SLOWLY DIGESTIBLE STARCH

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Nutrition Science Corner

Gaining nutrition through slow-released carbohydrates

Healthcare experts and professionals around the globe strongly advocate the importance and necessity of incorporating high-quality carbohydrates in the daily diet. The choice of suitable cereal foods as a source of carbohydrates, fibres and micronutrients is one of several long established factors that help prevent chronic diseases (*Lorenz and Lee, 1977; Mann et al., 2007*).

Preserving goodness of carbohydrates in mondelēz international's breakfast food offering

Mondelēz International has conducted over 15 years of research into carbohydrate quality, starch digestibility, slow-release carbohydrates and glycemic response to develop an innovative range of foods specially designed for breakfast and launched in more than 30 countries around the globe to date.

- This range of breakfast biscuits with whole grains has been developed with special care taken in the selection of ingredients while mastering the preservation of the intrinsic properties of starch through a specially controlled process and while continuously improving its nutrition profile.

- Thanks to their unique nutritional and metabolic benefits, when eaten as part of a breakfast, the biscuits from this specific range provide carbohydrates which are absorbed and released regularly and continuously throughout the morning, and induce a moderate postprandial glycemic response without disproportional increase of the insulinemic response.

Not all starches are the same

The relation between the quality of the diet – especially carbohydrate intake – and metabolic health is becoming increasingly recognized as a critical way to prevent non-communicable diseases. Carbohydrates irrefutably play a role as they are the main dietary components modulating postprandial glycaemia in human nutrition. The topics of glycemic response and the role of slow-release carbohydrates are being investigated for this purpose. The quality of available starch may be an additional concern to the current discrimination between sugars and starch in the public health domain. Numerous studies have shown that not all starches are the same. The metabolic impact of starch strongly depends on its intrinsic properties, such as chemical structure, hydration, and on its processing. They can widely impact starch digestibility in the human digestive system. Metabolic fate varies according to the difference in digestibility profile (either slow or rapid). The potential health benefits of the fraction of starch with slow but full digestibility have been recently acknowledged in regards to the moderation of glycemic response.

The present article highlights current knowledge on available starch structure causing a slow digestibility, which then leads to a slow rate of appearance of carbohydrates in the bloodstream and therefore to a moderate postprandial glycemic response. Moreover, it discusses their health implications

Understanding slowly digestible starch (sds)

Starch is a semi-crystalline polymer derived from grains (e.g. wheat, maize, rice, barley and spelt), tubers (e.g. potatoes and manioc), and legumes (e.g. peas, lentils, kidney beans and mung beans). The structure of this polysaccharide forms spherical granules in plant tissues, whose composition, shape, and size depend on their plant source (see Figure 1).

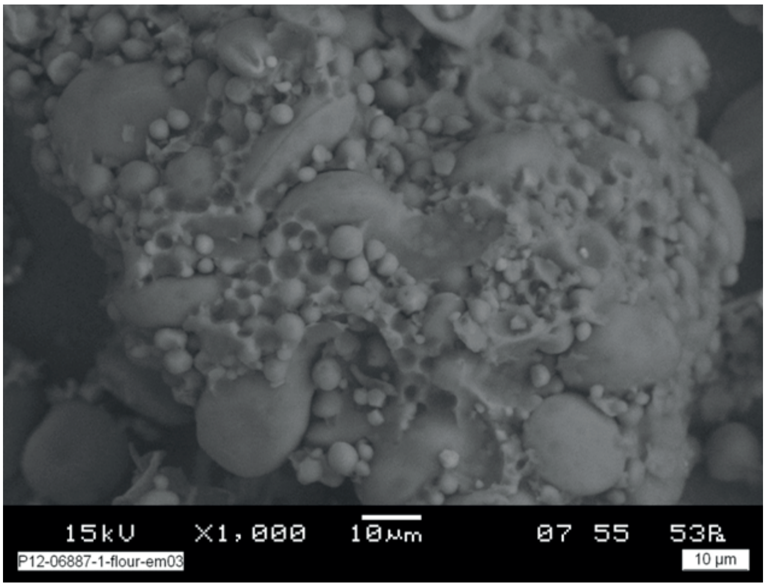

Figure 1: Starch granules embedded in the protein network in wheat flour – electron microscopy
Source: *Group RSSL, 2012*

In its native state, starch is protected by its granule structure and is therefore slowly degraded by digestive enzymes (amylases). The rate and extent of starch digestibility are influenced by:

- its botanical origin and the structure of the starch granule,
- all mechanical processes – for example during flour-milling – which may cause fissures on the granules and increase granules vulnerability to attacking enzymes (*Miao et al., 2013*),
- food processing, which influences intrinsic characteristics of starch. For example, heating in the presence of water induces starch gelatinization, which leads to dramatic changes of starch structure with the formation of swollen granules and amylose molecules released outside the granules.

Indeed, the degree of starch gelatinization is correlated with the rate of starch digestibility (*Englyst et al., 2003*). Thus, controlling food processing by limiting the extent of starch gelatinization helps to prevent the transformation of the native Slowly Digestible Starch (SDS) into Rapidly Digestible Starch (RDS) (*Englyst et al., 2003; Zhang and Hamaker, 2009*).

When it comes to controlling those aforesaid factors, measuring the rate and extent of starch digestibility in processed foods is important. Thus, starch digestibility can be assessed in vitro by quantifying nutritionally important starch fractions according to the method developed by Englyst and coworkers (see Figure 2). This method has been described in literature and validated by several clinical studies. It mimics the human enzymatic digestion after ingestion in order to determine the food sugar and starch fractions (*Englyst et al., 1992; Englyst et al., 1996; Englyst et al., 1999; Englyst et al., 2003*). Englyst research works have shown a clear relationship between SDS content and the gelatinization rate of starch in cereal foods. A higher SDS content indicates a lower starch gelatinization index in cereal products (*Englyst et al., 2003*).

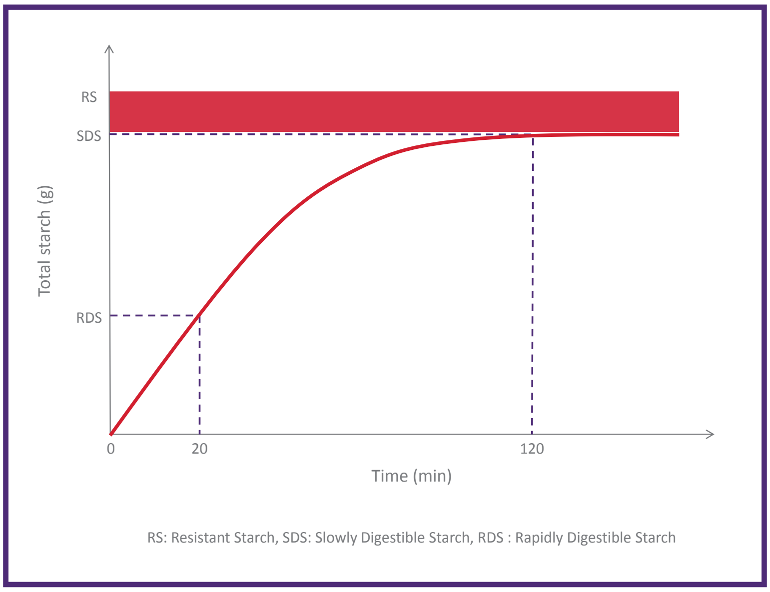

Figure 2: Rate of starch digestion as a function of time
Source: *Mondelēz International*

What is the difference between sds, rds and resistant starch?

Starches can be divided into three groups according to their rate of enzymatic digestion to glucose in the small intestine: Rapidly Digestible Starch (RDS), Slowly Digestible Starch (SDS) and Resistant Starch (RS). The latter resists digestion in the small intestine but tends to make its way to the colon where intestinal bacteria ferment it. Therefore, only RDS and SDS are considered to be available starch (see Figure 3).

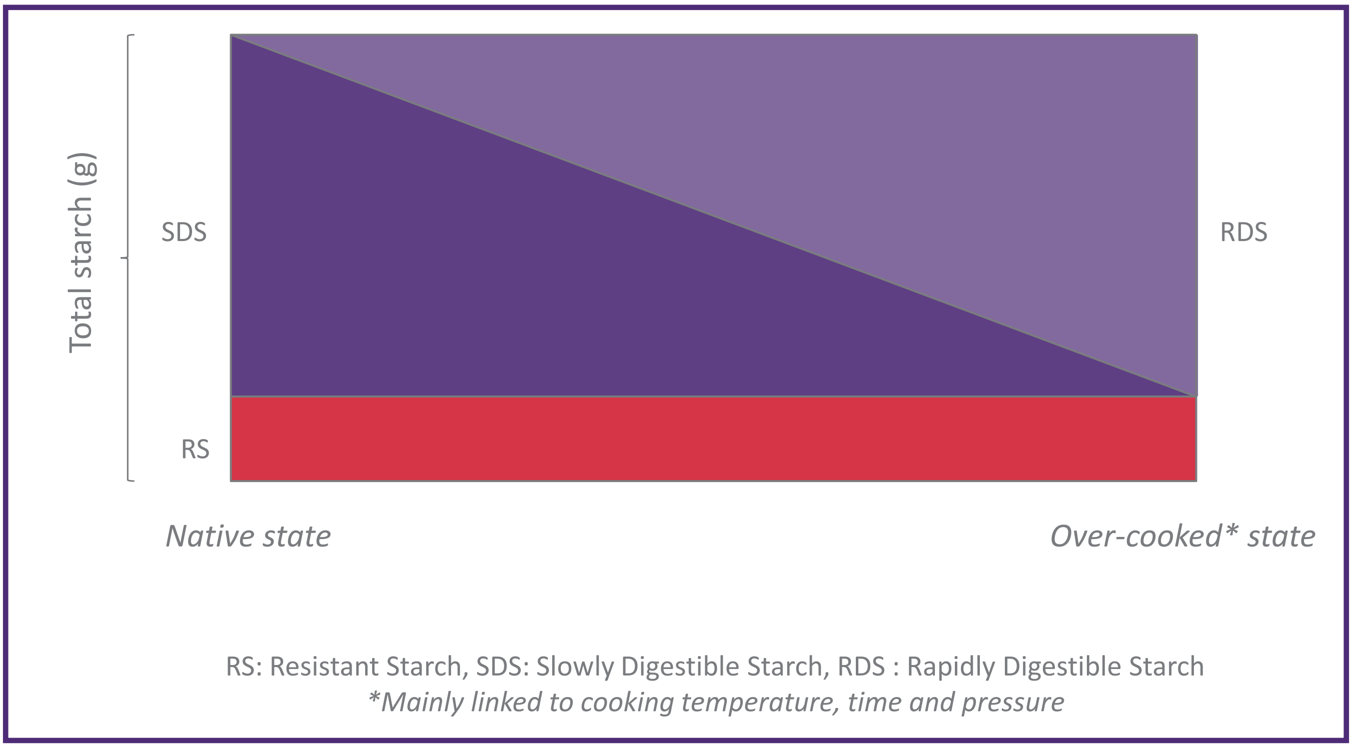

Figure 3: SDS/RDS ratio in starchy foods according to the process extent
Source: *Mondelēz International*

Available starch content (sum of SDS and RDS) is not usually labeled on staple foods, neither is RS. This leads to the question of how you can tell the difference between foods high in SDS and the others. There is no present labeling regulation for the SDS content in starchy foods and it cannot be determined from the nutrition table or ingredient line within the finished product. SDS is mixed with RDS and sugars on the carbohydrates line, and it's not because of a high content of unrefined grains (in whole grain cereals for example) that SDS has been preserved during the transformation process.

As just seen in the first paragraph, processing grains may induce starch gelatinization and consequently decrease the native ratio of SDS/RDS, while increasing RDS at the expense of SDS in the processed grains. For instance, heating in the presence of water induces starch gelatinization and therefore may decrease the SDS/RDS ratio in starchy foods.

Steamed plain rice

Over-cooked rice

Which foods contain sds?

SDS is present in traditional staple foods such as cereals, legumes, roots and tubers, as well as in the ingredients and processed foods made from them (*Englyst et al., 1996; Zhang and Hamaker, 2009*).

Table 1 shows a wide range of SDS content for foods described in the literature: from 0 g/100 g for puffed wheat to 12 g/100 g for some cooked pastas and 23 g/100 g for some specific plain biscuits (*Englyst et al., 1996; Englyst et al., 1999; Englyst et al., 2003; Garsetti et al., 2005*). Foods that may contain a high level of SDS include some al dente pastas, parboiled rice, barley porridge and specific crackers and biscuits, whereas puffed cereals and some white breads contain low levels of SDS.

Product category	Cereals	Pasta	Rice	Legumes	Other root, tuber and derivates	Bakery products and crackers	Breakfast cereals	Biscuits
SDS* content (g/100g)	1.4 - 12.0	9.0 - 12.0	5.6 - 10.0	0.8 - 9.8	0.4 - 2.8	0.7 - 9.6	0.5 - 13.6	3.8 - 22.9
References	Englyst et al. 1996, 1999	Englyst et al. 1996, 1999	Englyst et al. 1996	Englyst et al. 1996	Englyst et al. 1996	Englyst et al. 1996, 1999, 2003	Englyst et al. 1996, 1999, 2003	Englyst et al. 1996, 2003; Garsetti et al. 2005

*SDS: Slowly Digestible Starch

Table 1: SDS values (g/100 g) of a range of commercially available category of products, analyzed as consumed
Source: see within the table

Moreover, due to the major influence of the manufacturing process on starch digestibility in the finished product, the range of SDS content can be wide even within a single food category. For example in biscuit-making processes, even if the water content used during the process is low (compared to bread-making), the moisture content must be controlled to decrease the extent of starch gelatinization and preserve the content of SDS. Moreover, with the same purpose of better preserving the integrity of starch granules, biscuit-making processes are less traumatic in terms of mechanical constraints than extrusion cooking can be (*Englyst et al., 2003*). The hydro-thermic parameters used to process starchy foods (temperature, moisture content, cooking time and pressure) seriously affect the degree of starch gelatinization (Table 2).

Manufacturing processes	Type of foods	Process parameters				SDS content* * (%)
		Dough core temperature (°C)	Dough hydration level (%)	Cooking time (minutes)	Pressure (bar)	
Processes for biscuits and bread products	Biscuits	100-130	**15-30**	**5-15**	1	Moderate to high (10% to 30%)
	Bakery products Bakery substitutes	100-120	**40**	**20**	1	Low (around 4%)
	Crackers	100-130	**25-35**	2-3	1	Moderate (around 10%)
Cooking-extrusion	Extruded cereals	120-180	**14-30**	5	**50-200**	Low (around 2%)

*The critical parameters are in bold and red
* *SDS: slowly digestible starch expressed as a percentage of the total quantity of available carbohydrates

Table 2: Influence of manufacturing processes of cereal foods on SDS content
Source: *Bornet, 1993; Englyst et al., 2003; Lang, 2004*

Health benefits from consuming starchy foods with high sds content

In 2011, considering available evidence, the European Food Safety Authority (EFSA) validated a cause and effect relationship between the consumption of SDS, compared to the consumption of RDS, in cereal foods and reduced post-prandial glycemic responses (as long as postprandial insulinemic responses are not disproportionally increased). Moreover, EFSA established what should be considered to be a high content of SDS from a public health perspective: foods have a high SDS content if they contain at least 55% of their carbohydrates as available starch, of which at least 40% is SDS. In 2013, this efficacy of high SDS foods in reducing the postprandial glycemic response in comparison to foods with low SDS content was acknowledged by the Colombian national institute for food and drug vigilance (Instituto Nacional de Vigilancia de Medicamentos y Alimentos – INVIMA) as well.

The correlation between the SDS content and moderate postprandial glycemic responses (without exacerbated insulinemic responses) has been established via clinical studies presented in the scientific dossier supporting the European health claim that compares the physiological effects of various starchy foods (*Englyst et al., 2003; Nazare et al., 2010; Vinoy et al., 2013; Péronnet et al., 2015; Vinoy et al., 2015*). Moreover, the moderate postprandial glycemic response is best explained by SDS content (*Garsetti et al., 2005; Meynier et al., 2015*).

In order to complete the confirmed moderate postprandial changes on circulating plasma glucose concentration, the absorption rate of glucose derived from dietary carbohydrate was observed in two initial clinical studies. These were performed in order to gain a better understanding of the metabolic fate of glucose, thanks to a special tracking method by stable isotope labeling. Actually, SDS presents a specific and interesting mechanism of action. Indeed, the effect observed in foods with a high SDS content on glycemia is actually induced by a lower and more stable rate of appearance of exogenous glucose in the bloodstream than for foods low in SDS (*Nazare et al., 2010; Vinoy et al., 2013*).The impact of high SDS content on a lower and more stable rate of appearance of carbohydrates was recently confirmed in a third isotopic clinical study, as well as decreased postprandial glycemic and insulin responses after a high SDS meal compared to a low SDS meal (*Péronnet et al., 2015*).

Wishing to know even more?

We would like to invite you to the upcoming symposium: "Slow-release carbohydrates: Growing evidence on metabolic responses and public health interest" at the 12th European Nutrition Conference, to be held in Berlin, Germany on October 21, 2015. You will hear from internationally recognized experts about this new acknowledged science on SDS and slow-release carbohydrates, but also about emerging evidence on the importance of reducing glycemic response.

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