DETERMINING THE GEOGRAPHIC ORIGIN OF POULTRY MEAT AND DRIED BEEF BY A COMBINATION OF ELEMENT AND OXYGEN ISOTOPE ANALYSIS

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INTRODUCTION

European and Swiss legislation ask for traceability of food and because meat origin is an important criterion for consumers' purchase decision, the demand for tools to prove the geographic origin independently from mere paper traceability increases steadily. Also for PDO-labeled products a determination of the geographic origin of both meat origin and place of processing is desirable as it would protect regional producers and their products from potential frauds. First analyses gave indications that element and isotope analysis individually have quite a high potential to authenticate the geographic origin of meat (Franke et al., 2006; Franke et al., 2007). The aim of the present study was to test the extent to which combining such techniques might even improve the accuracy of this approach.

MATERIAL AND METHODS

A total of 78 poultry breasts were obtained from Brazil, France, Germany, Hungary, and Switzerland in two sample sets: the first comprising 22 samples from these countries (Phase I), the second 52 samples (Phase II). The authenticity of all samples had been certified with valid custom documents, specifying place and date of slaughter. Samples were vacuum-sealed and frozen at -25°C. Totally 71 dried beef meat samples (thereof 21 being collected in Phase I) were either directly collected from the production sites (samples produced in Switzerland) or purchased from producers in Australia, Austria, Canada, and USA between May 2004 and February 2006. The Austrian samples were produced from Brazilian raw meat, for the other non-Swiss samples raw meat originated from the country of processing. Swiss samples were partly produced in the Swiss canton of Valais using Swiss raw meat and partly in the canton of Grisons using both Swiss and Brazilian raw meat. Beef samples were vacuum-sealed and stored in a cooling room at 2.5 °C.

For element analysis between 0.4 - 0.5 g of dried beef and 0.8 - 1 g of poultry meat were subjected to micro-wave assisted pressure digestion with nitric acid and analyzed for a total of 48 elements/isotopes using a sector field Inductively Coupled Plasma-Mass Spectrometer (ICP-MS; Element 2, Finnigan MAT, Bremen, D) (Franke et al., 2006). Between analyses of Phase I and II the method was adapted to the state of the art (software-update of ICP-MS, new microwave-oven). For oxygen isotope analysis the water was extracted out of approx. 10 g of the sample by azeotropic distillation (toluene, 18h, 130°C). The determination of the oxygen isotope ratio ($\delta^{18}O$) was carried out with Isotope Ratio Mass Spectrometry (IRMS; Delta-Plus XL, Finnigan, Bremen, D) (Franke et al., 2007). Each sample was analysed in duplicate. Multivariate statistical analysis were performed using Linear Discriminant Analysis (LDA) with stepwise backward elimination (probability to enter / to remove: 0.15) on the combined data set of element and isotope analyses. Afterwards a validation was carried out by determining the origin of the samples in Phase I based on the data of samples in Phase II.

RESULTS AND DISCUSSION

For building the validation matrix LDA selected the elements ^{82}Se, ^{85}Rb, ^{88}Sr, ^{95}Mo, ^{142}Nd, ^{205}Tl, ^{23}Na, ^{44}Ca, ^{51}V, ^{75}As and $\delta^{18}O$. The results showed that it was possible to determine the origin of poultry breasts from the first sample set correctly at a mean rate of 55 % based on a statistical model build with samples of the second sample set (Table 1). Thereby samples from Brazil, France and Hungary could be classified at 100%, while samples from Germany were completely misclassified as being French. Swiss samples were misclassified as being Hungarian with the exception of one sample which was determined as being from Brazil. Reasons for the lack of discrimination between French and German samples might be the relatively close geographic proximity. However, it still was possible to separate Swiss samples from these origins despite comparable geographic distance. The reasons for the misclassification of the Swiss samples are not clear.

Table 1: Origin of poultry samples of Phase I as predicted based on results obtained in samples of Phase II

	Brazil	France	Germany	Hungary	Switzerland	% correct
Brazil	4	0	0	0	0	100
France	0	2	0	0	0	100
Germany	0	3	0	0	0	0
Hungary	0	0	0	6	0	100
Switzerland	1	0	0	6	0	0
Total	5	5	0	12	0	55

Dried beef samples were correctly classified at a mean rate of 43 % using the elements ^{10}B, ^{137}Ba, ^{42}Ca, ^{57}Fe, ^{69}Ga, ^{7}Li, ^{24}Mg, ^{55}Mn, ^{85}Rb, ^{88}Sr, ^{51}V and $\delta^{18}O$. Just all samples from Canada were correctly identified, while other samples were partly misclassified (Table 2). One sample of another origin was classified as coming from Canada, meaning that not all samples determined as being Canadian would come from there. However, it was possible to separate samples made of the raw meat origin and processed in different countries (BR/AT and BR/GR), but it was not possible to differentiate between samples of different raw meat origin and processed in the same area (BR/GR and CH/GR) as well as to differentiate between regions of Switzerland (CH/VS and CH/GR). All samples processed in the Swiss canton of Grisons were assigned correctly, but 2 out of 3 samples processed in Valais were predicted as being from Grisons. However, all samples processed in Switzerland using Swiss raw meat were identified as to have been processed in Switzerland.

Table 2: Origin of dried beef samples of Phase I, predicted based on results obtained in samples of Phase II

	AU/AU	BR/AT	BR/GR	CH/GR	CH/VS	CN/CN	US/US	% correct
Raw meat origin	Australia	Brazil	Brazil	Switzerland	Switzerland	Canada	USA	
Place of processing	Australia	Austria	Switzerland (Grisons)	Switzerland (Grisons)	Switzerland (Valais)	Canada	USA	
AU/AU	0	0	4	0	0	0	0	0
BR/AT	0	1	0	1	0	0	0	50
BR/GR	0	0	2	0	0	1	1	50
CH/GR	0	0	1	3	0	0	0	75
CH/VS	0	0	1	1	1	0	0	33
CN/CN	0	0	0	0	0	2	0	100
US/US	0	0	0	2	0	0	0	0
Total	0	1	4	11	1	3	1	43

Analyses were carried out in two steps covering a time span of more than one year. Especially for element analysis, the comparability of the data sets was checked by using reference material. The results showed that it would be possible to analyze samples of unknown origin and determine their origin by reading them into the existing data without the necessity to collect many authentic samples due to the fact that data from earlier analysis can obviously be used for authentication.

CONCLUSION

It can be concluded from these results that the determination of the origin of poultry meat is possible at least in certain regions. Although a differentiation of France and Germany as well as Switzerland and Hungary could not be made, each of these groups and samples from Brazil could be separated almost completely.

For dried beef the discrimination seemed to be more complex. It was possible to distinguish between samples of Brazilian raw meat origin, when processed in different countries, but samples from other raw meat origins, processed in the corresponding country of origin, could not be classified into clear groups. A differentiation of samples of varying raw meat origin but processed in one country was not clearly possible. It was also demonstrated that it might be possible to combine data of these techniques, taken over a longer period of time, to identify unknown samples without collecting a new complete authentic sample set, even when techniques were slightly changed.

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