







Maintaining the Quality of Homemade Kulen (Dry Croatian Sausage) During a Three-Year Period

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Abstract. The objective of this research was maintenance of the quality parameters of homemade kulen during a three-year period. Homemade kulen is a dry fermented sausage with specific sensorial characteristic (smell and taste) which originates from the use of the high quality pig meat, specific spices, smoking (use of open fire) and long ripening time (at least four months). The production of this indigenous dry sausage take place on small farms and it is conditioned by the climatic conditions. Namely, to produce a good quality kulen it is necessary to start the production during winter months, when the slaughter and production take place. After the smoking, fermentation and drying, the ripening takes place. The physical-chemical parameters (pH, a_w , moisture content, fat content, protein content and collagen content) of 25 samples of homemade kulen were determined each year. The current Croatian legislative prescribes only the moisture content (40%) and protein content (22%) for this kind of dry sausage. The results of this study showed variation in investigated parameters between the samples and between the production year. Variations can be contributed to different recipes used by producers, different climatic conditions and to different production technologies (smoking with different wood, ripening time, pig meat quality, etc.).

Keywords: Homemade kulen · Traditional production · Quality · Maintenance · Physical-chemical parameters

1 Introduction

Homemade kulen (Fig. 1) is dry sausage produced in Croatian region Slavonija and Baranja. The production is still in small scale, so there are many producers, which use different recipes and different production procedure. Homemade kulen manufacturing is a seasonal character and beings in late fall and last until the late spring (approximately six months), due to the favorable weather conditions (temperature and relative humidity) [1]. The peculiar aroma of this dry sausage manly originates from long-term ripening (more than 3 months), smoking, lactic acid bacteria activity, and special spices used in its production (sweet paprika powder, hot paprika powder and garlic) [2, 3]. According to

the actual Croatian Legislation [4] homemade kulen is a dry sausage made from coarsely chopped pork and pork back fat, salt, red spicy peppers and garlic, with the possibility of adding sugar, other spices or spice extracts, starter cultures, additives and smoke aromas. They should not contain more than 40% of moisture and must contain at least 22% of meat proteins [4].

The sausage is produced from the parts of the pig with the highest commercial value, the meat from the leg and loin with the addition of approximately 20% of shoulder and neck meat. The minced meat with the addition of max. 10% of pork back fat is seasoned with 2% of rock salt, 0.6% of sweet paprika powder, 0.6% of hot paprika powder and 0.3% of minced fresh garlic. This mixture is then stuffed in natural casing – pig appendix. The raw homemade kulen is then smoked, dried and ripened until it receives the satisfactory texture and aroma.



Fig. 1. Homemade kulen.

Dry fermented sausage are usually made from pork, or combination of pork and beef, mutton rarely, horse meat and chicken. Minced meat is mixed with pork fat, salt, spices (paprika, pepper, garlic, etc.) and, especially in industrial production, nitrate/nitrite, ascorbate, sugars, etc., in different mass fraction (different recipes). Specific sensory properties of certain dry sausage in addition to being associated with the technology of production (primary the smoking) and added substances (primarily spices) are a result of fermentation and maturation (proteolysis and lipolysis due to the activity of endogenous and exogenous enzymes) or activity of technological microflora that is specific for each microclimatic location [5–7]. The dry sausages from different European countries (Croatia, Spain, Italy, Greece and Bosnia and Herzegovina) were investigated for its physico-chemical properties with the purpose of standardization of its production [6, 8–16]. These study showed large variations in chemical composition and water activity and pH [17].

The small scale produces still use the traditional production without the possibility of controlled conditions (temperature and relative humidity) in smoking, drying and ripening stage. The production conditions are dependent on the weather condition in the

area of production. All mentioned results in high variability in chemical composition, of homemade kulen between different producers.

2 Material and Methods

2.1 Material

The samples of homemade kulen were collected at the traditional homemade kulen competition organized by The Chamber of Commerce in Osijek, Croatia. In year 2019, 47 samples were collected, in the years 2020 and 2021, 25 samples were collected. The lower number of samples collected in years 2020 and 2021 is probably related to the COVID-19 pandemic.

In the production of homemade kulen the pig meat from the pigs of at least 12 month old and over 150 kg live weight must be used. After the slaughter, dissection and deboning the meat is cooled to temperatures of 0–4 °C. The met pH at this stage should be from 5.6 to 5.9. The meat is then grinded trough a grinding plate with holes of 8 to 12 mm in diameter. The meat is them seasoned with 0.7% red paprika, 0.6% of hot paprika and garlic in the amount of 0.2%. Before this the salt is added in amount of 2%. After the mixing the mixture is stuffed into a pig's appendix (lat. *intestinum caecum*).

Raw homemade kulen is then smoked with open fire using dry hard wood (hornbeam, beech and its sawdust) approximately six to seven times during a 14 days period. After the smoking, homemade kulan is dried and ripened. After that the homemade kulen is ready for consumption.

2.2 Physico-Chemical Analysis

After discarding the casing, the samples were cut into small pieces and homogenized in a knife mill Gridomix GM 200 (Retsch, Germany). The FoodScan Meat Analyser (Foos, Sweden) was used to determine moisture, total protein, total fat and collagen according to the AOAC 2007 04.

The pH level was measured in a homogenate of the sample mixed with distilled water (1:10) with pH/Ion 510 – Bench pH/Ion/mV Meter (Eutech Instruments Pte Ltd/Oakton Instruments, USA) according to ISO 2917:1999 (HRN ISO 2917:2000) and manufacturer instructions (pH/Ion 510 Instruction Manual).

Water activity (a_w) was determined using a Rotronic Hygrolab 3 (Rotronic AG, Switzerland) according to manufacturer instructions, at room temperature (20 ± 2 °C). All measurements were conducted in three parallel.

3 Results and Discussion

In the Table 1 the general composition pH and a_w of the 47 samples of homemade kulen were presented. The moisture were from 25.92 to 44.13%.

Relatively large differences are related to the defend stages ripening of homemade kulen. According to the official Croatian legislative the maximal prescribed value of moisture content for this kind of sausage is 40%. The six samples of homemade kulen

Table 1. General composition, pH and a_w of homemade kulen in year 2019.

Sample	Fat (%)	Moisture (%)	Protein (%)	Collagen (%)	pH	a_w
HK1	30.23	34.22	29.13	2.08	5.41	0.89
HK2	21.65	33.99	35.42	3.61	5.95	0.87
HK3	14.4	44.13	33.56	2.17	5.34	0.89
HK4	14.71	39.68	36.49	2.39	5.47	0.86
HK5	13.22	41.27	36.27	2.27	5.49	0.88
HK6	13.34	41.44	35.89	2.54	5.46	0.88
HK7	23.15	25.97	38.48	3.31	5.86	0.80
HK8	21.25	36.76	34.02	2.93	5.24	0.88
HK9	23.61	35.83	34.78	2.66	5.02	0.88
HK10	20.98	36.55	34.43	2.91	5.24	0.88
HK11	22.05	32.26	35.55	2.38	5.43	0.86
HK12	23.04	35.14	33.24	2.95	5.35	0.87
HK13	23.87	32.05	34.43	3.43	5.12	0.86
HK14	20.87	30.91	36.41	3.11	5.96	0.83
HK15	21.3	37.31	33.37	2.74	5.57	0.89
HK16	27.56	34.14	30.19	3.15	5.65	0.86
HK17	27.87	28.93	33.27	4.96	5.81	0.84
HK18	24.64	25.92	36.28	4.39	6.09	0.81
HK19	27.63	30.58	33.64	3.01	5.74	0.86
HK20	28.17	28.96	34.37	4.26	5.62	0.84
HK21	23.24	30.53	34.85	4.83	5.53	0.83
HK22	17.14	40.03	34.99	2.79	5.33	0.89
HK23	23.2	32.31	34.44	3.34	5.46	0.84
HK24	15.86	37.11	36.16	3.03	5.58	0.87
HK25	19.3	33.94	36.26	3.22	5.2	0.87
HK26	17.65	43.54	32.71	2.23	5.24	0.91
HK27	17.27	42.98	33.01	1.89	5.23	0.89
HK28	22.93	32.66	34.77	3.01	5.73	0.87
HK29	32.52	27.47	34.04	4.11	5.29	0.82
HK30	22.01	30.03	35.23	4.26	5.4	0.84
HK31	33.3	31.22	28.05	3.33	5.4	0.88
HK32	36.27	30,03	26.07	1.5	5.05	0.86

(continued)

Table 1. (continued)

Sample	Fat (%)	Moisture (%)	Protein (%)	Collagen (%)	pH	a_w
HK33	28.04	30.67	29.88	2.95	5.23	0.82
HK34	27.51	26.67	28.11	0.27	5.49	0.86
HK35	26.01	27.83	34.46	3.62	5.51	0.85
HK36	18.68	35.98	34.39	2.69	5.53	0.87
HK37	25.63	29.64	34.54	3.74	5.12	0.86
HK38	24.41	34.92	29.51	0.75	5.74	0.88
HK39	20.37	31.52	36.48	3.47	5.41	0.85
HK40	19.6	33.11	36.31	3.21	5.35	0.86
HK41	21.4	33.79	34.47	2.49	5.59	0.86
HK42	22.68	32.11	33.61	2.7	5.39	0.85
HK43	26.46	30.64	33.63	2.5	5.57	0.86
HK44	25.56	29.17	35.34	2.91	5.52	0.84
HK45	22.96	32.67	34.53	2.93	5.61	0.86
HK46	28.96	32.65	30.5	1.78	5.38	0.87
HK47	27.75	27.67	34.52	4.25	5.47	0.84

were not in agreement with prescribed values (HK3, HK5, HK6, HK22, HK26 and HK27).

The fat content ranged from 13.22 to 36.27% with the average value of 23.04%. Protein content of examined samples were from 26.07 to 38.48%, collagen content ranged from 0.27 to 4.96%. pH values were in interval from 5 to 6.09 and a_w 0.80 to 0.91.

In the year 2020 two samples had a higher moisture content then prescribed (HK2 and HK3) (Table 2). Fat content ranged from 11.99 to 38.41%. Mass fraction of protein ranged from 26.94 to 40.15% and collagen from 1.10 to 5.13%. pH ranged from 5.09 to 6.19 and a_w 0.78 to 0.89.

Basic chemical composition, pH and a_w of 25 samples of homemade kulen in year 2021 are presented in Table 3. The moisture content varied from 25.35 to 41.51%. Four samples showed higher values then legally prescribed level. Mass fraction of fat were in range from 12.22 to 38.09%. Protein content of investigated samples were 24.08 to 37.72% and collagen from 0.85 to 4.01%. pH ranged from 5.12 to 6.15 and a_w 0.81 to 0.90.

In Table 4 the average, minimum and maximum values of examined physical-chemical parameters for each production year are presented. Average values of fat content were from 22.85 to 23.15% and showed little variations. Moisture content varied from 32.02 to 35.52%. Protein contents were from 33.26 to 34.26. Ambrosiadis et al. [18] reported higher values for moisture (38.74%), fat (40.75%) content and a_w (0.931) for Greek dry sausage. Also, the protein content (16.41%) and pH (4.88) were lower.

Table 2. General composition, pH and a_w of homemade kulen in year 2020.

Sample	Fat (%)	Moisture (%)	Protein (%)	Collagen (%)	pH	a_w
HK1	16.99	37.2	33.13	1.11	6.19	0.84
HK2	12.63	43.81	35.2	2.01	5.32	0.88
HK3	11.99	47.55	33.34	1.21	5.31	0.89
HK4	22.87	34.12	35.26	2.26	5.5	0.87
HK5	23.16	35.07	33.26	2.29	5.52	0.86
HK6	24.23	29.97	36.26	2.87	5.24	0.84
HK7	24.61	30.62	35.03	3.37	5.28	0.85
HK8	24.82	24.31	40.15	3.44	5.56	0.78
HK9	26.72	35.59	29.01	2.05	5.54	0.88
HK10	26.72	35.57	29.08	1.5	5.6	0.89
HK11	21.74	27.86	38.78	3.09	5.32	0.81
HK12	22.11	32.36	35.54	2.83	5.09	0.85
HK13	21.36	29.88	38.34	3.55	5.09	0.84
HK14	22.41	28.14	35.45	5.13	5.27	0.79
HK15	31.36	27.64	31.11	4.13	5.4	0.83
HK16	25.87	31.18	34.72	1.58	5.76	0.85
HK17	32.71	27.03	33.48	4.86	5.41	0.82
HK18	38.41	28.17	26.94	2.37	5.31	0.82
HK19	19.85	35.12	35.03	3.45	5.35	0.86
HK20	23.02	30.45	35.69	4.08	5.54	0.83
HK21	20.56	35.59	34.41	3.08	5.51	0.88
HK22	24.09	34.62	32.32	2.05	5.35	0.88
HK23	21.76	34.12	34.36	1.95	5.94	0.87
HK24	20.77	36.52	33.41	3.44	5.51	0.87
HK25	18.08	35.47	37.22	2.94	5.55	0.87

Similar as Greek dry sausages the Spanish dry sausage Iberian chorizo showed lower values for moisture content (18.6–19.42%), protein content (27.22–28.68%) and a_w (0.77–0.88), but higher values for fat content (33.50–35.98%) [9, 19]. pH values in the investigation by [18] (5.25–5.80) were similar to values presented in Table 4.

De Nobile et al. [20] reported higher protein (38.52%) and fat (27.98) content but lower moisture content (26.01) for Italian salami.

Croatian dry sausage *Istarska kobasica* showed higher fat content (49.01%), but lower protein (23.36%) and moisture content (22.31%) [12]. Other Croatian dry sausage such as Slavonska kobasica and *Kulenova seka* showed similar values of physical-chemical parameters as homemade kulen [21].

Table 3. General composition, pH and a_w of homemade kulen in year 2021.

Sample	Fat (%)	Moisture (%)	Protein (%)	Collagen (%)	pH	a_w
HK1	17.84	38.64	34.99	2.66	5.26	0.88
HK2	12.22	40.07	37.72	2.56	5.34	0.88
HK3	21.74	33.74	35.86	2.25	5.22	0.86
HK4	21.29	34.9	35.39	2.4	5.19	0.87
HK5	22.03	33.56	35.72	2.78	5.12	0.86
HK6	19.03	39.42	33.74	2.19	5.55	0.89
HK7	21.82	35.63	33.42	3.15	5.67	0.88
HK8	22.34	35.04	33.96	3.1	5.25	0.88
HK9	22.53	34.02	34.36	3.19	5.23	0.87
HK10	19.41	40.14	33.38	1.41	5.75	0.89
HK11	21.87	32.61	35.35	2.82	5.56	0.86
HK12	19.87	41.51	32.36	1.74	5.49	0.90
HK13	36.46	29.05	27.57	2.49	5.6	0.85
HK14	30.11	25.35	34.28	4.01	5.41	0.81
HK15	38.09	31.65	24.08	1.64	5.23	0.87
HK16	21.33	38.57	32.61	0.85	5.59	0.89
HK17	24.81	37.15	30.9	1.64	5.78	0.86
HK18	19.53	40.47	33.2	1.74	5.89	0.89
HK19	24.23	35.63	32.7	1.92	5.29	0.88
HK20	18.23	39.69	33.63	2.92	5.33	0.89
HK21	22.09	35.9	32.96	2.73	5.58	0.87
HK22	20.93	36.22	32.88	2.23	5.37	0.86
HK23	26.49	33.98	32.72	1.91	6.15	0.88
HK24	22.65	31.85	34.85	2.86	5.53	0.86
HK25	24.47	33.14	32.95	2.02	6.05	0.83

Portuguese Chorizo had higher pH of 5.78, a_w 0.94, higher mass fraction of water 50.40% and fat 25.60%, but lower protein content 19.10% [22].

Traditional Spanish dry sausage Fuet had similar moisture content 33.09% higher fat content 26.83% and lower mass fraction of protein 29.14%. Values of pH were similar 5.44 but water activity showed lower values (0.763) [23].

Martin et al. reported lower moisture content of 26.04%, lower water activity 0.785 but higher pH of 5.08 for Spanish dry sausage salchichón [24].

And Turkish-style fermented sausage, also known as sucuk had higher fat content (41.55%) but lower mass fraction of water (20.01%) and protein (34.77%). Sucuk showed lower pH value of 4.82 [25].

Table 4. Average, minimum and maximum values of general composition, pH and a_w of homemade kulen in years 2019–2021.

Year	2019			2020			2021		
	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Fat (%)	23.20	13.22	36.27	23.15	11.99	38.41	22.85	12.22	38.09
Moisture (%)	33.33	25.90	44.13	32.02	24.31	47.55	35.52	25.35	41.51
Protein (%)	33.83	26.07	38.48	34.26	26.94	40.15	33.26	24.08	37.72
Collagen (%)	2.96	0.27	4.96	2.82	1.11	5.13	2.37	0.85	4.01
pH	5.47	5.01	6.09	5.46	5.09	6.19	5.50	5.12	6.15
a_w	0.861	0.801	0.907	0.850	0.783	0.895	0.871	0.810	0.904

Jahic and Pracic [11] reported higher values of moisture of 43.58% but lower fat content (17.10%) and protein content (31.47%) for dry sausage Bosnian sudžuk.

This discrepancies between the homemade kulen and other European dry sausages may be related to smoking (most of the mentioned sausages are not smoked) and the by longer ripening stage of homemade kulen [1, 5].

4 Conclusions

Fat, moisture, collagen, protein content, pH and water activity of homemade kulen showed large variation between producers for all investigated years. This shows that producers still use very different recipes in production and that the samples homemade kulen were in different stage of production (different ripening stage).

The work on the standardization of production is needed. This can be achieved by using the controlled condition (temperature 15–17 °C, and relative humidity around 75%) of homemade kulen production. The small scale producers should use the automatic chambers for smoking, drying and ripening.

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