Sensory characteristics of Slovenian blood sausage *krvavica*

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Abstract— ***Krvavica* is a popular cooked blood sausage that is produced practically everywhere in Slovenia. The aim of this study was to investigate the main characteristics of *krvavica* produced by different manufacturers across seven different informal regions of Slovenia. Products from 45 producers, as households, small workshops or industrial plants were analysed for their sensory parameters, according to assessments of four profiles: appearance, texture in fingers or mouth, smell and flavour. An average Slovenian *krvavica* is marked by the smell and flavour of blood, pepper, marjoram, peppermint, barley, roast meat, onion, rice and millet, and rarely by the expressed scent and flavour of cloves, cinnamon, buckwheat, allspice and laurel. Different types regarding to informal geographical regions of *krvavica* can be distinguish that are specifically defined by their sensory attributes, including for buckwheat flavour/ smell and millet flavour on the one hand, and sweetness, colour, crumbly, and odd and cinnamon flavours on the other.**

Keywords—**Blood sausage, *krvavica*, sensory properties.**

I. INTRODUCTION

Krvavica is a popular cooked blood sausage (i.e., black pudding) that is produced in all of seven informal regions in Slovenia, and especially in winter. It consists of a mixture of blood (≤20%) and other offal, minced pork or beef, animal fat (as lard or tallow), cracklings (10%), soup or broth, and pork skin. In the manufacture of *krvavica*, ≤20% is made up of white bread, rice, barley, millet, buckwheat or corn flour, and different spices are also added, such as black pepper, marjoram and roasted onions, as well as allspice, cinnamon, cloves, cumin, thyme and nutmeg. According to the general scheme for its preparation, pork skin, entrails (pig lungs, tongue, heart, kidney), meat from the pig head and various trimmings are thermally treated (boiled) and broken up, after which the starch components (pre-cooked according to local procedures) and the salt, spices and blood are added and mixed in. The mixture is then stuffed into a natural casing (hog casings or beef rounds) that is washed in clean water prior to use, and bundled together with a wooden stick (*spila*). The product is then boiled for 1 h to 4 h (depending on the diameter of the product) at 85 °C to 95 °C. This is followed by the obligatory air cooling to 8 °C to 10 °C, with the final product stored chilled at 4 °C. Prior to consumption, *krvavica* is usually baked in the oven; medium thick *krvavica* is baked for about 80 min at 180 °C.

Blood sausages are traditional meat products, and their consumption is relatively popular in many European countries, although the ingredients used in their preparation differ according to the producing region [1,2]. Slovenian *krvavica* belongs to group of cooked sausages, known for the Balkan territories (e.g., ex-Yugoslavia). Generally speaking, the detailed characteristics of these products are not well known, and very few data are available for *krvavica* [3,4]. However, regional differences in the sensory characteristics of *krvavica* prevail over differences due the manufacturing practices.

As with the producers of Morcilla de Burgos, a blood sausage from Spain [5], the producers of *krvavica* from Slovenia are also considering the possibility of applying for Protected Geographical Indication (PGI). The aim of this study was to determine the main characteristics of *krvavica* produced by different manufacturers in seven regions of Slovenia, as the definition of the sensory characteristics is the first step towards the obtaining of recognition for this relatively little known product.

II. MATERIALS AND METHODS

The samples of *krvavica* were collected from 45 producers, as households (21), small workshops (18) or industrial plants (6). These producers were from seven regions in Slovenia; region I: Dolenjska (2 producers), II: Gorenjska, including the capital

Ljubljana (21), III: Koroska (1), IV: Primorska (7), V: Notranjska (2), VI: Stajerska (7), and VII: Pomurje (5). A total of three samples were randomly selected from each producer, at 24 h after their production, transported to the laboratory in refrigerated boxes at 4 °C, and than used for the sensory analysis.

To evaluate the sensory qualities, a panel of four qualified and experienced panellists in the field of meat products was appointed. The analytical-descriptive test [6] was performed by scoring the sensory attributes according to a non-structured scale from 1 to 7 points, where a higher score indicated greater expression of a given property. Exceptions here were for the appearance attributes, the texture and the saltiness, which were evaluated by scoring on a structured scale of 1 to 4 to 7 (1-4-7). Here, a score of 4 points was considered optimal, with scores of 4.5 or more indicated greater (to excess) expression of a property (darker colour, firmer, or too salty), and those of 3.5 or less indicated lesser (insufficient) expression of a property (paler colour, tenderer texture, or not salty enough). The sensory profile of the *krvavica* consisted of 45 descriptors that were grouped into four blocks, related to the visual attributes, to the texture in the fingers, to the olfactory attributes, and to the evaluation of the flavour attributes (Table 1).

For the sensory evaluation, the samples were roasted at 180 °C to a core temperature of 90 °C, and then cut as 1-cm-thick slices for the panellists to evaluate.

The differences according to the regions of the samples were analysed through a general linear model procedure and least squares mean test (SAS/STAT), with a 0.05 level of significance. Multivariate analysis included principle component analysis (PCA) and linear discriminant analysis (LDA) (SPSS).

III. RESULTS AND DISCUSSION

Table 1 shows the data for sensory analysis of the *krvavica*, with the basic statistical parameters calculated according to the regions, producers and as means across the regions. On average, these Slovenian *krvavica* show the characteristic colour (4.2 points), with a relatively high proportion of starch ingredients (4.5 points) and an optimal mosaic (4.0 points). The texture assessed in the fingers consisted of three properties, as the tactile evaluation of crispness of casing, fatness, and crumbliness of stuffing, all of which were rated slightly below optimum (3.7 to 3.9 points). The texture in the mouth was evaluated according to fatness and general texture, with these *krvavica* on average slightly too greasy (2.7 points), and with a markedly too soft texture (3.3 points).

In the profile of the olfactory attributes, besides the characteristic smells odd smells were also detected (e.g., smoke, paprika, stable manure, milk, among others). The relatively frequent occurrence of these odd smells affected the low average rating of the smell harmony (4.7 points). Although the average flavour rarely showed odd flavours (e.g., varnish, farmyard manure, paprika, stuffiness, smoke, and others) on average, the harmony of flavour was evaluated as relatively weak (4.8 points). The relatively intense general flavour of the *krvavica* (5.2 points) was dominated by distinctive pepper, blood, barley, onions, roast, marjoram, peppermint, liver, rice and millet flavours, with the rare detection of flavours of buckwheat, cloves, cinnamon and allspice. Generally, the flavours of pine nuts, raisins (data not shown), and laurel were not detected. On average, the saltiness of the *krvavica* was appropriate.

It raised the question whether the noticeable variability in the sensory profiles of these *krvavica* from different regions, and the differences in the production processes, would indicate the establishment, or not, of one type or group that would coincide with all seven of these informal regions in Slovenia.

PCA and LDA [7] were performed to classify producers and regions of *krvavica* production on the basis of the sensory profile of their *krvavica*. PCA was performed to provide a data structure study over a reduced dimension, to cover the maximum amount of the information present in the basic data. Therefore, 32 parameters were included in the LDA.

Figure 1A shows three separate groups of points. Most of the samples households were on the right side of the graph, where the odd, buckwheat, millet and cinnamon smell/ flavours, as well as sweetness lay. In contrast, most of the samples from industrial plants and small workshops lay on the upper or left side of the graph, groups are spread, 2 samples out of 45 misplaced.

Table 1 Sensory attributes of the *krvavica* according to the different Slovenian regions, as the mean across the regions, and according to the manufacturing practices.

	Average	Geographical regions							Manufacturing practices		
Property (LSM)	*krvavica*±SD	I	II	III	IV	V	VI	VII	HH	IP	SW
Appearance (1-4-7 scores)											
Colour	4.2 ±1.1	3.9^{bc}	4.2^{b}	3.2^{c}	5.4^{a}	4.2^{bc}	3.7^{bc}	3.4^{bc}	3.9	4.3	4.0
Proportion of components	4.5 ±0.8	4.7	4.4	5.0	4.3	4.5	4.6	5.0	4.8	4.6	4.3
Mosaic	4.0±0.8	4.0	4.1	5.0	4.0	4.3	3.9	3.8	4.2	4.2	4.1
Texture in fingers (1-4-7 scores)											
Crispness of casing	3.9±0.6	3.6^{b}	3.8^{ab}	2.3^{c}	4.2^{a}	4.1^{a}	3.8^{ab}	4.1^{a}	3.7	3.8	3.7
Fatness	3.9±0.9	4.2	4.0	4.8	3.9	3.2	3.8	4.1	4.0	4.1	4.0
Crumbly	3.7±0.9	4.5^{ab}	3.3^{d}	5.3^{a}	4.3^{bc}	4.1^{bc}	3.6^{cd}	3.6^{cd}	4.0	4.5	4.2
Texture in mouth (1-4-7 scores)											
Fatness	2.7±1.1	3.3^{a}	2.7^{a}	2.7^{ab}	2.6^{ab}	2.8^{ab}	3.2^{a}	2.2^{b}	2.6	3.0	3.0
Texture	3.3±1.0	3.4	3.2	4.0	3.6	3.3	3.1	2.7	3.1^{b}	3.8^{a}	3.6^{a}
Smell (1-7 scores)											
Roast	1.6±0.8	1.3^{ab}	1.7^{a}	1.0^{b}	1.1^{b}	1.2^{ab}	1.7^{a}	1.9^{a}	1.3	1.3	1.6
Millet	1.4±0.7	1.0^{c}	1.3^{bc}	1.3^{abc}	1.0^{c}	1.0^{c}	1.7^{ab}	2.0^{a}	1.4	1.2	1.3
Buckwheat	1.2±0.7	1.0^{c}	1.1^{c}	1.0^{c}	1.1^{c}	1.0^{c}	1.5^{b}	2.0^{a}	1.4	1.2	1.1
Barley	1.7±0.7	1.7^{bc}	1.9^{ab}	2.3^{ab}	1.6^{ab}	1.3^{b}	1.6^{ab}	1.1^{c}	1.4^{b}	1.9^{a}	2.0^{a}
Blood	2.0±0.8	2.2^{abc}	2.1^{b}	1.7^{abcde}	2.5^{a}	2.5^{ab}	1.8^{cde}	1.4^{e}	1.8^{b}	2.5^{a}	2.3^{a}
Onion	1.6±0.7	1.8	1.8	1.7	1.5	1.6	1.4	1.6	1.5	1.6	1.9
Pepper	1.8±0.7	1.6	1.8	2.8	2.0	1.5	1.8	1.7	1.8	1.8	2.1
Marjoram	1.7±0.8	1.8^{ab}	1.9^{a}	1.5^{ab}	2.1^{a}	1.5^{ab}	1.5^{b}	1.2^{b}	1.4	2.1	1.8
Peppermint	1.8±1.0	1.3^{bc}	2.0^{ab}	1.8^{abc}	2.3^{a}	1.3^{bc}	1.5^{c}	1.3^{c}	1.8	1.5	1.4
Cinnamon	1.2±0.6	1.2	1.1	1.0	1.4	1.6	1.2	1.0	1.2	1.4	1.2
Allspice	1.1±0.4	1.2^{b}	1.1^{b}	1.0^{b}	1.0^{b}	1.7^{a}	1.2^{b}	1.1^{b}	1.1	1.2	1.2
Cloves	1.2±0.6	1.0^{b}	1.2^{ab}	1.0^{b}	1.0^{b}	1.8^{a}	1.5^{ab}	1.0^{b}	1.2	1.6	1.2
Laurel	1.1±0.4	1.2	1.1	1.0	1.1	1.3	1.0	1.0	1.2	1.0	1.0
Odd	2.2±1.2	3.5^{a}	2.0^{b}	2.7^{abc}	2.2^{bc}	2.8^{ab}	1.8^{bc}	2.6^{a}	2.9^{a}	2.0^{b}	1.9^{b}
Harmony	4.7±0.8	4.0^{bc}	4.9^{a}	4.5^{ab}	4.7^{ab}	4.0^{bc}	4.8^{a}	4.4^{b}	4.1^{b}	4.9^{a}	5.0^{a}
Flavour (1-7 scores)											
Saltiness (1-4-7 scores)	4.0±0.7	3.8^{bc}	3.9^{c}	5.0^{a}	3.9^{bc}	4.0^{bc}	4.1^{bc}	4.3^{ab}	4.0	4.3	4.4
Rancidity	1.2±0.7	1.0^{b}	1.1^{b}	1.3^{ab}	1.0^{b}	1.6^{ab}	1.2^{b}	1.8^{a}	1.3	1.1	1.3
Roast	1.7±0.8	1.9^{abc}	1.8^{b}	1.3^{c}	1.3^{c}	1.7^{abc}	1.5^{bc}	2.4^{a}	1.4^{b}	2.2^{a}	2.0^{a}
Liver	1.5±0.6	1.7	1.6	1.0	1.4	1.5	1.3	1.1	1.2	1.6	1.5
Rice	1.5±0.6	1.8	1.6	2.0	1.7	1.5	1.5	1.2	1.6	1.8	1.7
Millet	1.5±0.8	1.0^{b}	1.5^{b}	1.3^{b}	1.2^{b}	1.2^{b}	1.5^{b}	2.3^{a}	1.7	1.1	1.1
Buckwheat	1.2±0.6	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	1.0^{b}	1.4^{b}	2.0^{a}	1.3	1.1	1.1
Barley	1.8±0.7	1.7^{bc}	1.9^{b}	2.7^{a}	1.7^{b}	2.1^{ab}	1.8^{b}	1.3^{c}	1.7^{b}	2.3^{a}	2.1^{a}
Blood	2.1±0.7	2.3^{ab}	2.0^{b}	2.0^{abc}	2.4^{a}	2.0^{abc}	1.9^{b}	1.5^{c}	1.8^{b}	2.4^{a}	2.4^{a}
Onion	1.8±0.7	1.7	1.8	1.8	1.7	1.7	1.8	1.9	1.6	1.8	2.0
Pepper	2.2±0.9	1.8^{b}	2.0^{b}	4.7^{a}	2.1^{b}	1.8^{b}	2.4^{b}	2.3^{b}	2.3	2.8	2.5
Marjoram	1.7±0.7	1.7^{ab}	2.0^{a}	2.0^{a}	1.8^{ab}	1.5^{ab}	1.4^{ab}	1.1^{b}	1.4^{b}	2.3^{a}	1.9^{a}
Peppermint	1.7±0.9	1.3	1.9	1.3	1.9	1.3	1.6	1.3	1.7	1.4	1.2
Cinnamon	1.1±0.4	1.2^{b}	1.1^{b}	1.0^{b}	1.3^{ab}	1.6^{a}	1.0^{b}	1.0^{b}	1.2	1.3	1.2
Allspice	1.1±0.3	1.2	1.1	1.0	1.1	1.3	1.2	1.1	1.1	1.1	1.2
Cloves	1.2±0.5	1.0	1.2	1.0	1.1	1.6	1.3	1.0	1.1	1.4	1.3
Pine nuts	1.0±0.3	1.0^{b}	1.0^{b}	1.0^{b}	1.3^{a}	1.0^{b}	1.0^{b}	1.0^{b}	1.1	1.0	1.0
Laurel	1.0±0.2	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0^{b}	1.2^{a}	1.0^{b}
Sweetness	1.5±1.1	2.3^{ab}	1.3^{c}	1.0^{c}	2.9^{a}	1.5^{bc}	1.1^{c}	1.1^{c}	1.9	1.4	1.2
Odd	2.3±1.2	2.8^{ab}	2.1^{ab}	2.8^{abc}	3.0^{a}	2.5^{abc}	1.6^{c}	2.3^{abc}	3.0^{a}	2.0^{b}	1.7^{b}
Intensity	5.2±0.7	4.8^{bc}	5.1^{abc}	5.7^{a}	5.5^{ab}	4.7^{c}	5.0^{abc}	5.5^{ab}	4.9^{b}	5.5^{a}	5.5^{a}
Harmony	4.8±0.8	4.5	5.0	4.5	4.5	4.7	4.9	4.7	4.2^{b}	5.3^{a}	5.4^{a}

^{a,b,c,d,e} least-squares means (LSM) with different superscripts within geographical regions or manufacturing practices differ significantly ($P < 0.05$), region I: Dolenjska, II: Gorenjska, III: Koroska, IV: Primorska, V: Notranjska, VI: Stajerska, VII: Pomurje, IP: industrial plant, HH: households, SW: small workshops.

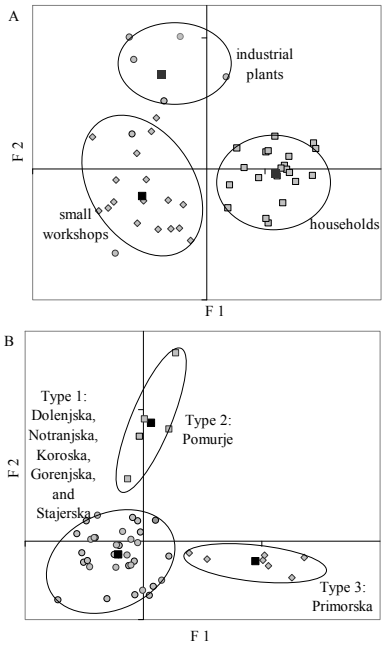

Fig. 1 LDA using scores for properties chosen by PCA for the 45 Slovenian *krvavica* samples originating from manufacturing practice (A), and geographical region type (B); (■, type centroid)

Using the results of these sensorial analyses, three types of *krvavica* were selected across the seven informal regions of Slovenia: type 1, from Dolenjska, Notranjska, Koroska, Gorenjska and Stajerska; type 2, from Pomurje; and type 3, from Primorska (Figure 1B).

Using LDA, twelve parameters were selected as the most discriminating variables: buckwheat flavour/ smell, blood flavour/ smell, millet flavour, roasted smell, sweetness, colour, allspice flavour, odd flavours and barley smell/ flavours. Function 1 explains 52.2% of the total variance, and function 2 explains 47.8%. As it can be seen, the *krvavica* samples (as three types) are well separated from each other; the accuracy of the placement of each sample into its corresponding type was 95.6%.

Figure 1B shows three separate groups of points. Most of the samples from type 3 were on the right side of the graph, where the variable sweetness, colour, crumbly, odd flavours and cinnamon flavour lay. In contrast, most of the samples from type 2 lay on the upper side of the graph, where the buckwheat flavour and smell, millet flavour and saltiness were grouped. Type 1, the most heterogeneous type, lay near to the origin.

IV. CONCLUSIONS

Krvavica is one of the traditional European meat products that include blood and have a major level of starch components. However, this product is made with a wide range of spices and starch components, which differentiate it from other blood sausages. For the sensory attributes, it is the marked smell and flavour of blood, pepper, marjoram, peppermint, barley, roast meat, onion, rice and millet, as well as the more rarely expressed smell and flavour of cloves, cinnamon, buckwheat, allspice and laurel that characterise Slovenian *krvavica*. Wide variability was found in both the sensory evaluation of sweetness, due to use of sugar in only the *krvavica* from the coastal area (Primorska, on the Mediterranean), and the buckwheat flavour/ smell in the Prekmurje region, which reflected differences in the production process. Most of the sensorial parameters have high variability, which makes it difficult to provide a designation of a unique product.

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