

The Density of Chocolate

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During this study the density of a variety of brown chocolate bars were measured, i.e. those described as 'milk', 'plain' or 'dark' chocolate. The cocoa solids content of the chocolates selected covered a wide range of those currently on the market, from 20% to 81% cocoa solids.

Method

The density of the chocolate was measured by means of weighing in air and hydrostatic weighing. The hydrostatic weighing was carried out via the top-pan method using water as the fluid displaced.

Calculations

The density of each chocolate was calculated using the equation:

$$\text{Density of chocolate} = \text{Air density} + ((\text{water density} - \text{air density}) \times (\frac{\text{air weight}}{\text{water weight}}))$$

Results

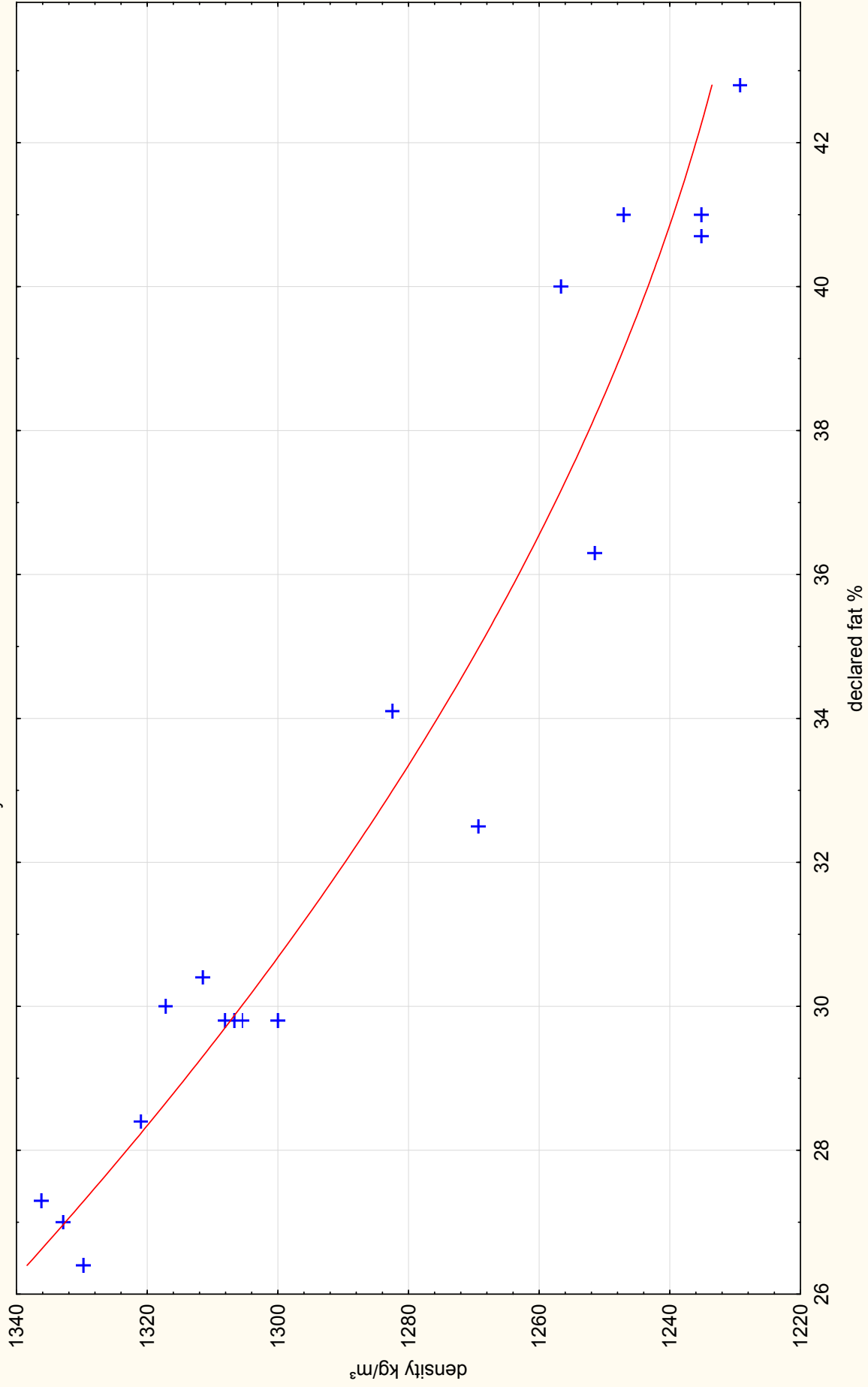
The results of the weighing in air and hydrostatic weighing were recorded including the cocoa solids, fat, carbohydrate and protein content present in each chocolate. The composition of each piece of chocolate and its calculated density are presented in Table 1. The uncertainty of the chocolate density quoted in Table 1 is $\pm 4\text{kg/m}^3$ at $k=2$. Where multiple samples have been taken from one bar of chocolate, the measured densities are consistently within the estimated uncertainty.

Chocolate	H&D Reference #	Density kg/m ³	Cocoa %	Fat %	Carbohydrates %	Protein %
Milk Chocolate	1A	1308	20	30	57	7.5
Milk Chocolate	1B	1306	20	30	57	7.5
Milk Chocolate	1C	1307	20	30	57	7.5
Dark Chocolate	4	1229	81	43	23	10
Milk Chocolate	5	1300	20	30	57	7.5
Milk Chocolate	6	1333	28	27	62	5.8
Milk Chocolate	7	1269	25	33	56	6.6
Milk Chocolate	8	1336	36	27	59	4.7
Dark Chocolate	9	1330	50	26	55	7.4
Dark Chocolate	11	1257	70	40	33	8
Dark Chocolate	12	1235	70	41	31	8
Dark Chocolate	13	1247	74	41	32	9.7
Milk Chocolate	15	1317	20	30	57	7.5
Milk Chocolate	16	1251.5	39	36.3	45.9	9.6
Plain Chocolate	17	1311.5	45	30.4	60	5.8
Plain Chocolate	18	1321	50	28.4	60.8	7.1
Dark Chocolate	19	1235.2	45	40.7	43.6	7.5
Dark Chocolate	20	1282.5	55	34.1	49.7	6.7

Table 1:

Summary of results including chocolate description, H&D Reference number, measured density, declared cocoa content, declared fat content, declared carbohydrates content and declared protein content for each piece of chocolate measured. The uncertainty of the chocolate density quoted is $\pm 4 \text{ kg/m}^3$ at $k=2$.

measured density v declared fat content for brown chocolate



Analysis

It was initially suggested that the density of chocolate would be dependent on the percentage cocoa solids present in the chocolate. However the results in Table 1 do not support this. The results show that there appears to be a stronger correlation between density and declared fat content ($r=0.97$) than between density and declared cocoa solids content ($r=0.62$). The relationship between density and declared fat content is shown in Figure 1.

Conclusions

It can be concluded from the results of this study that the density of chocolate is not dependent on the declared cocoa solids content alone. The density of chocolate is more strongly related to the declared fat content.