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Correspondence

Reply to Prosky and Mugford
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Dear Sirs,

The points made by Prosky and Mugford, which relate to the performance of resistant starch in a dietary fiber assay, are quite well taken. The issues revolve around: (a) the open questions regarding the physiological functions of dietary fiber, containing a portion of resistant starch; and (b) how the physical chemistry of resistant starch plays a role in its quantification in a fiber assay.

1. There is no "formal" definition for dietary fiber, and the term "colloquial" probably should have been used. Trowell (1972) is probably most often quoted on this subject, where he has stated that "Dietary fiber has been defined as the skeletal remains of plant cells." Starch, a storage carbohydrate, would not be considered a structural component. In the development of resistant starch-based commercial ingredients, I have heard objections from within the food industry asserting that fiber is non-starch in nature. There seems to be a prevalent, and perhaps erroneous, opinion that dietary fiber is composed of non-starch polysaccharides. Additionally, this opinion is supported by definitions given in general nutrition texts, such as, "In addition to lignin and cellulose, dietary fiber also includes hemicellulose, gums, pectin and other carbohydrates not normally digested by man," (Krause & Mahan, 1984). Clearly, most starch is "normally digested by man." Hence, the "complication" cited in the review is that the colloquial definition of dietary fiber is in conflict with the fact that the official AOAC methods quantify at least a portion of the resistant starch as dietary fiber. Therefore, the task ahead of us is to elucidate the physiological function of resistant starch, which would support its inclusion in the dietary fiber assay. Further, professionals within the food industry must be educated on the functional benefits of all types of dietary fiber, including resistant starch.

2. Englyst, Trowell, Southgate and Cummings (1987) present an argument to define dietary fiber as non-starch polysaccharides. In error, my review attributed this statement to Asp, Furda, Schweizer and Prosky (1988). If the physiological benefit of resistant starch is similar to that of traditional fibers, why not retain it within the current assay as defined by the AOAC methods?

3. The portion of resistant starch quantified by the official AOAC dietary fiber method would be expected to pass the small intestine, since the assay uses a thermophilic amylase at 95–100°C. The compact structures, forming resistant starch, "melt" at elevated temperature. Consequently, the forms resistant to enzymatic hydrolysis at the elevated assay temperature would most certainly be resistant to human digestive enzymes at physiological temperature, 37°C. The assay's hydrolysis step is 15 min, however, normal digestion occurs over many hours. Over the long time scale of digestion, especially after transiting the small intestine, resistant starch can be broken down, and has been found to ferment in the large intestine. Much of the literature supporting this is presented in the review.

4. In order to understand how resistant starch is quantified by any assay, it is necessary to first understand that resistant starch is not a single chemical entity, nor is there a formal definition for it. Resistance to enzymatic hydrolysis is derived from the compact structures attained by starch chains, which inhibit or exclude enzyme access. These structures are highly affected by thermal history and degree of starch hydration. The different structures can be quantified by DSC, and exhibit different peak widths and peak temperatures. Consequently, it seems that even the environment of the assay becomes important in quantification. In our laboratory, we have used both AOAC methods (985.29 and 991.43) to measure the resistant starch levels in pure starch products. Table 1 compares the values obtained from raw amylomaize VII starch (Hylon® VII, National Starch and Chemical Company, Bridgewater, NJ) with two RS_3 products made in our laboratory by differing hydro-thermal processes. In each case, method 991.43 gave lower TDF (resistant starch) values. The exact mechanism, by which AOAC method 985.29 and 991.43 differ, when measuring pure starch systems, is unclear to me. The general cause of the effect is due to the breadth and complexity of the associated starch structures, which form the resistant starch. With respect to the non-starch components of dietary fiber, I would expect that the two methods give the same values. Other assays found in the resistant starch literature, utilizing lower temperatures, give higher estimates of resistant starch. This is clearly a reflection of the thermal stability of the resistant starch structures.

5. The official AOAC/AACC methods have done a great service in standardizing what is referred to as "dietary fiber." Prosky and Mugford rightfully point out that this is the worldwide standard. Resistant starch has no such standardizing definition, and therefore relies on existing methodology, like the AOAC methods, for quantification. As noted above (1), since resistant starch is not a specific chemical entity, its quantification becomes method dependent.

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Table 1
Percent resistant starch as measured by AOAC TDF methods

	Method 985.29	Method 991.43
RS_2 (raw amylomaize VII)	28	11
RS_3 (process 1)	37	32
RS_3 (process 2)	32	26

Clearly, the AOAC methods quantify some fraction of resistant starch as dietary fiber. This is appropriate, based on the results of physiological studies reported in the literature, which indicate that resistant starch exhibits many properties expected of dietary fiber. The methods underestimate the amount of starch passing the small intestine, however (see, for example, Faisant, Champ, Colonna & Buléon, 1993), indicating that they are a conservative estimator. As Prosky and Mugford point out, it is necessary for research to continue with the goal of standardizing definitions for resistant starch and to elucidate the nutritional impact.

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