i'Tec_Q2
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Physical properties of the additives used in animal feed: Operation of a database

1. Introduction

Since 1992, TECALIMAN has been characterising animal feed additives and running tests on their technological behaviour. One of the outcomes of these two activities has been the establishment of a general database on these products. A "representative" dataset was selected from this database and used to conduct a wider study on the physical and behavioural properties of these additives.

2. General database

This currently contains 247 samples of additives sold in France:

- 22 samples of Antibiotics (A).
- 70 samples of Coccidiostats (D).
- 11 samples of colorant (F).
- 3 samples of preservatives (G).
- 45 samples of vitamins (H).
- 72 samples of oligo-elements (I).
- 16 samples of growth factors (J).
- 8 samples of nitrogen products (P).

They are classified and coded according to the positive list of additives (Directive 70/524/EEC), excluding nitrogen products, which are coded P.

			Percentage of the total population						
			Minimum			Median			Maximum
Parameters				10%	15%	25%	25%	15%	10%	
Bulk density	BD	g/cm^3	0.148	0.400	0.500	0.644	1.014	1.242	2.830
Tap density	TD	g/cm^3	0.182	0.480	0.565	0.722	1.209	1.472	3.100
Hausner ratio	HR		1.013	1.050	1.078	1.135	1.229	1.320	1.690
Particulate matter density	PMD	g/cm^3	0.978	1.201	1.344	1.501	2.360	3.530	14.957
Porosity	POR	%	0.343	0.442	0.504	0.600	0.689	0.742	0.914
Laser diffraction median diameter analysis (dry)	D50	µm	3.3	16.4	47.2	148.6	316.0	536.8	953.5

Table 1: Physical characterisation parameters taken from the animal feed additive database, drawn up by TECALIMAN since 1992.

There are only 6 properties available for the whole set of samples (Table 1). For each property, the additive population is described using various distribution criteria, making no assumptions about the manner of this distribution. For example, for bulk density:

- the minimum (0.148) and maximum (2.830) values are indicated at each end of Table 1. The median value is shown in the middle of the list (0.644). 50% of the additive population lies between the median and each of these two extremities.
- the quartiles (0.500 and 1.014) on either side of the median are given. These criteria, along with the median value, divide the population into four 25% quarters. Fifty percent of the population on either side of the median lies between the two quartiles, and can be described as the central population.
- Table 1 contains two final criteria - the values below (0.400) and above (1.242) which lie 10% of the population. These values and respectively, the minimum or maximum, indicate the population endzones for the studied property.

All these criteria can be used to evaluate the position of a given additive within the population as a whole. This population can also be studied based

on its constituent groups. Table 2 to 7 list the number of representatives of each class, and for each property according to the population's cumulated percentages. These tables demonstrate that each class contains a large number of samples in the central zone (25-75%). In addition, no property may be considered as the guaranteed identifying element of a given class of additives.

Code	Cumulated % of the total population				
	< 10%	10-25%	25-75%	75-90%	> 90%
A	2	2	18		
D	7	22	40	1	
F		2	9		
G			1	2	
H	8	11	24		2
I			22	31	19
J	4	3	2	3	4
P			8		

Table 2: Number of individuals of each additive class per test portion of the distributed population in ascending order of bulk density

Code	Cumulated % of the total population				
	< 10%	10-25%	25-75%	75-90%	> 90%
A	2	2	18		
D	7	22	39	2	
F	1	2	8		
G			2	1	
H	7	12	24		2
I			22	28	22
J	7		2	6	1
P			8		

Table 3: Number of individuals of each additive class per test portion of the distributed population in ascending order of tap density

Code	Cumulated % of the total population				
	< 10%	10-25%	25-75%	75-90%	> 90%
A	3	1	13	3	2
D	8	18	28	10	6
F	4	5	2		
G	1		2		
H	6	6	23	7	3
I	2	5	36	19	10
J		2	12	1.	1.
P			8		

Table 4: Number of individuals of each additive class per test portion of the distributed population in ascending order of Hausner ratio

Code	Cumulated % of the total population				
	< 10%	10-25%	25-75%	75-90%	> 90%
A	2	4	16		
D	2	16	46	6	
F	9	1	1		
G			3		
H	11	9	24	1	
I			22	25	25
J		1	10	5	
P	1	6	1		

Table 5: Number of individuals of each additive class per test portion of the distributed population in ascending order of particulate matter density

Code	Cumulated % of particulate matter density				
	< 10%	10-25%	25-75%	75-90%	> 90%
A		6	10	3	3
D	6	2	29	20	13
F			11		
G			3		
H	7	6	32		
I	12	20	29	9	2
J		1	4	4	7
P		2	6		

Table 6: Number of individuals of each additive class per test portion of the distributed population in ascending order of laser particle size analyser median diameter analysis (dry channel)

Code	Cumulated % of the total population				
	< 10%	10-25%	25-75%	75-90%	> 90%
A		3	14	5	
D	1	5	49	13	2
F	4	4	2	1	
G			1		
H	5	6	23	4	7
I	11	11	26	9	15
J		6	4	5	1
P	2	2	4		

Table 7: Number of individuals of each additive class per test portion of the distributed population in ascending order of porosity

This observation can also be made via a principal component analysis that distributes the additives within a composite area designed on the basis of their six properties (Figure 1).
Without differentiating between the groups, it can be readily observed that most of the products are present over a restricted domain area. This area was identified using 30 representative additives, for which a greater number of properties were studied.

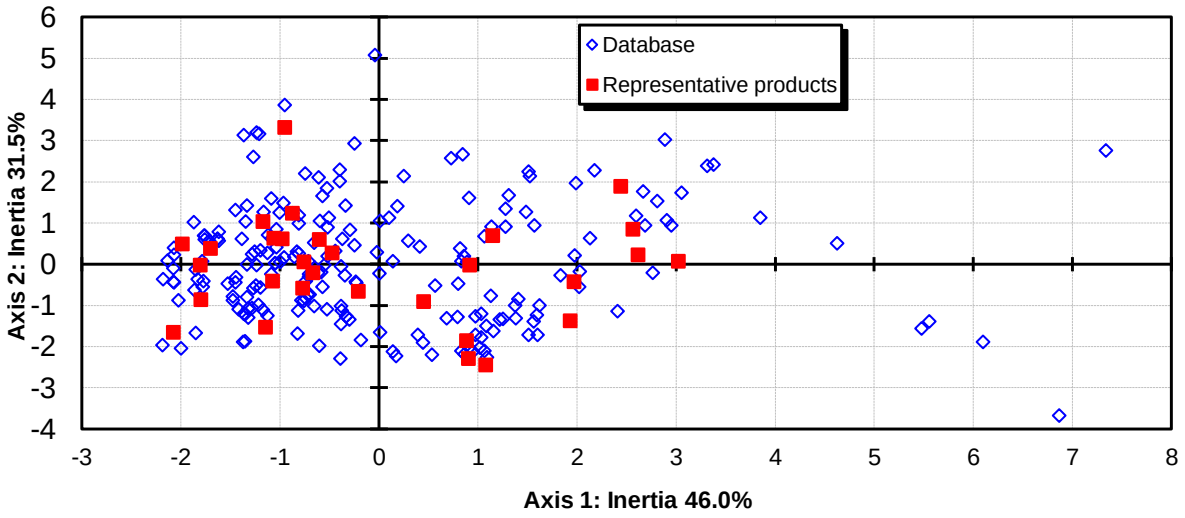

Figure 1: Principal component analysis of the 6 parameters of the database on the physical characterisation of animal feed additives - drawn up by TECALIMAN since 1992.

3. Representative products

33 properties were identified for each of these thirty products. The criteria set out in Table 9 for each property are identical to those given in Table 1.

Property	Low figure	High figure
AS - ASD - AOR - AOS - SFD	Smooth flow	Poor flow
HR	Minimal automatic compaction - Smooth flow	Subject to automatic compaction - Poor flow
D10 - D100 - BD - TD	Light and loosely packed	Heavy and compact
PMD	Light	Heavy
HSG	Minor weight variation despite the significant variation in ambient moisture levels	Large, rapid change in weight when ambient moisture levels vary
ERH	Minor weight variation when ambient moisture levels are low	Minor weight variation when ambient moisture levels are high
ED - LED	Low-level dust emission - Minor risk of carry-over	Dusty - increased risk of carry-over
D50 - VMD	Fine	Coarse
SPAN	Even particle size	Uneven particle size
SS - SSA	Not likely to establish interparticle contacts with other products	Likely to establish interparticle contacts with other products or conducive to gaseous exchange
I100	Coarse	Fine
NP	Risk of poor mix distribution	Promotes mix distribution
POR	Dense	Aerated
SUR - WID - LEN - PER - DIA	Fine	Coarse
ELF	Elongated particles	Particles with projected shapes approximating to disks or squares
FOF	Non-circular particle shapes tending towards an ellipse	Particle shape approximating to a circle for which FOF = 1.
COR	Smaller particles or larger with ragged edges	Larger particles
EC	Insulating	Less insulating
CH	Limited exchange of moving electric charges	Large exchange of moving electric charges
ACC	Weak capacity to accumulate electric charges	Strong capacity to accumulate electric charges

Table 8: Meaning of all the parameters

The methods for interpreting each property for animal feed additives are given in Table 8 (references for the properties are given in Table 9).

4. Conclusions

The years to come will see continued expansion of the TECALIMAN database. There will be slightly more measurements made than the six properties currently available. Measurements of angles of repose (AOR) and of smallest flow diameters (SFD) will be made systematically. The complete data set is available at Tecaliman.

			Percentage of the population						
			Minimum			Median			Maximum
Parameters				10%	15%	25%	25%	15%	10%	
Angle of spatula	AS	°	30.7	44.1	49.5	63.5	71.2	73.3	74.2
Angle of slope - distribution	ASD	°	36.8	40.7	45.5	50.7	56.3	59.7	63.1
Angle of repose	AOR	°	36.3	42.7	46.2	62.6	70.3	73.3	76.9
Angle of slope	AOS	°	29.2	34.5	37.4	41.7	46.0	52.3	56.0
Smallest flow diameter	SFD	mm	3.0	6.7	9.9	26.0	30.9	34.1	40.7
Tap density at 10000 Pa	D10	g/cm^3	0.329	0.509	0.605	0.947	1.387	1.567	1.795
Tap density at 100000 Pa	D100	g/cm^3	0.437	0.547	0.667	1.066	1.599	1.750	2.239
Bulk density	BD	g/cm^3	0.201	0.424	0.493	0.640	1.111	1.305	1.383
Tap density	TD	g/cm^3	0.262	0.488	0.550	0.705	1.298	1.515	1.656
Hausner ratio	HR		1.043	1.049	1.080	1.140	1.191	1.283	1.312
Increasing weight gradient under controlled humidity conditions	HSG	g/%	0.004	0.016	0.037	0.130	0.202	0.247	0.481
Equilibrium relative humidity	ERH	%	0.111	0.326	0.428	0.538	0.626	0.714	1.000
Emission of dust	ED	mg/kg	6.7	31.7	109.3	364.7	1222.7	2652.9	6985.3
Log (Emission of dust)	LED		1.9	3.5	4.6	5.9	7.1	7.9	8.9
Particulate matter density	PMD	g/cm^3	1.129	1.271	1.342	1.523	2.498	3.442	5.052
Laser diffraction median diameter analysis (dry)	D50	µm	7.4	15.2	48.1	122.8	276.9	575.0	889.1
Volume median diameter	VMD	µm	26.7	52.2	79.6	142.5	333.9	636.4	941.0
SPAN	SPAN		1.1	1.3	1.6	2.2	3.0	7.4	47.2
Specific surface	SS	m^2/g	0.01	0.01	0.09	0.58	0.65	0.21	3.86
Percentage of particles < 100 µm	I100	%	0.2	1.2	12.6	45.8	75.0	88.6	99.4
Number of particles per gram	NP		2.1E+04	5.1E+05	3.1E+07	5.0E+08	6.8E+08	1.0E+09	4.3E+09
Porosity	POR	%	0.39	0.47	0.52	0.60	0.68	0.73	0.89
Surface	SUR	µm^2	2.6	6.9	80.6	1311.8	17467.5	60106.5	267209.8
Width	WID	µm	1.4	2.0	6.5	23.3	100.4	190.7	477.6
Length	LEN	µm	1.9	2.8	9.5	32.3	129.9	294.0	758.5
PERIMETER	PER	µm	5.7	8.0	28.8	95.8	391.6	981.5	2187.8
Diameter	DIA	µm	1.5	2.1	6.7	24.6	107.1	198.5	535.3
Elongation factor	ELF		0.52	0.55	0.65	0.71	0.74	0.77	0.81
Form factor	FOF		0.45	0.53	0.58	0.63	0.72	0.76	0.81
Compactness ratio	COR		0.32	0.43	1.28	4.90	22.95	40.03	103.86
Specific surface area	SSA	m^2/g	0.04	0.12	0.22	0.45	2.35	5.86	13.10
Electrical conductivity	EC	S/m	2.3 10^{-14}	4.6 10^{-13}	3.2 10^{-12}	1.0 10^{-10}	9.0 10^{-8}	6.0 10^{-7}	3.0 10^{-5}
Chargeability	CH	nC/g	-12.4	-5.6	-4.1	-1.5	-0.2	3.6	24.6
Accumulation of charges under an electric field	ACC	pC/g	86	105.9	499.5	998.5	2875	4711	12800

Table 9: Summary table of the properties of the range of thirty representative additives

5. For more information on the methods used

I'Tec_Q3/Q9 and Q4

Tecaliman Report No. 9, 1998. Assessment of the internal quality of laboratory methods used to characterise animal feed additives - Phase 2a.

Tecaliman Report No. 10, 1998. Comparison of the laboratory methods used to characterise animal feed additives - concerning measurement ranges, discriminatory powers and redundancies - Phase 2b.

Special Tecaliman report No. 68, 1998. Summary of the programme for predicting the technological behaviour of additives in industrial environments.