

Mixing Two Foods Short in Different Things Beats Either One

— Scoring a protein by its smallest fulfilment ratio, food A scores **0.555556** (short in lysine) and food B **0.545455** (short in sulphur amino acids) — the separator is whether one asks about each food alone or about the combination — [Paper 852]

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Abstract

Mixing two low-scoring foods is expected to give a low score. This paper counts what mixing does when the score is set by a minimum. No new theorem or law is claimed. First, both score low: food A scores **0.555556** and food B **0.545455** (Section 2). Second, they are short in different things: A in lysine, B in sulphur amino acids (Section 2). Third, and this is the core. The mixture beats both: at a **0.428010** share of A the score is **1.051280**, which is **1.892304** times the better single food (Section 3). Fourth, the best share is where the shortfalls swap. There lysine fulfils **1.051280** and sulphur **1.051285**, a difference of 4.323×10^{-6} (Section 3). Fifth, the score is not an average: at a **0.4** share the mixture scores **1.018182**, while the average of the scores is only **0.549495** (Section 4). Sixth, the separator is whether one asks about each food alone or about the combination: a quantity set by a minimum cannot be assembled from the scores of its parts (Section 5). **Keywords:** limiting amino acid, amino acid score, law of the minimum, complementation, mixing ratio, model.

Scope of this paper (scope note): No new theorem or law is claimed: that protein quality is judged by the most limiting essential amino acid (the amino acid score, the limiting amino acid), and that foods short in different amino acids complement each other when combined, are both known. No nutritional advice is given. What to eat and how much is not stated. No real food values are claimed: the compositions of A and B and the requirements are model values placed for comparison. Digestion is not included: absorption and changes from processing are not treated. Only four amino acids are used: amino acids other than lysine, sulphur amino acids, threonine and tryptophan are not included. Relation to earlier papers: Paper 477 showed that while the wrong input is being added the limit is somewhere else, placing Liebig's law of the minimum among the known. This paper does not sit in that seat but stands beside it: there adding one input moves the limit; here mixing two foods short in different things fills each other's gaps. Paper 471 showed that piling more on does not help when what is short is a ratio. Here too the mixing ratio decides the answer. What is added is stepping the mixing share and laying out the score's peak, confirming that the fulfilment ratios cross at the best share, measuring that the mixture's score far exceeds the average of the scores, and placing the separator on each food alone versus the combination.

1. Notation and the Question

Setting: let a_j be the content of amino acid j and n_j its requirement, and let a protein's score be its smallest fulfilment ratio. Mixing two foods in shares w and $1 - w$ makes the contents a weighted sum.

$$S(a) = \min_j \frac{a_j}{n_j}, \quad a_j^{\text{mix}} = w a_j^A + (1 - w) a_j^B$$

Contents mix by addition; the score takes a minimum and so does not.

Question: what happens to the score when two low scorers are mixed?

2. Two Foods

Computation 2.1: the scores of model foods A and B were computed.

food	score	short in
A	0.555556	lysine
B	0.545455	sulphur amino acids

Observation 2.2

both score low, and they are short in different things. Lysine holds A back and sulphur amino acids hold B back: one food's gap is not a gap in the other.

3. The Mixture's Score

Computation 3.1: the share of A was stepped by 0.1.

share of A	score	short in
0.0	0.545455	sulphur
0.2	0.781818	sulphur
0.4	1.018182	sulphur
0.5	0.988889	lysine
0.6	0.902222	lysine
0.8	0.728889	lysine
1.0	0.555556	lysine

Observation 3.2

this is the core. The mixture beats both. A 0.4 share of A scores 1.018182, far above A alone at 0.555556 and B alone at 0.545455, because each food's surplus fills the other's gap.

Computation 3.3: the share was stepped by 10^{-5} to find the best point.

quantity	value
best share of A	0.428010
score there	1.051280
lysine fulfilment	1.051280
sulphur fulfilment	1.051285
their difference	4.323×10^{-6}
factor over the better single food	1.892304

Observation 3.4

the best point is where the shortfalls swap. There the two fulfilment ratios meet; less A and sulphur holds it back, more A and lysine does: the peak sits where two straight lines cross.

4. The Score Is Not an Average

Computation 4.1: at a 0.4 share of A, the mixture's score was compared with the average of the scores.

quantity	value
score of the mixture	1.018182
average of scores ($0.4 \times 0.555556 + 0.6 \times 0.545455$)	0.549495
difference	0.468687

Observation 4.2

the mixture's score far exceeds the average of the scores. The difference is 0.468687: contents mix as averages but the score takes a minimum, so the whole's score cannot be built from the parts' scores.

Observation 4.3

at the ends the law of the minimum returns. A alone scores 0.555556 again: the gain from mixing appears only when the shortfalls differ.

5. The Separator

Observation 5.1

the separator is whether one asks about each food alone or about the combination. Alone they score 0.555556 and 0.545455; combined, up to 1.051280: for a quantity set by a minimum, adding the parts' assessments does not give the whole's.

Observation 5.2

placed beside Papers 477 and 471. 477 showed that while the wrong input is added the limit is elsewhere. There adding one input moves the limit; here mixing two foods short in different things fills each other's gaps. The adding side and the mixing side of one law of the minimum. 471 showed that what stalls progress is a short ratio, not a short amount. Here too the mixing ratio decides.

Observation 5.3

what is not said. What to eat, real food values, digestion and other amino acids are not treated. What is shown is that a minimum-set score is no average, and a mixture can beat both of its parts.

6. Census and Closing

1. A scores 0.555556 (Computation 2.1): **short in lysine.**
2. B scores 0.545455 (Computation 2.1): **short in sulphur.**
3. 0.4 share gives 1.018182 (Computation 3.1): **beats both.**
4. best **1.051280** at 0.428010 (Computation 3.3): **the core.**
5. **1.892304** times the better food (Computation 3.3): **nearly double.**

6. fulfilments differ by 4.323×10^{-6} (Computation 3.3): the swap point.
7. average of scores **0.549495** (Computation 4.1): falls short.
8. difference **0.468687** (Computation 4.1): not an average.
9. A alone returns to **0.555556** (Observation 4.3): the minimum at the ends.
10. alone, or combined (Observation 5.1): the separator; Papers 477, 471.

Closing: Mixing two foods short in different things beats either one. Scoring by the smallest fulfilment ratio, food A scores **0.555556** (short in lysine) and food B **0.545455** (short in sulphur), while a **0.428010** share of A scores **1.051280**, which is **1.892304** times the better one, because each food's surplus fills the other's gap, and at the best share the two fulfilments meet to within 4.323×10^{-6} . And against the mixture's **1.018182** at a **0.4** share, the average of the two scores is only **0.549495**: contents mix as averages, but the score takes a minimum and cannot be built from the parts' scores. The gain appears only when the shortfalls differ, and returning to A alone returns the score. Placed among the earlier papers: beside Paper 477's "add, and the limit moves" as the side that mixes to fill gaps, and counting with Paper 471 that the ratio decides. To be honest: the compositions and requirements are model values, and nothing is said about what anyone should eat.

References

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