Only Protein Differs by Nearly a Third Between the Calorimeter and the Label

— the gap between heat of combustion and conversion factor is **2.4390** per cent for carbohydrate and **4.7619** for fat, yet **29.2035** per cent for protein — the body discards nitrogen as urea with combustible matter still attached — [Paper 567]

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— *From thinking to syncing.* —

Abstract

The calories on a food label are taken to be heat measured by burning.What this paper shows is that they are an estimate, by conversion factors, of what the body can extract, and that the gap from the heat of combustion gathers almost entirely in protein.No new theorem or law is claimed. First, protein's gap is of another size——carbohydrate 2.4390, fat 4.7619 and alcohol 1.4085 per cent, against 29.2035 for protein (Section 2). **Second, the factors can be rebuilt——applying digestibility and the urinary loss gives 3.977, 8.9775, 4.048 and 7.1, rounding to 4, 9, 4 and 7** (Section 3). **Third, and this is the core.Of protein's gap of 1.65 kcal/g, 0.757576 is the urinary loss——the body discards nitrogen as urea, which still contains combustible matter; the calorimeter burns that too** (Section 3). **Fourth, the order of the corrections differs by 0.1, and rounding absorbs it——exactly 1.25×0.08, returning 4 either way** (Section 3). **Fifth, a food's ratio follows its protein share——calorimeter over label is 1.025 for pure carbohydrate, 1.4125 for pure protein and 1.114865 for an ordinary composition** (Section 4). **Sixth, the separator is whether an element burns completely or is discarded——carbon and hydrogen go all the way to carbon dioxide and water, while nitrogen leaves half-burned** (Section 5). **Keywords**: Atwater factors, food energy, protein, heat of combustion, nutrition labelling.

Scope of this paper (scope note): **No new theorem or law is claimed——the Atwater factors and their derivation have been known for over a century.No nutritional advice is given——what to eat is not discussed; only what the label number represents.The values are representative——heats of combustion (4.10, 9.45, 5.65, 7.10 kcal/g) and digestibilities (0.97, 0.95, 0.92) are classic mixed-diet values. Replacing the heats with other representative values (4.15 , 9.40) leaves the rounded integers unchanged, which was checked, but the second decimals themselves are not asserted.The urinary loss is taken from Atwater as measured——its composition, 1.25 kcal per gram of protein, is not examined.Fibre, sugar alcohols and organic acids are excluded——other factors apply to them.National food-composition methods are not treated——some tables use food-specific factors or compute from amino-acid composition; only the general factors are examined here.Individual variation is excluded——gut flora and digestion move the digestibilities from person to person.Relation to earlier papers**: **Paper 338 showed that being a promise and being arbitrary are not the same thing——4, 9 and 4 are exactly that: a promise rounded to integers, yet rebuildable from measured heats and two corrections, and so not arbitrary.Paper 551 showed an index unmoved while defects rose 359-fold, a broad name over narrow content——"calorie" has the same shape, named for heat while counting only what the body extracts.Paper 300 showed that sharing a root is decidable——"the gap gathers in protein" and "a food's ratio follows its composition" share one root, nitrogen.**What is added is **rebuilding all four factors from heats of combustion and two corrections and confirming that each rounds to its integer**, **matching the 0.1 difference between orders of correction to the closed form 1.25×0.08 to 12 digits**, **measuring the urinary share of protein's gap as 0.757576**, **setting out the ratio for six compositions and showing it rises monotonically with protein**, and **placing the separator on whether an element burns completely or is discarded**.

1. Notation and the Question

Setting: **food energy is reckoned by multiplying the masses of carbohydrate, fat, protein and alcohol by 4, 9, 4 and 7 kcal/g and summing: the Atwater general factors.Burning the same substances in a bomb calorimeter gives heats of combustion of 4.10, 9.45, 5.65 and 7.10 kcal/g.**

Observation 1.1

both are written in the same unit.Both are kcal/g, and both are called "calories"——yet one is the needle of a calorimeter and the other an account of what passes through a body.

Question: **where does the gap come from, and how much does it matter?**

2. Protein’s Gap Is of Another Size

Computation 2.1: **the gap between heat of combustion and factor.**

component	heat of combustion (kcal/g)	factor	gap fraction
carbohydrate	**4.10**	**4**	**0.024390**
fat	**9.45**	**9**	**0.047619**
protein	**5.65**	**4**	**0.292035**
alcohol	**7.10**	**7**	**0.014085**

> **Observation 2.2**
>
> **only protein comes near a third.Above 0.29 and below 0.30 (measured 0.292035)——more than five times any of the other three.**

> **Observation 2.3**
>
> **the other three agree at a few per cent.Their gaps are only what is not absorbed——protein alone carries something more.**

3. The Factors Can Be Rebuilt

Computation 3.1: **multiplying heats by digestibility, and for protein subtracting the urinary loss of 1.25 kcal/g.**

component	rebuilt value	rounded
carbohydrate	$4.10 \times 0.97 = \mathbf{3.977000}$	4
fat	$9.45 \times 0.95 = \mathbf{8.977500}$	9
alcohol	$7.10 \times 1.00 = \mathbf{7.100000}$	7
protein (urine first)	$(5.65 - 1.25) \times 0.92 = \mathbf{4.048000}$	4
protein (digestibility first)	$5.65 \times 0.92 - 1.25 = \mathbf{3.948000}$	4

Observation 3.2

all four return to their integers.The factors are not chosen at will but follow from measured heats——with a rounding on top.

Observation 3.3

the order of correction differs by 0.1.That difference matches the closed form $1.25 \times (1 - 0.92) = 0.1$ to 12 digits——a comparison with a separately assembled formula. Either order stays within 0.06 of the integer 4, so the rounding absorbs the difference.

Observation 3.4

other representative heats change nothing.With 4.15 for carbohydrate and 9.40 for fat the rebuilt values are 4.025500 and 8.930000, still 4 and 9——the conclusion does not rest on the second decimal of the heats.

Computation 3.5: the urinary share of protein's gap of $5.65 - 4 = 1.65$ kcal/g: $1.25/1.65 = \mathbf{0.757576}$, above 0.75 and below 0.76.

Observation 3.6

this is the core.Three quarters of protein's gap arise not from failing to absorb but from failing to burn what was absorbed——the body discards nitrogen as urea, which still carries combustible carbon and hydrogen. The calorimeter burns it; the label does not.

4. A Food’s Ratio Follows Its Protein Share

Computation 4.1: calorimeter over label for varied compositions.

composition (protein, fat, carbohydrate in g)	calorimeter	label	ratio
0, 0, 100	410.00	400.00	**1.025000**
0, 100, 0	945.00	900.00	1.050000
10, 5, 75	411.25	385.00	1.068182
20, 10, 50	412.50	370.00	**1.114865**
30, 20, 10	399.50	340.00	1.175000
100, 0, 0	565.00	400.00	**1.412500**

Observation 4.2

pure protein gives exactly $5.65/4$**1.412500** to 12 digits——the ratio of heat to factor itself.

Observation 4.3

an ordinary composition differs by a little over a tenth.**1.114865** at 20, 10, 50 (above 1.11 and below 1.12) ——burning the food would give a tenth more than its label.

Observation 4.4

the ratio rises with protein.10, 20 and 30 g give 1.068182, 1.114865 and 1.175000——and a mixed food’s ratio lies between the smallest (1.025) and largest (1.4125) of its pure components.

Observation 4.5

high-protein foods drift furthest.Where a composition leans towards meat or beans, the label lies furthest from the calorimeter——not that one is right, but that they measure different things.

5. The Separator

> **Observation 5.1**
>
> **the separator is whether an element burns completely or is discarded.Carbon and hydrogen reach carbon dioxide and water in the body as in the calorimeter——nitrogen burns in the calorimeter but leaves the body as half-burned urea. Carbohydrate and fat carry no nitrogen and protein does, which is why the gap gathers in protein.**

> **Observation 5.2**
>
> **alcohol is the control.Without nitrogen and almost wholly absorbed, its gap stays at 0.014085——entering the body without nitrogen, it barely differs from the calorimeter.**

> **Observation 5.3**
>
> **an example of Paper 338's promise that is not arbitrary.4, 9 and 4 are a promise rounded to integers——and rebuildable from measured heats and two corrections, so not arbitrary. A measurement folded inside a convention.**

> **Observation 5.4**
>
> **the broad-name shape of Paper 551.There an index named for capability watched only spread——here a "calorie" named for heat counts only what the body extracts.**

> **Observation 5.5**
>
> **one root, under Paper 300."The gap gathers in protein" and "a food's ratio follows its composition" both come from nitrogen——for foods without nitrogen both vanish.**

6. Roll Call and Closing

1. **protein's gap 0.292035** (Computation 2.1): **over five times the others.**

2. **carbohydrate 3.977000, fat 8.977500** (Computation 3.1): **round to 4 and 9.**
3. **protein 4.048000 and 3.948000** (Computation 3.1): **4 either way.**
4. **the order differs by $0.1 = 1.25 \times 0.08$** (Observation 3.3): **to 12 digits.**
5. **other heats still give 4 and 9** (Observation 3.4): **not resting on the second decimal.**
6. **urinary share 0.757576** (Computation 3.5): **the core.**
7. **pure protein 1.412500** (Observation 4.2): **$5.65/4$.**
8. **ordinary food 1.114865** (Observation 4.3): **a tenth and more.**
9. **the separator is complete burning** (Observation 5.1): **nitrogen divides it.**
10. **alcohol 0.014085** (Observation 5.2): **a nitrogen-free control.**

Closing: **The calories on a food label are taken to be heat measured by burning.Yet the gap from the heat of combustion gathers in protein——carbohydrate 2.4390, fat 4.7619 and alcohol 1.4085 per cent against protein's 29.2035, over five times any of the others. The factors are not arbitrary: multiplying heats by digestibility, and for protein subtracting the urinary loss, gives 3.977, 8.9775, 7.1 and 4.048, rounding to 4, 9, 7 and 4. The order of correction differs by 0.1, matching 1.25×0.08 to 12 digits and absorbed by the rounding, and other representative heats leave the integers unchanged.Of protein's gap of 1.65 kcal/g, 0.757576 is the urinary loss——three quarters of it arise not from failing to absorb but from failing to burn what was absorbed. The body discards nitrogen as urea, which still carries combustible carbon and hydrogen; the calorimeter burns it and the label does not.So a food's ratio follows its protein share——calorimeter over label is 1.025 for pure carbohydrate, exactly $5.65/4 = 1.4125$ for pure protein and 1.114865 for an ordinary composition, rising monotonically with protein. High-protein foods drift furthest, not because one number is wrong but because they measure different things.The separator is whether an element burns completely or is discarded——carbon and hydrogen burn completely in both, while nitrogen burns in the calorimeter and leaves the body half-burned; nitrogen-free alcohol stays at 0.014085. Under Paper 300 the concentration in protein and the dependence on composition share one root, nitrogen.Placed among the earlier papers——it is Paper 338's promise that is not arbitrary, a measurement folded inside a convention, and it has the broad-name shape of Paper 551, a "calorie" named for heat that counts only what the body extracts.To be honest——no nutritional advice is given. Heats and digestibilities are classic mixed-diet values, their second decimals not asserted. The urinary loss of 1.25 kcal/g is used as Atwater measured it, without examining its composition. The other factors for fibre, sugar alcohols and organic acids, the methods of national food tables, and individual variation in digestibility are all left aside.**

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