.650	0.209	1.153	0.394	0.454	6.250	38.895	61.105	2.100	27.300
9.	Vegetal pâté (P9)	0.360	2.220	4.572	0.202	1.072	0.450	0.482	11.390	37.340	62.660	3.100	21.000

Table 3

Pearson correlation matrix between the dependent variables

Pearson's *r*	Viscosity	Hardness	Adhesivity	Cohesivity	Elasticity	Gumminess	Chewingness
Viscosity	1						
Hardness	-0.177	1					
Adhesivity	0.385	-0.502	1				
Cohesivity	0.241	0.682	-0.288	1			
Elasticity	-0.480	-0.338	0.281	-0.802	1		
Gumminess	-0.085	0.982	-0.445	0.801	-0.447	1	
Chewingness	-0.377	0.929	-0.421	0.482	0.002	0.889	1

By studying the values of correlation coefficient from the table above it is found very strong positive associations between the texture parameters *Hardness* and *Gumminess* (*r* = *+0.982*) and *Hardness* and *Chewingness* (*r* = *+0.929*), as well as very strong negative associations between *Cohesivity* and *Elasticity* (*r* = *-0.802*).

Low negative associations is found between *Viscosity* and *Gumminess* (*r = -0.085*), as well as low positive associations between *Elasticity* and *Chewingness* (*r = +0.002*).

Also, in order to obtain a complete characterization of the texture parameters variance it must be studied the association between the independent variables (composition of pâtés samples) and dependent variables (texture parameters). Thus, the Pearson correlation matrix between the independent and dependent variables is shown in table 4.

Table 4

Pearson correlation matrix between independent and dependent variables

Pearson's *r*	Viscosity	Hardness	Adhesivity	Cohesivity	Elasticity	Gumminess	Chewingness
Starch	0.703	0.043	0.014	0.213	-0.589	0.052	-0.265
Dry substance	0.376	-0.564	0.470	-0.117	-0.026	-0.483	-0.606
Moisture	-0.541	0.707	-0.465	0.267	0.220	0.658	0.876
Protein	0.218	0.645	-0.360	0.635	-0.763	0.651	0.334
Fat	-0.136	-0.847	0.499	-0.664	0.613	-0.828	-0.617

From studying the values of the correlation coefficient in table 2 results very strong negative associations between the independent variable *Fat* and the dependent variable *Hardness* (*r = -0.847*), which indicates the fact that an increased concentration of fat in pâtés samples leads to a lower value of hardness and vice versa. Also, it shows a very strong negative association between the independent variable *Fat* and dependent variable *Gumminess* (*r = -0.828*), which indicates the fact that an increased concentration of fat in pâtés samples leads to a lower value of *Gumminess* and vice varsa.

A high positive value of Pearson correlation coefficient it is noted between independent variable *Moisture* and dependent variable *Chewingness* (*r = +0.876*). Values of Pearson correlation coefficient close to 0 is observed between the independent variable *Dry substance* and dependent variables *Adhesivity* and *Hardness* (*r = +0.014*, respectively *r = +0.043*).

Principal component analysis (PCA)

By utilizing statistic method *Principal Component Analysis (PCA)* it is shown the possible correlations between variables. The relative positions between the dependent variables are found in figure 22

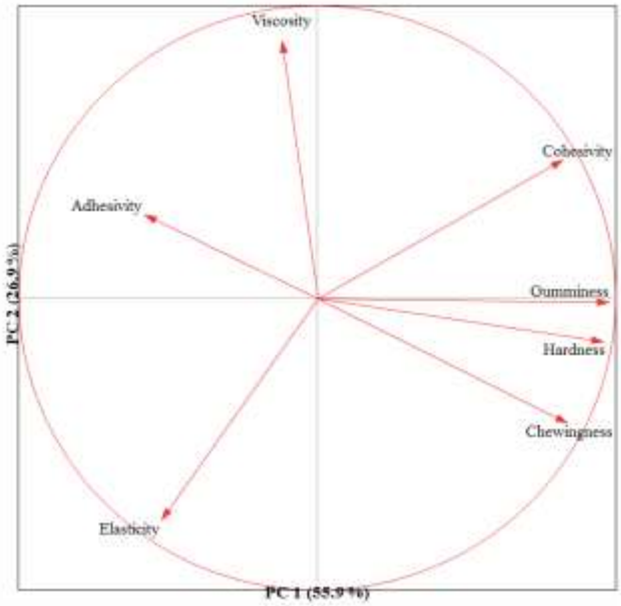

Fig. 22 Principal Component Analysis (PCA)

Relationship between studied independent and dependent variables

It is shown that the first two principal components explain 82.8 % of data variance (*PC1 = 55.9%; PC2 = 26.9%*).
vectors. Position of variables *Hardness* and *Gumminess* towards the first principal component (PC1) from figure 2 shows that between them is a strong, direct connection. The correlation between them is positive, which can be observed also due to the small angle between the corresponding The position of variables *Hardness* and *Chewingness* also shows a very strong positive connection. Between *Cohesivity* and *Gumminess*, as well as between *Hardness* and *Chewingness* it can be observed a very strong positive association, which results from the very small angle between the vectors corresponding to the two pairs of variables. Vectors positions corresponding to variables *Cohesivity* and *Elasticity* shows a very strong negative association.

4. Conclusion

This experimental study was conducted to highligh the influence of starch addition on the rheological, textural and technological properties of the animal and vegetal pâtés. The main functions of starch in food products are the following:
- thickening agent;
- colloidal stabilizer;
- agent for retaining moisture;
- gelling agent;
- binding agent;
- covering agent.

The main role of starch addition in animal and vegetal pâtés is of thickening agent and agent for retaining moisture.
New studies have highlighted the fact that not all types of starch have the same effect on the body. One of them are digested very quickly and produces a sharp increase of blood glucose, meanwhile other types of starch are slowly digested, having a minor effect on the glycemic index. Moreover, the resistant starch it is not digested in the small intestine and does not increase blood glucose level almost at all.
From the experimental results obtained from the three types of pâtés: pork, chicken and vegetal the influence of the starch content is very obvious as well as the influence of chemical composition on the rheological and textural properties.
Using statistic methods of Pearson correlations and Principal Component Analysis we can remark semnificative correlations between dependent variables – texture parameters of pâtés samples, at different values of independent variables (starch, dry substance, moisture, protein and fat and certain formed groups of these variables.

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