Vegetable Fats in Chocolate

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Since August 2003, the EU has permitted the use of vegetable fats in chocolate throughout all member states. Up to that point vegetable fats were permitted in only seven countries – United Kingdom, Ireland, Denmark, Sweden, Finland, Austria and Portugal. So what's new?

A great deal has, in fact, changed, even for those countries that already permitted the use of vegetable fat in their chocolate. Previously it was possible, in theory at least, to use almost any vegetable fat in chocolate in these countries. Now the vegetable fats that can be used are much more tightly defined and controlled.

They must be:

- Based on non-lauric oils - indeed the regulations define the base oils even more tightly than this in that only six base fats are permitted: Palm oil; Illipe (also known as Borneo tallow or Tengkawang); Sal; Shea; Kokum gurgi; Mango kernel
- Rich in symmetrical monounsaturated triglycerides of the type POP, POSt, StOSt
- Miscible in any proportion with cocoa butter and compatible with its physical properties
- Obtained only by refining or fractionation or both

The regulations are such that they maintain the compositional integrity of chocolate in terms of its triglyceride content. Cocoa butter is itself rich in the symmetrical monounsaturated triglycerides, POP, POSt and StOSt. By insisting that any vegetable fat used in chocolate also contains significant quantities of these triglycerides, the EU maintains the characteristics of the chocolate. This maintaining of chocolate characteristics is further strengthened by the requirement for the vegetable fats to be miscible and compatible with cocoa butter. By meeting these requirements the resulting fats can be considered to be equivalent to cocoa butter and therefore can be called cocoa butter equivalents (or CBEs)

The six oils that are permitted contain varying levels of POP, POSt and StOSt (Table I). Clearly, illipe and kokum gurgi can be used directly in cocoa butter equivalents without further processing. However, the other oils need some form of processing to concentrate the total symmetrical monounsaturated triglycerides.

Table 1
Typical symmetrical monounsaturated triglyceride contents of the six permitted oils

	Palm oil	Illipe	Shea	Sal	Kokum gurgi	Mango kernel
POP	26	7	<1		Tr	
POSt	3	34	6	7-12	6	
StOSt	Tr	45	30	26-44	72	
Total	29	86	36	33-56	78	48

This is achieved by a process of fractionation in which the fats are held at such a temperature that the higher melting triglycerides crystallize out and can then be separated by filtration. In most of these oils (palm oil is the exception) the POP-POSt-StOSt triglycerides are the highest melting triglycerides and can therefore be concentrated by this process. Palm oil undergoes a double fractionation - one to remove the high-melting trisaturated triglycerides and a second fractionation to concentrate the POP-POSt-StOSt triglycerides.

The composition of the resulting fractions is shown in Table 2.

Table 2
Symmetrical monounsaturated triglyceride compositions of fats and fractions suitable for use in cocoa butter equivalents

	Cocoa butter	Palm fraction	Shea fraction	Illipe	Sal fraction	Kokum	Mango kernel fraction
POP	16	66	1	7	Tr	Tr	1
POSt	37	12	7	34	10	6	16
StOSt	26	3	74	45	60	72	59

The effect of these fractionation processes is to give fats that can then be used directly in cocoa butter equivalents. However, no single fat or fraction has a composition similar to that of cocoa butter so, in order to produce a CBE it is then necessary to blend these fractions. Palm fraction will contribute POP and some POSt to the blend; illipe will contribute POSt and StOSt to the blend; the remaining fats and fractions contribute mainly StOSt to the blend.

These components can be blended in different ratios to give different types of cocoa butter equivalent which will then have varying characteristics and applications.

Essentially, they can be divided into three groups of fats:

- POP-rich palm fraction
- POSt-rich illipe
- StOSt-rich shea fraction, sal fraction, mango kernel fraction and kokum

If they are blended in such a way that the POSt-rich and StOSt-rich fats predominate then they will have physical characteristics which in many ways can be considered to be 'better' than those of cocoa butter. Such blends are called 'cocoa butter improvers' and are used especially to give improved hardness and heat resistance to chocolate.

If, however, they are blended so that there is a balance between the three major triglycerides that is closer to that normally found in cocoa butter then we have a cocoa butter equivalent.

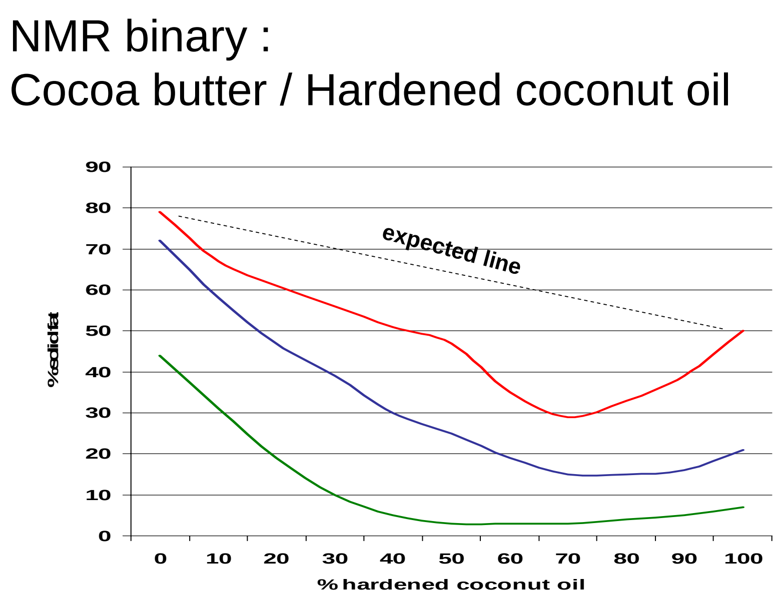
This does, therefore, bring us to the question as to what the Directive means by miscibility and compatibility.

Essentially these relate to the ways in which the triglycerides in cocoa butter and the triglycerides in the vegetable fat interact with each other. I'm sure that most people are familiar with the idea of putting salt on to icy surfaces to 'melt' the ice. What is actually happening is that a eutectic is being formed between the salt and the ice which reduces the freezing point of the water. This can happen when two fats or even two triglycerides are blended with each other. In some instances a eutectic composition can be formed in which the melting point or solid fat content of the blend is below that of the individual components. It is this effect that the Directive is keen to prevent by ensuring that the vegetable fats used in chocolate do not form a eutectic with cocoa butter and therefore unduly soften the chocolate.

Fortunately, it is relatively easy to demonstrate eutectic formation by means of a binary phase diagram. In its simplest form this is a diagram based on binary blends showing the solid fat contents at different temperatures.

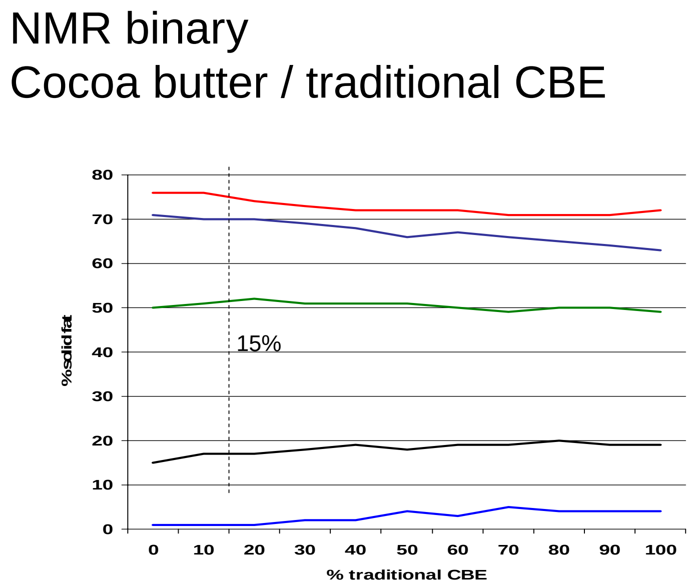
Fig 1 shows the binary phase diagram of the NMR solid fat contents of cocoa butter and hardened coconut oil. It is clear from this diagram that a eutectic is formed between cocoa butter and hardened coconut oil at about 75% coconut oil/25% cocoa butter. If the two fats had shown compatibility then the solid fat contents would have fallen much closer to the 'expected line'. It is this lack of compatibility between cocoa butter and a vegetable fat that the Directive is intended to prevent.

Figure 1



On the other hand, an example of very good compatibility between cocoa butter and a vegetable fat is shown in Fig 2. This is a similar type of diagram but, in this case Coberine, a well-known cocoa butter equivalent is blended with cocoa butter. The difference is immediately apparent. Cocoa butter and Coberine show no eutectic compositions and the lines joining 100% cocoa butter and 100% Coberine are straight.

Figure 2



This shows that cocoa butter and Coberine are fully compatible over the complete range of compositions. This is important because the Directive says that the fats must be miscible and compatible in any proportions and not just in the proportions that would be equivalent to a 5% usage level in chocolate. No lowering of solid fat content at any temperature is detected as one fat is added to the other. In addition, there is no indication of separate phases unique to one or other component.

This then brings us to the final restriction on the fats that can be used - that of the processes which are permitted. Only fractionation and refining are allowed to be carried out on the fats. This means that hydrogenation is not allowed. Hydrogenation is a very common oil modification process the products from which are used widely within the food industry. Essentially it is a process that changes the *cis* unsaturated double bonds within an oil converting them to either saturated single bonds or, more often, to *trans* unsaturated double bonds. In this way it is possible to produce fats that have a similar melting profile to cocoa butter but which, when blended with cocoa butter have only a limited compatibility. Since, as we have seen, one of the physicochemical criteria in the Directive is that CBEs should be compatible with cocoa butter in all proportions it is clear why this processing method has been prohibited.

The Directive also specifically prohibits the use of enzyme-catalysed modification or enzyme-catalysed interesterification. Enzyme-catalysed modification is a process which generates the StOSt triglyceride needed for CBEs. It essentially relies on using an enzyme as a catalyst that is position-specific in the sense that it will allow the interchange of fatty acid groups between triglycerides or between a triglyceride and a fatty acid - only at the 1- and 3- positions. Any fatty acids at the 2-position are left completely unchanged. So it is possible to start with an oil containing a high proportion of oleic acid at the 2-position. This can then react with stearic acid in the presence of an enzyme and interchange at the 1- and 3-positions will result in the formation of StOSt. The drawback with this process is not a technical one but possibly a political one in that all the raw materials necessary for the process can be obtained from 'temperate' oils rather than using oils such as shea, sal and illipt: from tropical developing countries.

The EU Directive has been a long time in the making, with discussions having started on this over 30 years ago. But now we have it and, although there are the restrictions on vegetable fats usage as I have explained, it is important to make good use of all the positive attributes that cocoa butter equivalents can bring to chocolate.

References

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