USE OF SWEETENERS IN ANIMAL NUTRITION

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"The bitter truth about the sweet taste of excess, new research shows even low-calorie sweeteners seduce the appetite" (1990), "Diet soft drinks - too good to be true?" (1987), these were headlines in The Independent and the New York Times. Since then the assumption, that new non-calorie sweeteners support the trend to be slim, has become shaky. Many scientific studies have been designed to find out whether non-calorie sweeteners increase the total calorie intake.

The knowledge from these studies could be useful for animal feeding in order to guarantee and improve feed intake and daily weight gain.

What role does taste play?

Everyone knows the sensations of taste and smell; they can cause, often to a high degree, pleasant feelings or aversions. In contrast to the senses of seeing and hearing, the senses of smell and taste are not highly developed in humans. Their influence on us, however, is strong. The sense of smell, in particular, is closely associated with our emotions. This is confirmed by the physiology of the brain where the olfactory centre and the centres responsible for emotions and instincts are located together within the limbic system. Taste and smell need to be looked at separately because substances which smell are characterised by a tendency to be highly volatile, whereas substances which taste are non-volatile. The following discussion concentrates on the sense of taste.

How important is taste to animals?

Taste plays a more important role in livestock animals (such as pigs and calves) than in humans. This is demonstrated in the following table.

Table 1: Number of taste buds in different species (according to Kare, 1966)

Species	Number of taste buds
Chicken	24
Pigeon	37
Cat	473
Dog	1.706
Human	9.000
Pig / goat	15.000
Rabbit	17.000
Calf	25.000

The possibility of influencing the taste of feedstuffs positively is by the use of sweeteners. The perception of taste, and thus preference, depends on individual characteristics such as age, surroundings or imprint. There is meanwhile some evidence that a kind of imprint already takes place in the womb.

In pigs and cattle the preference for sweet substances decreases with age. In the following preference trial, pigs of different live weights were offered two kinds of feed which only differed in added flavour. During the first part of the fattening period a combination of a vanilla flavour plus sweetener and a feed without flavour supplement were offered at the same time. Later, the same flavour-sweetener combination was tested with a special vanilla flavour (characterised by a slightly bitter, spicy note) without addition of a sweetener (Figures 1 and 2).

Figure 1: Preference test in pigs (live weight 22 - 49 kg) at the University of Leuven (Belgium, 1993)

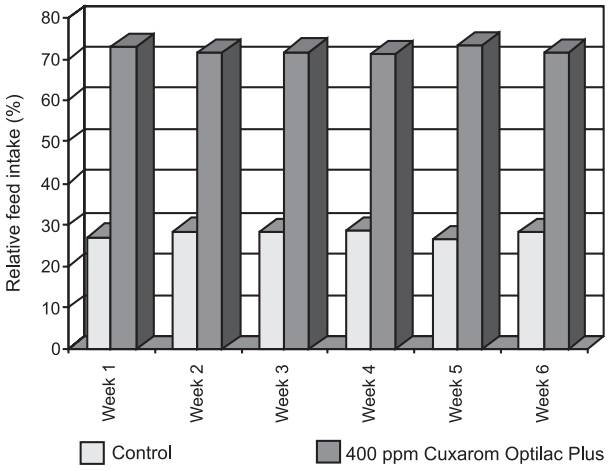
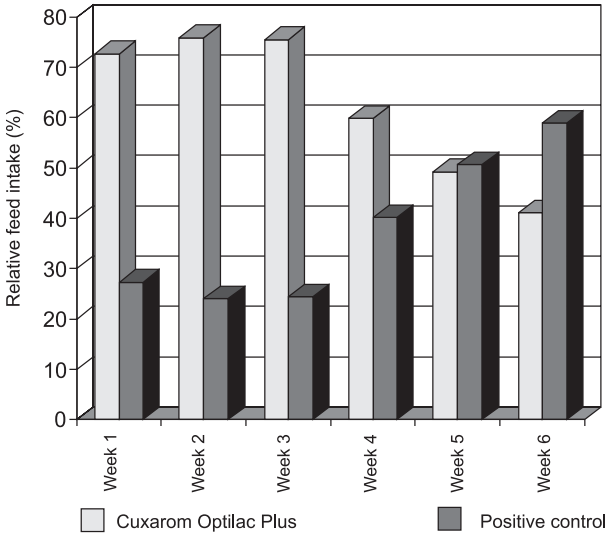


Figure 2: Preference test in pigs (live weight 76 - 107 kg) at the University of Leuven (Belgium, 1993)



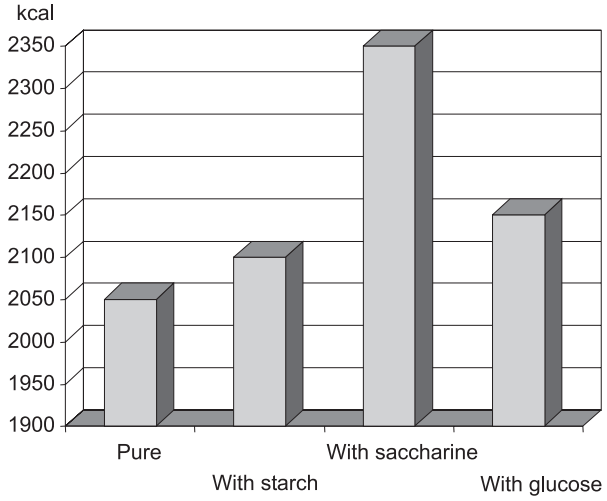
Initially it is clear that the animals very much prefer the sweet feed but the sweetness loses its attractiveness as the animals become older. However, this effect may not

only be due to sweetness as the vanilla flavour could also have an influence and the latter should therefore also be taken into consideration.

What are sweeteners used for?

In so-called 'light' products, the food industry replaces sugar by artificial sweeteners so that sweet products are also available for consumers who watch their weight. In time, however, it was realised that the opposite effect was being achieved. These 'light' products lead to an increase in weight because the appetite is increased by the sweeteners and therefore the total calorie intake increases as well. Rogers and Blundell (1989) showed that, in humans, the desire to eat and the feeling of hunger significantly increased after the consumption of yoghurt sweetened with saccharine compared with a non-sweetened or glucose-sweetened yoghurt. Regarding taste, the two sweet variations had equivalent sweetness.

Figure 3: Cumulative energy intake during one day after the intake of yoghurts with different supplementations (Rogers and Blundell, 1989)



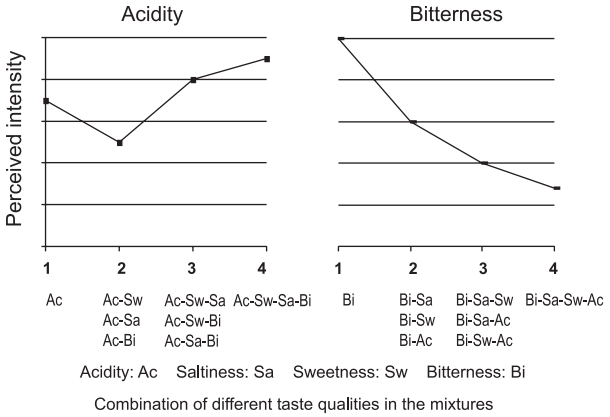
These different sensations did not only occur at short notice they also had significant consequences for the total daily calorie intake. The question is whether these results may be extrapolated from humans to animals. Care must be taken in any comparison, however, the senses of smell and taste in humans can at least serve as basis. Because it is not possible to establish what the subjective senses of aroma and taste in animals are, certain assumptions have to be drawn between humans and animals. Omnivores such as pigs can be compared better with humans than herbivores (eg. adult ruminant), and young mammals have similar taste preferences to humans.

There are many references in the literature that sweet tasting components significantly increase feed intake in animals and this fact is today widely accepted.

A further reason for the use of sweeteners is the masking of negative tastes such as bitterness or sourness, which could reduce feed consumption.

Returning to the human senses, everyone knows that the bitter taste of a grapefruit can be softened by sprinkling sugar on it. Bartoshuk (1975) scientifically examined this phenomenon of masking in humans. Based on the fact that four different kinds of taste can be perceived on the tongue - namely sweet, sour, salty and bitter - the taste intensity changes were examined, when the four types of taste (sugar = sweet, salt = salty, hydrochloric acid = sour and quininhydrochlorid = bitter) were available as mixtures and not as single substances. The substance to be tested first was judged alone for intensity. Then the other substances were successively eaten and the substance which was first tested was judged again for intensity (Figure 4).

Figure 4: Sourness and bitterness perception in relation to the number of taste factors



Source: Bartoshuk (1974)

This trial shows that bitterness can be masked by the addition of sweetness. Also sourness can be partially masked by sweetness. The use of suitable sweeteners may be an obvious alternative to mask the bitter taste in feedstuffs and medicinal products.

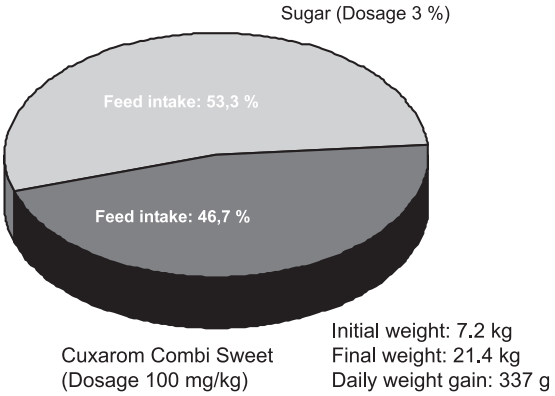
What type of sweeteners are there?

For many years sweet tasting substances have been added to feed to improve palatability. In former times these were mainly sugar (sucrose), dextrose or lactose as there were no alternative substances available. Today the cost of adding 3 - 5 % sugar to compound feedstuffs is too high if sweetness is the only reason for its use. Moreover, high application rates of sugar can encourage diarrhoea. Despite these reasons which refuse the use of sugar and which support the use of non-calorie sweeteners, sugar is still often used because of the fallacy that sugar is the most accepted sweetener by animals. Now however, with the introduction of the 'new generation' of non-calorie sweeteners the same acceptance by animals can be achieved as with sugar.

In the following preference trial (Figure 5), piglets were offered two sweetened feeds at the same time: one was supplemented with sucrose and the other one with a special sweetener combination (Cuxarom Combi Sweet). Both feeds were equal regarding the level of sweetness. The performance level in this trial was relatively high in the two groups. In group 1, with an initial body weight of 8.1 kg and 24.4 kg at the end, the daily feed intake was 643 g/d and the daily gain 388 g. In group 2 (live weight

6.3 kg - 18.4 kg), the daily feed intake was 474 g/d and the daily gain 288 g/d. The trial period was 42 days.

Figure 5: Preference trial with piglets (live weight 7 - 25 kg) at the University of Leuven (Belgium, 1994)



This trial shows that feedstuffs with a suitable non-calorie sweetener combination are consumed to the same extent as those supplemented with sugar. With regard to acceptance, there are no reasons which argue against the use of artificial sweeteners.

The total market for non-calorie sweeteners is very large and the following criteria must be fulfilled for their routine use in feedstuffs:

- Registration according to feed law
- Stability (heat, pH)
- Cost effectiveness.

There are only a limited number of products from the human sector which can be used in animal nutrition (Table 2).

Table 2: Non-calorie sweeteners used in animal nutrition

Name	Origin	Intensity of sweetness compared with sugar
Glycyrrhicine	extract of liquorice root	50 - 100
Saccharine	synthetic	300 - 400
NHDC*	hydrated components of citrus fruits	2000 - 4500
Thaumatin	protein of the katemfe plant	200

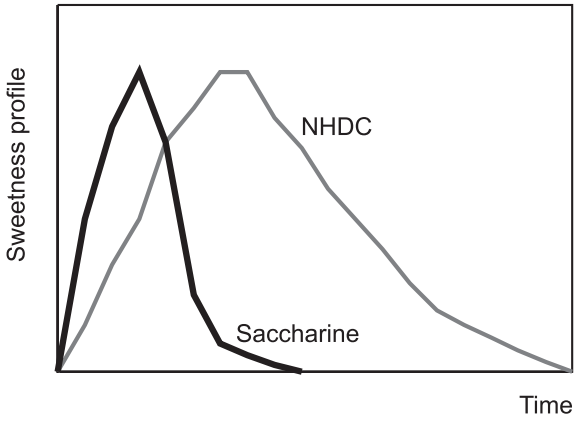
*NHDC = neohesperidin dihydrochalcon

The best known and most used sweetener is **saccharine**. The main advantage of this synthetic sweetener is its favourable price while its disadvantage is the metallic aftertaste, which occurs when high doses are used.

A similar disadvantage applies to **glycyrrhicine** which has a liquorice-like aftertaste which is not surprising as liquorice originates from glycyrrhicine. Feed intake can be negatively influenced if the supplementation levels are too high.

The metallic taste of saccharine can be masked by the addition of **NHDC**. Another advantage of the synthetic substance NHDC is that, in mixtures with saccharine (depending on the ratio of the two substances) synergy effects may occur which can increase the original additive sweetening power by up to 80%. The sweetness profiles of these two sweeteners vary in an organoleptic way (see Figure 6).

Figure 6: The sweetness profile of saccharine and NHDC



Saccharine causes a rapid increase of 'sweetness' on the tongue. However, this effect decreases relatively soon whereas the sweetness of NHDC develops more slowly but its effect remains for longer.

Besides the very good characteristics of combination products including NHDC, its price is a decisive factor for not using NHDC as a single substance.

What about **thaumatin**? Based on the aforementioned criteria, this sweetener would initially seem to be extremely suitable for use in feedstuffs. However, the trials of Hellekant (1980) and Hard Af Segerstad and Hellekant (1989a, 1989b) showed that thaumatin does not cause any nerve response in the brain in relevant species such as pigs and calves. In these trials single substances such as salt (NaCl), glucose, saccharine, etc. were administered and then the response for example of the chorda tympani-nerve in the brain was measured. From the peak height of a reaction a conclusion cannot be drawn as to whether a substance can be regarded as positive or negative, it can only be determined whether a substance can be perceived or not. There was no reaction with thaumatin and therefore it is deduced that thaumatin is not perceived by relevant livestock animals (pigs and calves). It still remains to be seen what practical use can be made of thaumatin in feedstuffs. Thaumatin (as well as NHDC) can increase the intensity of flavours, particularly the fruity types.

How do sweeteners work?

Theoretically an increased calorie intake can be caused by a drop of blood glucose level as a result of a cephalically caused insulin reflex. The trials of Teff et al. (1995) and Abdallah et al. (1997) concerning possible changes in plasma insulin and plasma glucose levels by saccharine and aspartam showed no effect. Also Härtel et al.

(1993) found no effects of different non-calorie sweeteners on the insulin and glucose level.
In a systematically structured trial about saccharine Tordoff and Friedman (1989a-d) tried to determine the effects which led to an increased feed intake. The hypomotic potential of saccharine plays a minor role, while insulin is slightly influenced by the administration of saccharine. However, this is not responsible for increased feed intake. There are indications that the liver is involved.

Moreover, Rogers et al. (1988) found out that the intake of a solution containing saccharine compared with pure water or with a glucose-sweetened solution changes the food selection in humans. The preference for fatty, carbohydrate-rich food and the quantity consumed increased with saccharine.

Most of the trials (Rogers et al. (1989), Rogers et al. (1990), Canty and Chan (1991), Tordoff and Reed (1991)) showed that a sweet taste has a stimulating effect and is therefore decisive in an increased feeling of hunger.

How are sweeteners regulated in the feed law?

In the EC sweeteners are classified as aromatic and appetizing substances in chapter III of directive 70/524/EEC. All natural and nature-identical substances within the field of aroma and flavour substances can be used without any restriction and glycyrrhicine and thaumatin come under this regulation. Saccharine and NHDC belong to the synthetic group of substances and their use is therefore restricted.

Table 3: Regulation of synthetic sweeteners via the feed law

Name	Species	Maximum age of animal	Max. dosage (g/t final feed)
Saccharine	piglet	4 months	150
Na-saccharine	piglet	4 months	150
Ca-saccharine	piglet	4 months	150
NHDC	piglet	4 months	35
	dog		35
	calf		30
	sheep		30

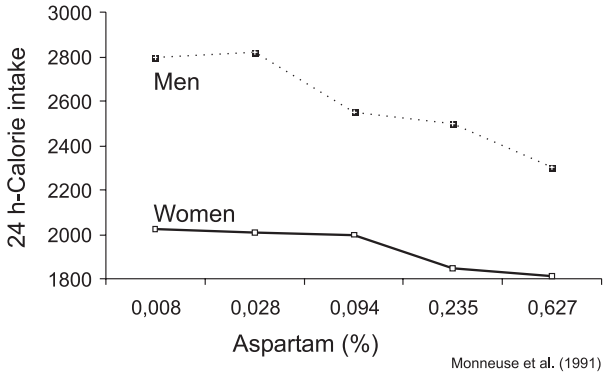
The restrictions for saccharine in some species have to do with ommisions in the original registration and not with any reservations concerning health. Currently FEFANA is trying to register saccharine for use in calves.

What is the optimum level for sweeteners?

The level generally depends on the sweetener content in the commercial product and the proportion of carrier but in principle one should follow the producer's recommendations for use. Most of the marketed products have a range of 50 - 150 g/t feed. The feed law regulations concerning restriction of use in relation to registered combinations must be taken into account.

It should be remembered, however, that sweeteners are not substances that necessarily help a lot when administered in large quantities. A level which is too high may lead to refusal of feed. There are indications that the total calorie intake may be increased by reducing the level.

Figure 7: Calorie intake depending on the aspartam concentration in humans



Monneuse et al. (1991)

After the intake of yoghurt, which was sweetened with different levels of aspartam, Monneuse et al. (1991) showed that, in women as well as in men, the total calorie intake over a period of 24 hours was higher in the case of lower levels.

Conclusions

Although the influence of sweeteners on the increase in feed intake is not clear, their use in young animals is common. In medicinal feedstuffs the masking of bitterness is the main objective. The sweeteners selected to achieve optimum results need to be tested and an appropriate combination of new sweetener sources may be succesful in this case.

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