Isoglucose and sucrose (household sugar) can be assessed similarly in terms of the potential to damage health

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Isoglucose, also known as high-fructose corn syrup (HFCS), is used in the food industry as a substance to sweeten processed foods such as soft drinks, creams, cakes, confectionery, yogurts etc. The Federal Institute for Risk Assessment (BfR) has been asked by various parties whether these sweeteners, which contain a high proportion of the free monosaccharide (simple sugar) fructose, pose a particular risk to health as compared to other sweeteners such as sucrose (household sugar, beet sugar, cane sugar).

Isoglucose contains variable amounts of the simple sugars glucose and fructose in unconnected forms. This means that the two sugars are present as monosaccharides. In comparison, sucrose also contains glucose and fructose, but in this case the sugars are present in a connected form in a ratio of exactly one-to-one as a disaccharide. In the variants of isoglucose that are frequently used at the present time, the two monomers glucose and fructose are present in roughly comparable amounts; with respect to the fructose level, the difference as compared to sucrose is relatively low. In this case, it can be expected that there are no differences or no significant differences between isoglucose and sucrose from a nutritional perspective and that their health assessments are thus also similar. However, the prerequisite for this is that the intake level of added sugars does not increase significantly overall. If isoglucose variants with a significantly higher proportion of fructose are to be added to processed foods, it must be pointed out that the consumption of high amounts of fructose can have adverse effects on the metabolism. In concrete terms, it can contribute to metabolic syndrome as well as lipometabolic disorders, fatty liver, obesity and diabetes mellitus type 2. In addition, there are known intolerances to fructose.

It is considered scientifically proven that regular excessive consumption of sugar added to foods (including added fructose) is detrimental to health and should be reduced. Consumers should ensure that their daily intake of added sugar does not exceed 10 % of their total daily intake of energy from food, including beverages. The consumption of added sugar should be even lower if possible. Therefore, an adult with energy requirements of approximately 2000 kilocalories should not consume more than 6 - 12 teaspoons of added sugar per day from all food, including beverages.

Isoglucose as an additive to sweeten processed foods

Isoglucose, also known as high-fructose corn syrup (HFCS) when derived from corn, is used in the food processing industry as a sweetener. Depending on the water content, isoglucose occurs in a liquid/viscous form, usually as a syrup. During the manufacturing process, corn starch, a polysaccharide (made of connected glucose units of assembled multiple sugars) is enzymatically hydrolysed into the simple sugar glucose (dextrose, monosaccharide) and finally converted into fructose (fruit sugar, monosaccharide) in variable amounts through isomerisation with mediation of specific enzymes. The two monosaccharides glucose and fructose are thus present in unconnected free form - unlike in the disaccharide sucrose (household sugar, beet sugar, cane sugar). Depending on availability, source materials other than corn, such as wheat starch, are possible for this process, which is referred to as saccharification. Because fructose is sweeter than glucose, the sweetening power of the glucose/fructose mixture increases with a higher level of fructose. With a proportion of fructose of over 42%, the mixture tastes sweeter than conventional sugar from sugar beets or sugar

cane (sucrose, household sugar, disaccharide, compound made of one glucose molecule and one fructose molecule).

Difference between isoglucose and household sugar (sucrose)

While isoglucose ("high-fructose corn syrup" - HFCS) is a mixture of the two simple sugars glucose (dextrose) and fructose (fruit sugar) in free form in variable ratios to one another together with different water content, sucrose as a disaccharide (household sugar from sugar beets or sugar cane) contains the two connected components glucose and fructose in a one-to-one ratio in crystalline form. In addition to the form connected with glucose found in sucrose, fructose also occurs naturally in foods in free form, for example in fruit, honey and various vegetables. It can also be an element of oligosaccharides and polysaccharides (Hauner, 2009; FDA, 2014).

Isoglucose in compound foods

The syrup known as “high-fructose corn syrup” (HFCS) with a fructose content of approximately 55% (HFCS-55) has been widely used in the USA since the 1970s and is used, for example, in soft drinks instead of conventional sugar (FDA, 2014; Malik, Hu, 2015). Mixtures with a higher proportion of fructose are also possible and in use. As compared to sucrose (household sugar), the syrup is cheaper to manufacture, is sweeter and has various technological properties that are of advantage to manufacturers. A non-crystalline consistency of the added sweetener can be beneficial in technological terms, in particular in sweetened drinks such as soft drinks, but also in other ready-made foods such as creams, cakes, sauces and yogurts. It is also useful as a humectant in confectionery such as marzipan (Hauner, 2009; EUFIC, 2014; White, 2008; White et al., 2015). Depending on whether there is a higher glucose or fructose content in the syrup, this food ingredient is listed as glucose-fructose syrup or fructose-glucose syrup (in this context, see: Art. 2 Para. 4 of the regulation on certain sugars intended for human consumption, German Sugar Types Regulation (ZuckArtV) 2003, http://www.gesetze-im-internet.de/bundesrecht/zuckartv_2003/gesamt.pdf).

Intake of isoglucose into the body

Sucrose (a disaccharide consisting of one unit each of glucose and fructose, also known as household sugar, beet sugar or cane sugar) is enzymatically hydrolysed into the monosaccharides glucose and fructose after intake in the human body. Glucose causes a release of insulin into the blood ("insulin response"). Insulin increases the intake of glucose into certain body cells. Glucose primarily serves to provide energy in the cells and is converted into glycogen by the liver for storage. Glucose also enters fat synthesis (lipogenesis) via metabolic byways. The release of insulin with the subsequent metabolic regulations makes a significant contribution to creating a feeling of fullness. In contrast, fructose causes a significantly lower "insulin response" and - with primary further processing in the liver - also becomes a substrate in energy metabolism to an extent but enters fat synthesis (lipogenesis) to a higher degree as compared to glucose. In addition, with a high intake, fructose can increase the synthesis of uric acid and the triglyceride blood level (Malik, Hu, 2015; Stanhope 2015; Tappy et al., 2010; Tappy, Lê, 2015; Basaranoglu et al., 2013; BfR, 2009).

The following correlation was confirmed by the European Commission as an authorised health claim: “Consumption of foods containing fructose leads to a lower blood glucose rise compared to foods containing sucrose or glucose” (Commission Regulation (EU) 536/2013; VZSH, 2014).

Health assessment of isoglucose as compared to sucrose

In the context of the different metabolic pathways of glucose and fructose, scientific studies have provided indications that the consumption of high levels of fructose in one's diet can have significant adverse effects on the metabolism, particularly with respect to a possible special contribution to metabolic syndrome and hyperlipidaemia, fatty liver, obesity and diabetes mellitus type 2 (DIfE, 2005; Tappy et al., 2010; Akram, Hamid, 2013; Malik, Hu, 2015; Stanhope et al., 2011; Stanhope et al., 2015; Basaranoglu et al., 2013; Van Buul et al., 2014; Bray, 2013).

In addition, there are certain known intolerances to fructose, such as gastrointestinal fructose malabsorption, whereby individually variable levels of fructose cannot be tolerated (anymore), and hereditary fructose intolerance, which is a metabolic disorder due to a lack of the enzyme fructose-1-phosphatealdolase (aldolase B deficiency) (Raithel et al., 2013).

In the variants of isoglucose that are frequently used at the present time, the two monomers glucose and fructose are present in roughly comparable amounts; with respect to the fructose level, the difference as compared to sucrose is relatively low. In this case, it can be expected that there are no differences or no significant differences between isoglucose and sucrose from a nutritional perspective (MRI, 2017) and that the health assessments of these two substances for sweetening foods are thus also similar. However, the prerequisite for this is that the intake level of added sugars does not increase significantly overall.

If isoglucose variants with a significantly higher proportion of fructose are to be added to processed foods and consumed regularly in large amounts, the listed possible adverse effects of this sugar on the metabolism must be pointed out. The higher proportions of fructose in isoglucose added to foods as compared to sucrose from which there is a particularly significant contribution to the development of obesity and associated accompanying and secondary diseases are currently a subject of controversial discussion in some of the literature, require further study and cannot be conclusively defined at the present time (Hauner, 2009; DGE, 2007; FDA, 2014; Chung et al., 2014; Kelishadi et al., 2014; Raatz et al., 2015; Tappy, Lê, 2015).

In relation to the European Union, experts expect a considerable increase in the import and production of isoglucose over the next few years (ENVI, 2017). Any increase in the use of added sugar in the form of isoglucose, which is generally cheaper, with the result that processed foods and food products in general become sweeter and the already high consumption of sugar as well as calorie intake continue to rise overall, must be seen in a critical light from a nutritional point of view with respect to a possible contribution to the development of chronic illnesses and should be avoided (DiabetesDE/DAG, 2017).

Recommendation to consumers

Existing scientific data clearly indicates that the excessive consumption of sugar added to foods (including added fructose) is undesirable in general, without any special emphasis on particular sugars, and should be avoided or reduced (Zeratsky, 2015; American Heart Association, 2014; Fitch, Keim, 2012; Malik, Hu, 2015; Tappy et al., 2010; Van Buul et al., 2014).

In this context, reference can be made to the current "strong recommendation" of the World Health Organisation (WHO) that the intake of free sugar in adults and children should amount to less than 10 % of the total energy intake per day for health reasons. Free sugar refers here to all monosaccharides and disaccharides added to foods, including beverages,

by manufacturers, chefs/cooks or consumers, as well as the sugar naturally contained in honey, syrups, fruit juices and fruit juice concentrates. A further reduction of the consumption of free sugar to 5 % of the total energy intake ("conditional recommendation") is proposed by the WHO under certain conditions. In mathematical terms, this would correspond to a maximum of 50 g or 25 g of free sugar (about 12 or 6 teaspoons of sugar) in adults with an estimated energy intake from food and drinks of approximately 2,000 kilocalories per day (WHO, 2015; DGE, 2014; DGE, 2015). As far back as in 2005, recommendations were published advising that the intake of sugar added to food and drinks should not exceed 10 % of the overall energy intake from food for the general population. In people who wish to or need to lose weight, a further restriction of the intake of free sugar was deemed useful (Toeller et al., 2005).

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