Titanium/IV/ oxide as an optimum catalyst for the single-sample chemical classification of meats and meat-industry products

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At the 26th Congress of European Meat Researchworkers /Colorado Springs, USA/ we reported the use of zirconium/IV/ oxide as a catalyst in the simultaneous analysis of the biologically important constituents of meats and meat-industry products. In a medium of high H^+ ion activity, Zr^{4+} ions react with phosphate anions to give an insoluble precipitate of $Zr_3/PO_4/_4$, and hence the total phosphorus content and P number of meat products could be determined only indirectly, with a separate destructive decomposition involving the use of a Se catalyst. In contrast with the simultaneous analysis with zirconium/IV/ oxide, the use of titanium/IV/ oxide has simplified the procedure considerably.

We first made an experimental comparison of the catalytic activities of the TiO_2, ZrO_2 and $CuSO_4$. For this investigation, samples of lyophilized bovine musculus longissimus dorsi, Bologna sausage and salami were used; these had fat contents in the range 3-44%, which covers the interval generally found in meat-industry products. The results:

Sample	Destruction time /min/		
	TiO_2	ZrO_2	$CuSO_4$
Lyophilized beef /m.long.dorsi/	5o-55	5o-55	12o
Bologna sausage	2o-25	2o-25	12o
Salami	45-5o	4o-45	12o

Thus, it was concluded on the basis of the "destruction time" that the catalytic procedure with titanium/IV/ oxide is equally as efficient as that with zirconium/IV/ oxide. Previous experiments with zirconium/IV/ oxide have demonstrated that there is no need for "post-boiling": the proteins are broken down completely during the experimentally established destruction period. A "post-boiling" was not found to be necessary with titanium/IV/ oxide either if the destruction was carried out for 2o-5o min in the various cases. The tabulated data show titanium/IV/ oxide to require substantially shorter destruction times than those with copper/II/ sulphate. Table I reveals that the total protein contents /N x 6.25/ found by the titanium/IV/ oxide and copper/II/ sulphate procedures agree well; at a level p = o,o5, the calculated F values are in all cases smaller than the tabulated F values.

The data of Stamm and Gertz on meat products, published in 198o, indicate that the results of Kjeldahl destruction with titanium/IV/ oxide as catalyst practically coincide with those obtained with the AOAC 2o49 procedure with mercury/II/ oxyde.

Table II shows that the catalytic effect of titanium/IV/ oxide is not influenced by the Sn^{2+} ions used in the determination of hydroxyproline.

The use of titanium/IV/ oxide as catalyst permits a simpler one-sample analysis than in the case of the zirconium/IV/ oxide method:

1. Water determination

   Dry matter content determination /dehydration at 18o°C/

2. Partial hydrolysis /Sn^{2+}/H_2SO_4/

   2.1 Fat content determination /tetrachloroethylene extraction/

   2.1.1 Total protein content determination /Nx6.25/ /solvent removal; TiO_2 catalysis/

   2.1.1.1 Total P content determination

   2.1.1.2 Ca content determination /complexometry/

   2.1.1.3 Na content determination /flame-photometry/

3. Complete hydrolysis /Sn^{2+}/H_2SO_4/

   Hydroxyproline determination

Course of simultenaous analysis:

1. Dehydration /water content determination/

10 g homogenized meat /meat product/ is dried for 25 min at 180 °C.

2. Partial hydrolysis

The sample dehydrated in /1/ is washed into a 250 cm^3 flask with 50 cm^3 30% sulphuric acid containing 1 g $SnCl_2.2H_2O$. The acidic solution of the sample is refluxed for 10 min.

2.1 Extraction /fat content determination/

100 cm^3 tetrachloroethylene at 60 °C is added to the solution obtained in /2/, and the mixture is refluxed for 15 min. After cooling, the two phases are separated in a separating-funnel; the lower portion is run off into a 200 cm^3 volumetric flask and the extraction is repeated with 95 cm^3 tetrachloroethylene. The solvent is removed and the fat content is measured gravimetrically.

2.1.1 Total protein content determination /N x 6,25/

The acidic aqueous phase obtained in /2.1/ is taken in a 250 cm^3 beaker and the solvent is removed on a water-bath. The solution is washed into a 100 cm^3 volumetric flask and the volume made up to the mark with 30% sulphuric acid. 20 cm^3 of the resulting stock solution is pipetted into a 250 cm^3 Kjeldahl flask, and 10 g K_2SO_4, 0,15 g $CuSO_4.5H_2O$, 0,15 g TiO_2 and 30 cm^3 conc. sulphuric acid are added. The solution is boiled until it clears. Depending on the protein and fat contents of the sample, the "destruction time" is 15-55 min. The resulting solution is washed into a 200 cm^3 volumetric flask, the volume is made up to the mark with water, and the amount of ammonia formed from a 20 cm^3 aliquot is determined with a Parnass-Wagner apparatus.

$$\text{Total protein content} = \frac{F \times f \times 1.4008 \times 6.25 \times 10}{G} \times 100$$

where F = consumption of 0.1 N H_2SO_4 /cm^3/; f = factor of 0.1 N H_2SO_4;

G = mass of sample taken /mg/.

2.1.1.1 Total phosphorus content determination

10 cm^3 of the 200 cm^3 stock solution obtained in /2.1.1/ is pipetted into a 100 cm^3 volumetric flask, and 10 cm^3 is added from a solution of 20 g ammonium molybdate, 1 g ammonium vanadate and 140 cm^3 conc. nitric acid made up to 1000 cm^3 with distilled water. Photometry is performed against a blank in 1 cm cells at 420 nm. KH_2PO_4 solutions are employed for the calibration plot.

$$\text{Total P content} = \frac{a \times 20 \times 5}{G} \times 100 \text{ mg/100 g}$$

where a = P quantity read off calobration plot /mg/; G = mass of sample taken /g/.

2.1.1.2 Ca content determination

Starting from the 200 cm^3 stock solution obtained in /2.1.1/, the quantity of calcium is determined in the normal manner by direct titration with EDTA.

2.1.1.3 Na content determination

The sodium content is determined by flame photometry in the customary way, on the 200 cm^3 stock solution obtained in /2.1.1/.

3. Complete hydrolysis /hydroxyproline determination/

We set out from the residue /80 cm^3/of the solventfree 100 cm^3 stock solution obtained in 2.1.1. The solution is kept in a drying oven at 105 °C for 15 hr. /This is preferybly done overnught immediately after sample taking./ The determination is subsequently carried out as described at the 26th Congress.

n an example of the simultaneous analysis procedure developed, analytical data on beef usculus longissimus dorsi/ are presented in Table II. It can be seen that, with the commended procedure, it is possible to determine the following chemical parameters multaneously on one sample:

1/ Water content /%/
Dry matter content /%/

2/ Feder number

3/ Foreign water content /%/

4/ Fat content /%/

5/ Water - fat index

6/ Fat - protein index

7/ Hydroxyproline content /%/

8/ Connective tissue protein content /%/

9/ Relative connective tissue protein content /%/

10/ Meat protein content free of connective tissue protein /%/

11/ Total protein /row protein content /%/ /N x 6.25/

12/ Total P content /%/

13/ P number

14/ Ca content /mg/100 g/

This procedure is comparatively fast and cheap, and permits serial analyses in small and medium-sized plants, whereby 14 chemical parameters can be determined simultaneously on one sample. Similarly to zirconium/IV/ oxide, the tinanium/IV/ oxide applied is cheap, available on a technical scale, and non-toxic, and addordingly causes no environmental pollution.

References:

1/ Selmeci, Gy., Cseh, F., Nové, L.: Simultaneous determination of constituents of meat and meat products on one sample. 26th European Meeting of Meat Research Workers, Colorado Springs, 1980, USA.

2/ Stamm, H., Hertz, Ch.: Praktische Erfahrungen bei der Verwendung von Titandioxid als Katalysator bei der Stichstoffbestimmung nach Kjeldahl in Fleisch - und Wurstwaren, Lebensmittelchemie u. gerichtl. Chemie, 34 70-72 /1980/.

Table I.

Total protein /row protein/ determination with titanium/IV/ oxide as catalyst

	Mode of analysis	No. of measurements	Mean protein content /%/	Error of mean /E/	Square error of mean /E^2/	F /calcd./	F /tabulated/ /p=0,05/
Lyophilized musc. long. dorsi /beef/	I	20	79,27	0,085	0,0072	1,014	2,17
	II	20	79,29	0,084	0,0071		
Bologna sausage	I	5	11,22	0,081	0,0066	3,300	6,39
	II	5	11,22	0,045	0,0020		
Salami	I	5	25,02	0,044	0,0019	1,188	6,39
	II	5	25,03	0,040	0,0016		

I. Titanium/IV/ oxide as catalyst

II. Control: copper/II/ sulphate as catalyst

Table II.

Simultaneous analysis of beef /musc. long. dorsi/ with titanium/IV oxide as catalyst

	Parameter	I.	II.
1.	Water content /%/	71,66	71,76
1.1	Feder number	3,44	3,41
1.2	Foreign water content /%/	o	o
2.1	Fat content /%/	3,45	3,71
2.1.1	Water - fat index	2o,77	19,34
2.1.2	Fat - protein index	o,17	o,18
2.2	Hydroxyproline content /%/	o,17	o,18
2.2.1	Connective tissue protein content /%/	1,36	1,46
2.2.2	Relative connective tissue protein content /%/	6,53	6,94
2.2.3	Meat protein content free of connective tissue protein /%/	19,47	19,58
2.3	Raw protein content /%/	2o,83	21,o4
2.3.1	Total P content /%/	o,12	o,13
2.3.2	P number	1,32	1,42
2.3.3	Ca content /mg/loo g/	1o,82	1o,14

I. Means of simultaneous analyses with titanium/IV/ oxide

II. Controls: means of individual analyses