The Composition of Fat Bloom on Lauric Compound Coatings

Geoff Talbot and Kevin W. Smith
Consultants to Loders Croklaan

Introduction

Over the past year or so there has been considerable pressure on food manufacturers to reduce the levels of trans fatty acids used in their products. Indeed some countries, Denmark for example, have defined legislative limits for trans in food. Others such as the USA are planning to bring in labelling requirements for trans. Confectionery manufacturers are being affected by these changes along with the rest of the food industry.

One area where the confectionery manufacturers are being particularly affected is that of compound coatings where there has been widespread use of fats based on partially hydrogenated and fractioned vegetable oils such as soyabean oil, rapeseed oil and palm oil. These, of course, then contain high levels of trans fatty acids, often as high as 50%. Whilst the oils and fats manufacturers have responded to this by developing lower trans content compound coating fats and indeed, in the case of Loders Croklaan, even a zero-trans content compound coating fat, the confectionery industry has also looked at alternatives.

If the coatings are to be trans-free, then there are two basic routes that a confectionery manufacturer can take. One is to move more towards a supercoating. This is a vegetable fat with similar composition and properties to cocoa butter. In most cases, they are cocoa butter equivalents used at a much higher level than would generally be permitted in chocolate. This allows a manufacturer to make a coating which, whilst less expensive than chocolate, is more expensive than the partially hydrogenated compound coating and which also requires tempering.

The other route, which will be considered here, is to move to using a lauric fat in the coating. This allows the manufacturer to make a compound coating with a similar cost structure to that of the partially hydrogenated compound coating, but there are other factors which he needs to take into account.

The partially hydrogenated non-lauric fats used in the high trans coatings have a limited tolerance to cocoa butter such that up to 20% of the fat phase of the coating may be cocoa butter. This allows the manufacturer to use some cocoa mass in the total recipe and gives a more rounded chocolate flavour to the coating. If these non-lauric compound fats were directly replaced with a lauric fat and the same level of cocoa butter were used then fat bloom would rapidly form on the coating. This is because such lauric fats have little or no tolerance to the presence of cocoa butter. Indeed, no more than 4-5% cocoa butter (based on the fat phase) will be tolerated by lauric fats in a compound coating. This restricts the manufacturer to using a cocoa powder based

recipe instead of a cocoa mass based recipe with consequent effects on the flavour perception of the coating.

These comments would apply to any lauric fat used in such a coating. In practice, the types of fats normally used in these types of coating are palm kernel stearines (PKS) and fully hydrogenated palm kernel stearines (HPKS).

Whilst it is well known that bloom will occur on these coatings if the level of cocoa butter used exceeds 4-5% of the fat phase, what has not been studied to any great extent is exactly what this bloom is. Is it, for example, the limited amount of cocoa butter present in the coating recrystallising on the surface, or is it a further crystallisation of the bulk fat in the coating, i.e. the lauric fat portion?

To try to define which, if indeed either, of these two scenarios is the correct one we looked in great analytical detail at lauric coatings stored at a range of temperatures for 12 months.

The Fats

Two lauric fats were used – PKS and HPKS – both from Loders Croklaan. Their triglyceride and fatty acid compositions were analysed by means of triglyceride carbon number (TG-CN) GC and fatty acid methyl ester (FAME) GC. They were deliberately formulated into a coating recipe which contained 10% cocoa butter, i.e. about double the recommended limit. This high level was used to ensure that bloom occurred during storage. The cocoa butter part of the formulation was also analysed in the same way. The triglyceride and fatty acid compositions of these three fats are shown in Tables 1 and 2.

Table 1 Triglyceride composition of fat components

Carbon number	PKS	HPKS	CB
C32	3.6	3.5	
C34	6.5	6.6	
C36	26.3	25.7	
C38	23.9	23.2	
C40	14.3	14.2	
C42	9.1	9.0	
C44	5.2	5.2	
C46	3.4	3.3	
C48	2.7	2.8	0.4
C50	1.3	1.4	17.6
C52	1.1	1.4	45.8
C54	1.2	1.5	33.8
Other	1.1	1.6	1.6

Table 2 Fatty acid composition of fat components

Fatty acid	PKS	HPKS	CB
C10:0	2.6	2.5	
C12:0	59.7	59.0	
C14:0	20.2	19.7	0.1
C16:0	7.7	8.0	25.8
C18:0	2.2	8.7	34.2
C18:1	5.4	0.1	35.2
Other	2.2	2.0	4.7

The differences between the two lauric fats and the cocoa butter are immediately obvious. In terms of their fatty acids, almost 60% of the lauric fats is lauric acid (C12:0) and no more than 16-17% is made up of the longer chain palmitic, stearic and oleic acids. In contrast about 95% of cocoa butter is composed of these three longer chain acids. These differences then translate themselves into the triglyceride compositions with over 75% of the lauric fats falling within the C34-C42 range and only 3-4% within the C50-C54 range. Cocoa butter has no triglycerides within the C34-C42 range but over 97% of its triglycerides fall within the C50-C54 range.

So, from the point of view of distinguishing between whether the bloom is coming from the lauric fat or the cocoa butter these differences are of great help.

From a triglyceride grouping point of view, cocoa butter contains mainly SOS type triglycerides (S=saturated; O=oleic) whereas the two lauric fats are mainly SSS type fats (indeed the HPKS is almost totally SSS because it has been fully hydrogenated).

The coatings

Coatings were made using the two lauric fats, both to the same recipe (see Table 3)

Table 3 Coating recipes

Lauric fat (PKS or HPKS)	31.2%
Cocoa powder (containing 22-24% CB)	15.1%
Icing sugar	45.3%
Skimmed milk powder	8.0%
Lecithin	0.4%

The ingredients were blended, milled and conched by processing in a Lloveras conch for 5 hours at 50-55°C. They were then melted at 65°C for 30 minutes before cooling to 40°C and holding for another 30 minutes. They were moulded into 50g tabletted bars which were then stored for 12 months at 15°C, 20°C or 25°C. This lengthy storage time coupled with the higher than normal level of cocoa butter in the coating was sufficient to induce bloom formation in all the samples.

The bloom that had formed was carefully scraped off at 20°C using a thermally insulated scalpel so as not to melt the bloom. Care was also taken to minimise the amount of

contamination from the removal of any of the underlying compound chocolate. The removed bloom samples were again analysed by TG-CN GC, FAME GC and also by argentation (Ag+) HPLC which separates the fat into triglyceride groupings based on unsaturation, i.e. SSS is separated from SOS etc. The results are shown in Table 4 (TG-CN GC), Table 5 (FAME GC) and Table 6 (Ag+ HPLC)

Table 4 TG-CN GC of Bloom Samples

	PKS/CB Compound Coating				HPKS/CB Compound Coating			
	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C
C34	6.4	5.1	5.6	4.2	6.4	5.4	6.6	5.2
C36	23.4	17.9	23.7	37.8	24.5	16.5	29.4	43.8
C38	21.1	15.0	16.2	23.9	21.6	10.1	20.3	22.6
C40	12.7	8.6	7.3	13.3	12.7	4.5	9.2	10.0
C42	8.0	5.4	4.0	7.4	7.8	2.6	5.4	5.6
C44	4.5	3.2	2.1	3.0	4.4	1.4	3.0	2.1
C46	2.9	2.5	1.3	1.4	2.8	0.8	1.7	0.9
C48	2.4	2.3	1.2	1.0	2.3	0.8	1.5	0.7
C50	3.2	7.5	3.8	1.2	2.7	9.1	2.2	1.0
C52	5.6	16.7	13.2	2.2	5.1	26.2	7.4	2.4
C54	4.2	11.0	17.4	1.7	4.2	17.0	9.2	2/4
Other	5.5	3.9	3.4	2.0	5.5	4.5	3.3	2.5

Table 5 FAME GC of Bloom Samples

	PKS/CB Compound Coating				HPKS/CB Compound Coating			
	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C
C12:0	48.9	30.5	41.3	54.3	49.6	30.1	52.3	67.4
C14:0	19.8	10.7	10.4	12.8	20.0	9.3	13.7	13.6
C16:0	11.1	15.9	10.2	9.9	10.6	25.1	7.9	6.1
C18:0	6.3	16.4	17.5	4.7	12.1	18.3	13.9	6.1
C18:1	10.0	18.2	13.6	7.8	4.2	11.3	5.8	2.2
Other	2.5	5.2	4.7	3.8	2.3	4.4	5.2	3.6

Table 6 Ag+ HPLC of Bloom Samples

	PKS/CB Compound Coating				HPKS/CB Compound Coating			
	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C
SSS	85.3	48.1	48.5	97.5	91.1	38.3	79.0	98.6
SOS	7.6	48.2	50.2	0.0	6.9	58.0	19.1	0.0
Other	7.1	3.7	1.3	2.5	2.0	3.7	1.9	1.4

In looking at what is happening in terms of bloom formation it is simplest to start with the Ag+ HPLC information in Table 6. Bearing in mind that both PKS and HPKS are very

rich in SSS and cocoa butter is very rich in SOS, the original coatings are both rich in SSS because PKS or HPKS is the main fat present. However, when we look at the bloom from the PKS/CB coating we find that at 15°C and at 20°C there is considerably more SOS than is present in the underlying coating. The SSS/SOS ratio shifts from about 12:1 in the original coating to about 1:1 in the bloom. This indicates an enrichment of cocoa butter in the bloom compared to the original compound. At 25°C, however, the whole thing turns completely around and the bloom is almost totally SSS with no SOS present at all, indicating that the bloom at 25°C is coming exclusively from the PKS.

In the HPKS/CB coating we find somewhat similar results at 15°C and 25°C storage. At 15°C the bloom is very much enriched in cocoa butter SOS triglycerides, even more so than with the PKS/CB system; at 25°C the bloom is again almost totally SSS indicating that it is coming exclusively from the HPKS. At 20°C the situation is slightly different in that the bloom has a SSS/SOS ratio of about 4:1 – much richer in SSS than with PKS/CB at the same temperature.

In general terms we can say that as the storage temperature increases then the composition of the fat bloom becomes enriched in PKS/HPKS triglycerides until by 25°C they form the whole of the fat bloom. It also appears that the temperature at which this concentration of PKS/HPKS triglycerides in the bloom occurs is lower for the more saturated and harder HPKS system than for the PKS system.

We can now put some 'flesh' on these 'bones' by looking more deeply into the more detailed FAME GC and TG-CN GC analyses. As far as the FAME GC results are concerned the changes in C12:0 (lauric acid) and C18:1 (oleic acid) levels with storage temperature are interesting. These are shown graphically in Fig 1. The lauric acid level in the bloom gradually increases with storage temperature whilst the oleic acid level decreases. In the PKS/CB system the lauric acid level in the bloom would be expected to be at the same level as that in the coating at a storage temperature of about 22.9°C whereas in the HPKS/CB system this would occur at 19.4°C. The corresponding temperatures for oleic acid are 23.1°C for PKS/CB and 22.2°C for HPKS/CB.

As far as the TG-CN GC results are concerned, we've already seen from Table 1 that the fats themselves fall within two group with both PKS and HPKS being rich in C34-C42 and cocoa butter being rich in C50-C54. Taking these two groups as a whole we can use the TG-CN GC data to see what differences there are in the fat bloom (Table 7).

Table 7 TG-CN GC – summary analysis of fat bloom

	PKS/CB Compound Coating				HPKS/CB Compound Coating			
	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C	Original coating	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C
C34-C42	71.6	52.0	56.8	86.6	73.0	39.1	70.9	87.2
C50-C54	13.1	35.2	34.4	5.1	12.0	52.3	19.9	6.9

A useful way of summarising the whole sets of analyses and defining whether bloom under particular conditions is enriched in lauric fats or in cocoa butter is to calculate enrichment factors. Enrichment factors are the ratio of a particular component in the

bloom to the level of that component in the original coating. If the factor is greater than 1 than the bloom is enriched in that component; if it is less than 1 then the bloom is depleted in that component. We can take as representative of the full analyses, the SSS and SOS levels from the Ag+ HPLC, the lauric acid level from the FAME GC and the C34-C42 and C50-C54 groups from the TG-CN GC. These enrichment factors are summarised in Table 8.

Table 8 Bloom Enrichment Factors

	PKS/CB Coating			HPKS/CB Coating		
	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C	Bloom at 15°C	Bloom at 20°C	Bloom at 25°C
Lauric fat indicators:						
SSS	0.56	0.57	1.14	0.42	0.87	1.08
C12:0	0.62	0.84	1.11	0.61	1.05	1.36
C34-C42	0.73	0.79	1.21	0.54	0.97	1.19
Cocoa butter indicators:						
SOS	6.34	6.61	0.00	8.40	2.77	0.00
C50-C54	2.69	2.63	0.39	4.36	1.66	0.58

These enrichment factors clearly show that at 15°C in both systems the bloom is considerably enriched in cocoa butter whereas at 25°C it is almost completely composed of lauric fat. At 20°C the bloom is cocoa butter rich but this is more predominant in the PKS/CB coating than in the HPKS/CB coating. It is clear that there is a general trend of the bloom being more enriched in cocoa butter the lower the storage temperature.

The composition of the bloom is therefore defined. But this is only part of the story. The thermal and polymorphic characteristics of the bloom are equally important, especially in defining how the bloom arises and what can be done to prevent it. This, then, is clearly the subject of further investigation into this fascinating subject.

In finishing, just a word and speculation about ‘ghost bloom’. A ‘ghost bloom’ has been observed by a number of workers on various occasions on a lauric-containing coating. This bloom only occurs at low storage temperatures and on warming up the coating it disappears. Based on the analyses shown here it does beg the question as to whether this ‘ghost bloom’ is a low stability form of cocoa butter crystallising from the coating which then melts as the coating warms up to 20°C. But this, perhaps, is also the subject of another study.

Fig 1 Change with storage temperature in lauric acid and oleic acid levels in bloom