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## Survey of commercially available chocolate- and cocoa-containing products in the United States. 2. Comparison of flavan-3-ol content with nonfat cocoa solids, total polyphenols, and percent cacao

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### Abstract

A survey of a broad range of chocolate- and cocoa-containing products marketed in the United States was conducted to provide a more detailed analysis of flavan-3-ol monomers, oligomers, and polymers, which can be grouped into a class of compounds called procyanidins. Samples consisted of the three or four top-selling products within the following six categories: natural cocoa powder, unsweetened baking chocolate, dark chocolate, semisweet baking chips, milk chocolate, and chocolate syrup. Composite samples were characterized for percent fat (% fat), percent nonfat cocoa solids (% NFCS), antioxidant level by ORAC, total polyphenols, epicatechin, catechin, total monomers, and flavan-3-ol oligomers and polymers (procyanidins). On a gram weight basis epicatechin and catechin content of the products follow in decreasing order: cocoa powder > baking chocolate > dark chocolate = baking chips > milk chocolate > chocolate syrup. Analysis of the monomer and oligomer profiles within product categories shows there are two types of profiles: (1) products that have high monomers with decreasing levels of oligomers and (2) products in which the level of dimers is equal to or greater than the monomers. Results show a strong correlation ( $R(2) = 0.834$ ) of epicatechin to the level of % NFCS and also very good correlations for  $N = 2-5$  oligomers to % NFCS. A weaker correlation was observed for catechin to % NFCS ( $R(2) = 0.680$ ). Other analyses show a similar high degree of correlation with epicatechin and  $N = 2-5$  oligomers to total polyphenols, with catechin being less well correlated to total polyphenols. A lesser but still good correlation exists between the calculated percent cacao (calcd % cacao) content, a proxy for percent cacao, and these same flavanol measures, with catechin again showing a lesser degree of correlation to calcd % cacao. Principal component analysis (PCA) shows that the products group discretely into five classes: (1) cocoa powder, (2) baking chocolate, (3) dark chocolate and semisweet chips, (4) milk chocolates, and (5) syrup. PCA also shows that most factors group closely together including the antioxidant activity, total polyphenols, and the flavan-3-ol measures with the exception of catechin and % fat in the product, which group separately. Because catechin distribution appears to be different from the other flavan-3-ol measures, an analysis of the epicatechin to catechin ratio was done, indicating there is a >5-fold variation in this measure across the products studied. The cocoa-containing products tested range from cocoa powder with 227.34 +/- 17.23 mg of procyanidins per serving to 25.75 +/- 9.91 mg of procyanidins per serving for chocolate syrup. These results are discussed with respect to other studies on commercial products, the bioavailability of the flavanols, and the possible role of processing on the amount of catechin in products.

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