Mycelia of *Pleurotus sapidus* and *Lentinula edodes* as functional raw material in comparison to different vegetable proteins in döner kebab system

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The stickiness of raw minced meat döner kebab (MMDK) is of crucial importance for manufacturing the product. To achieve the desired results, plant or animal proteins with other additives and spices are added as brine to the minced meat. Additionally, the loss of water and oil and the sliceability during the grilling process are important for minced meat kebab producers. As some proteins are derived from genetically modified plants, are allergens or of limited availability, new protein sources, e.g., from basidiomycetes, are required as ingredients of functional additives. Mycelia from *Lentinula edodes* grown on carrot pomace (Döhler, Darmstadt) and *Pleurotus sapidus* grown on palatinose molasses (Südzucker AG, Offstein) were tested as technological binding components and compared with different plant proteins and egg white powder. The stickiness and the texture profile analyses of grilled MMDKs were measured by texture analyzer. All haptic and sensory evaluations and manufacturing steps were analyzed by the R&D team and the ethnic fast food team of the company VAN HEES GmbH, Walluf. The stickiness, browning, sliceability and oil and water losses of the added proteins of basidiomycetes are comparable with the currently used plant proteins like soy protein.

Key Words – manufacturing and grilling minced meat döner kebab cone, Basidiomycetes mycelia, *Pleurotus sapidus*, texture profile analyses

I. INTRODUCTION

MMDK is made from 3 mm pieces of minced meat and fat of possibly different animal species. The minced meat is shaped into a cone and impaled on a döner kebab stick. The cone-manufacturing process includes three steps: (i) portioning the cooled MMDK mass, (ii) kneading and forming the portions and (iii) sticking the MMDK cone and connectorization between the portions.

The ability to effectively bind minced meat pieces and particles is important for the production of most restructured and processed meat [1, 2]. Different plant proteins like soy protein isolate or concentrate, pea protein isolate or animal derived proteins like egg proteins are added to MMDK as a functional additive compound to facilitate the cone construction, since they have the optimum stickiness to form the minced meat cone. These additives can influence the water holding capacity, the oil binding capacity, the sliceability, the hardness, and the stickiness of the raw minced döner mass and the stickability of the MMDK cone. Additionally, during the grilling the different additive protein sources can hold more water and oil for a better yield. Furthermore, the different additives influence the sliceability and thus the juiciness of the MMDKs.

An ideal replacement for soy (GMO, allergen) and other plant or animal proteins are basidiomycetous mycelia. Mycelia of basidiomycetes grown on different agricultural side streams have a protein content usually between 25% and 35% and a very interesting aroma profile.

Our objective was to develop a better binding ability in MMDK compared with different plant and animal proteins by using basidiomycetous mycelia. The mycelia of *Lentinula edodes* grown on carrot pomace and *Pleurotus sapidus* grown on palatinose molasses were tested in comparison with plant protein concentrates from soy, sunflower, pea, and potato as well as with egg white powder as an animal protein. Dextrose was used as the control substance. The first step of this study deals with the preparation of the raw MMDK, the haptic measurement of its stickiness during the preparation and the texture measurements of the final raw product.

II. MATERIALS AND METHODS

The freshly cut meat cubes were blended with a meat grinder with blending function (K+G Wetter, Germany) for 5 min and minced to 3 mm pieces. The ground meat was divided into 10 kg portions. Nine different marinating mixtures were prepared with 150 mL/kg water, 29 g/kg functional blend (12 g/kg salt (esco, Germany), 8.0 g/kg potato starch (Roquette, France), 4.5 g/kg sodium citrate (Ter-Hell, Hamburg), 1.5 g/kg cellulose powder (Rettenmaier & Söhne GmbH, Germany) and 13 g/kg of the different proteins mentioned above, Dextrose (CON) or basidiomycetous

mycelia), and 30 g/kg spice blend (ArtNo 207002; VAN HEES GmbH, Germany). The marinating mixtures of each group were added to the minced meat in a vacuum paddle mixer (Ekomex, Poland) and mixed with 43 rpm in reduced atmosphere pressure at -1 °C for 15 min. Subsequently, bread crumbs (30 g/kg) were added and the product was mixed again for 10 min at the same settings. The masses were stored at 2 °C for 12 h. After storage the masses were portioned in 1 kg balls. Each 1 kg portion was kneaded for 1 min and then placed on a döner kebab stick. The finished MMDK cones were frozen at -18 °C for seven days. The evaluation of the form and the stickiness of the MMDK was performed by an ethnic fast food expert group. The texture (stickiness) and the ash, fat, protein and water content were evaluated. All raw MMDK products were tested in triplicate. The water content was determined by drying an appropriate amount of the sample after levigating with sea sand for 15 h at 105 °C. The ash content was determined with a Phoenix microwave muffle furnace (CEM, Germany). The protein content was measured using the Kjeldahl method, the total fat content according to the Weibull-Stoldt method. The carbohydrate content was calculated by subtracting all measured values from 100 %.
All instrumental texture measurements were performed at 22 °C. For each independent batch, ten measurements were made directly after kneading of the 1 kg portions, and mean values were reported. Samples were reduced to 10 g portions, formed in bowls by hand and measured with a Dia Cylinder using a TAXT2i texture analyzer. The Dia Cylinder was operated at 0.5 mm s^{-1} and had a 10 s hold time for 1500 g before pulling back. The target parameter was force. The height of the negative peak is the maximum force required to separate the MMDK mass from the cylinder (maximum detachment force) and the total amount of forces involved in the mass withdrawal from the cylinder (work of adhesion) was calculated from the area under the force versus time curve.

III. RESULTS AND DISCUSSION

Table 1 shows the chemical parameters of raw MMDKs. Water, protein, fat and ash content were measured in triplicate. The absolute values varied, but without significance ($p < 0.05$). The average values of the water 56.4 % ± 0.6 and proteins contents 14.3 % ± 1.2 are in line with Seeger *et al.* and Küpeli *et al.* [3, 4]. The average fat contents of the samples were 14.1-18.0 % for raw MMDKs. Since MMDK loses some fat by melting and draining with heating a lower fat content in the grilled samples will be expected. Proteins, for example soy protein isolate, can emulsify fat by the above named technological steps as mentioned in the introduction (i-iii) [5]. The ash content of fresh meat is approximately 1%, and this value increases with the addition of spices and additives.

Table 1: Parameters of raw minced eat döner kebabs

	Water [%]	[SD]	Protein [%]	[SD]	Fat [%]	[SD]	Ash [%]	[SD]
CON	56.4	0.8	12.2	0.5	16.0	0.5	2.62	0.03
SPI	56.2	0.9	12.6	0.7	14.1	0.5	2.47	0.02
SPC	57.5	0.8	15.0	1.9	15.0	0.2	2.55	0.05
SFC	55.9	0.9	14.7	0.8	15.6	1.4	2.58	0.04
PPI	55.7	0.2	14.0	0.8	14.9	1.3	2.52	0.04
POPI	57.4	0.1	15.7	0.3	18.0	0.6	2.65	0.02
EWP	56.5	0.5	15.4	0.1	16.4	0.1	2.55	0.03
PSA_PM	56.3	0.4	14.7	0.4	17.6	0.5	2.48	0.04
LED_KTD	57.0	0.9	14.3	0.5	17.4	0.5	2.54	0.04

The large MMDK producers in Germany pay special attention to the processability of the raw döner kebab masses for time savings and customer satisfaction (döner kebab restaurants who buy frozen döner kebab cones). Three haptic attributes (portioning, forming, sticking) of the various MMDKs were evaluated on a 1-9 hedonic scale by three practically trained persons. The results are shown in Table 2. The comparison of the control product (CON) with the two kebabs containing PSA_PM and LED_KTD show that the handling of CON produced better results than for *Lentinula edodes* mycelia, but the outcome was worse in comparison with *Pleurotus sapidus* mycelia. Looking at the raw MMDK with plant proteins, LED_KTD performed similar to this. On the other hand PSA_PM showed a marked improvement in the processability relative to all other used proteins. By rating the handling of all manufactured products two groups were identified: one includes the plant proteins without POPI (SPI, SPC, SFC, PPI) and the basidiomycetous mycelia LED_KTD with moderate rankings (5.7-6.3), the other group consists of the animal protein product EWP and the PSA_PM, POPI products, which have been ranked very good (above 6.5). With 6.3, CON, the control product, is classified in the middle of both. For the manufacturing process, the connectorization and the functionality of the proteins are important parameters in the raw MMDK system. In the literature, the two proteins from potato and egg white are described as highly water-soluble proteins (albumin fraction) [6, 7].

Table 2: Haptic and manufacturing evaluation of raw minced meat döner kebabs

	portioning	[SD]	forming	[SD]	sticking	[SD]
	Average values on a hedonic scale (sensory properties)*					
CON	6.3 (100)	0.6	6.0 (100)	0.0	6.7 (100)	0.6
SPI	6.0 (100)	0.0	5.7 (66.6)	0.6	6.7 (100)	0.6
SPC	6.0 (100)	0.0	6.0 (100)	0.0	5.7 (66.6)	0.6
SFC	6.0 (100)	0.0	5.3 (33.3)	0.6	5.7 (66.6)	0.6
PPI	6.0 (100)	0.0	5.7 (66.6)	0.6	5.7 (66.6)	0.6
POPI	6.0 (100)	0.0	7.0 (100)	0.0	6.7 (100)	0.6
EWP	6.7 (100)	0.6	6.7 (100)	0.6	6.7 (100)	0.6
PSA_PM	7.3 (100)	0.6	7.7 (100)	0.6	7.7 (100)	0.6
LED_KTD	5.7 (33.3)	0.6	6.3 (100)	0.6	6.3 (100)	0.6

*Percentage of panelists that scored each tested property between 6 and 9 is given between parentheses

As the results of their haptic evaluation were similar to those for PSA_PM, it may be assumed that PSA_PM also possesses this property. This must be verified in further studies. As a result, it could be shown that similar PSA_PM or LED_KTD as a replacement of either vegetable or animal proteins in raw MMDK.
Table 3 shows the maximum detachment force of the different samples. With the addition of plant proteins (SPI, SPC, SFC, PPI) and LED_KTD to the raw MMDK system the maximum detachment force increased compared to CON. For the raw MMDKs with POPI, EWP, and PSA_PM, the detachment force decreased and therefore the samples became stickier than CON. The detachment force of PSA_PM showed that this basidiomycetous mycelia delivered the highest stickiness of all evaluated proteins. A statistical test showed that the results for PSA_PM significantly differed from all other samples except EWP. The other basidiomycetous mycelia LED_KTD had the same maximum detachment force as PPI and was stickier than SPI, SPC, and SFC. To summarize, for stickiness (Table 3) the same groups could be identified as for the haptic and manufacturing evaluation (Table 2). There is one group with more stickiness than CON including PSA_PM, POPI and EWP and another group with lower stickiness including PPI, LED_KTD, SPI, SFC, and SPC.

Table 3: Stickiness of raw MMDK masses

	max. detachment force [g]	[SD]	work of adhesion	[SD]
CON	-473.35	72.41	-4030.17	517.27
SPI	-448.73	30.26	-2884.26	505.8
SPC	-407.77	44.49	-3923.51	304.76
SFC	-414.02	48.46	-3841.04	586.46
PPI	-452.97	46.41	-3442.32	438.83
POPI	-476.45	38.48	-3718.75	441.9
EWP	-505.48	54.62	-3585.5	398.43
PSA_PM	-569.79 ^{abcdefh}	44.48	-5329.91 ^{abcefgh}	632.03
LED_KTD	-452.59	23.47	-2503.45 ^{ABCEG}	471.72

a: Significant difference between PSA_PM and CON **b:** Significant difference between PSA_PM and SPI **c:** Significant difference between PSA_PM and SPC **d:** Significant difference between PSA_PM and SFC **e:** Significant difference between PSA_PM and PPI **f:** Significant difference between PSA_PM and POPI **g:** Significant difference between PSA_PM and EWP **h:** Significant difference between PSA_PM and LED_KTD **A:** Significant difference between LED_KTD and CON **B:** Significant difference between LED_KTD and SPI **C:** Significant difference between LED_KTD and SPC **D:** Significant difference between LED_KTD and SFC **E:** Significant difference between LED_KTD and PPI **F:** Significant difference between LED_KTD and POPI **G:** Significant difference between LED_KTD and EWP

The work of adhesion of 10 g raw MMDKs is also represented in Table 3. The maximum detachment force and the work of adhesion are not correlated. Contrary to the maximum detachment force, the work of adhesion refers to the complete removal mechanism of the sample from the measurement tool. The work of adhesion shows the quality of stickiness or connectorization. PSA_PM was identified as the sample with the highest work of adhesion. It was significantly different from the other tested proteins and delivered the only value lower than CON. LED_KTD exhibited with -2503.45 the highest work of adhesion and also differed significantly from values for all other manufactured samples.

IV. CONCLUSION

The aim of this study was to test the two basidiomycetous mycelia of *Pleurotus sapidus* and *Lentinula edodes* in MMDK systems in comparison with animal proteins that are used today in MMDKs, vegetable proteins and dextrose as control. It could be shown that during the manufacturing process portioning, forming and sticking are comparable to the other samples. Thus, basidiomycetous mycelia can be used in the production of raw MMDKs. They have the same measured values as MMDK products presented in the literature [8, 9]. This is additionally underlined by the measurement of stickiness. It could be shown that the connectorization is guaranteed by the addition of basidiomycetous mycelia. Overall, it can be concluded that the mycelia of *Pleurotus sapidus* and *Lentinula edodes* are well suitable alternatives to proteins which are currently being used in the manufacturing of MMDK.
In the second step of the study the MMDK cones were grilled on a open gas grill. Results of the whole study will be published in 2017.

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