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Comparing Alternative Nutritional Functional Units for Expressing Life Cycle Greenhouse Gas Emissions in Food Production Systems

Alissa Kendall[1]

Sonja B Brodt[2]

University of California, Davis
1. Department of Civil and Environmental Engineering
2. Agricultural Sustainability Institute

Inspiration for this work

- Our team at UC Davis has been working on agricultural and food LCAs in California
- We have ended up working on some very dissimilar food products
  - Even with similar products (e.g. process tomatoes in different forms) the issue of functional unit can be challenging

The Functional Unit in Food LCA

- Functional units should reflect both the goal of a study and the role of a particular food product in a diet.
- The issue has been in addressed in
  - diet-level assessments
  - meal-based assessments
  - comparison of organic and conventional production methods
  - comparisons across food products or product categories
- What about direct comparison of food products? Or baseline studies deciding on what functional unit to report?

The status quo

- Mass based:
  - May facilitate comparison among similar products (e.g. organic versus conventional)
  - Useful for generating life cycle inventories
  - Fails to capture the nutritional value or how products are used (Heller et al. 2013)

The status quo

- Meal and diet-based functional units address many of the shortcomings of simple mass or calorie-based
  - But these studies limit generalizability of results
- The landscape of recommendations can be confusing
    - e.g. the European Food Sustainable Consumption and Production Round Table recommend mass or volume-based functional units (Camillis et al. 2012)

Study Approach

- This study compares three dissimilar foods produced and consumed in California

Almonds

Rice (10% brown and 90% white)

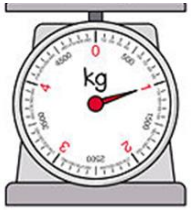
Processed tomatoes

1. Diced
2. Paste

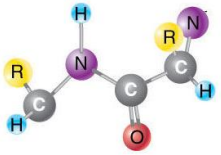
LCAs of the three products

- Though the studies included different impact categories, all included energy and global warming potential (GWP)
- In this research we just include GWP

Functional Units Compared

- Mass 

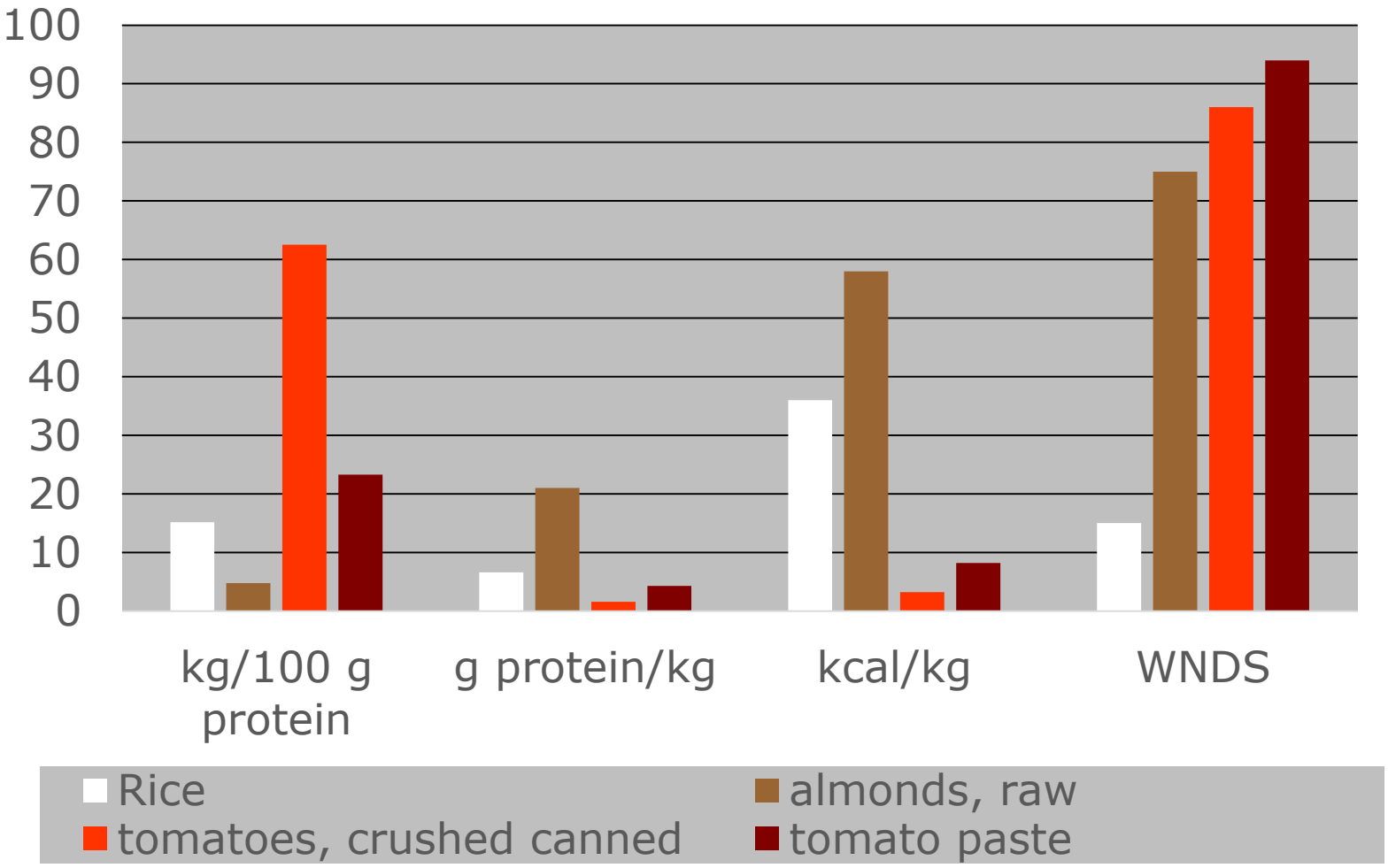
- Serving size 

- Calories 
- Protein content 

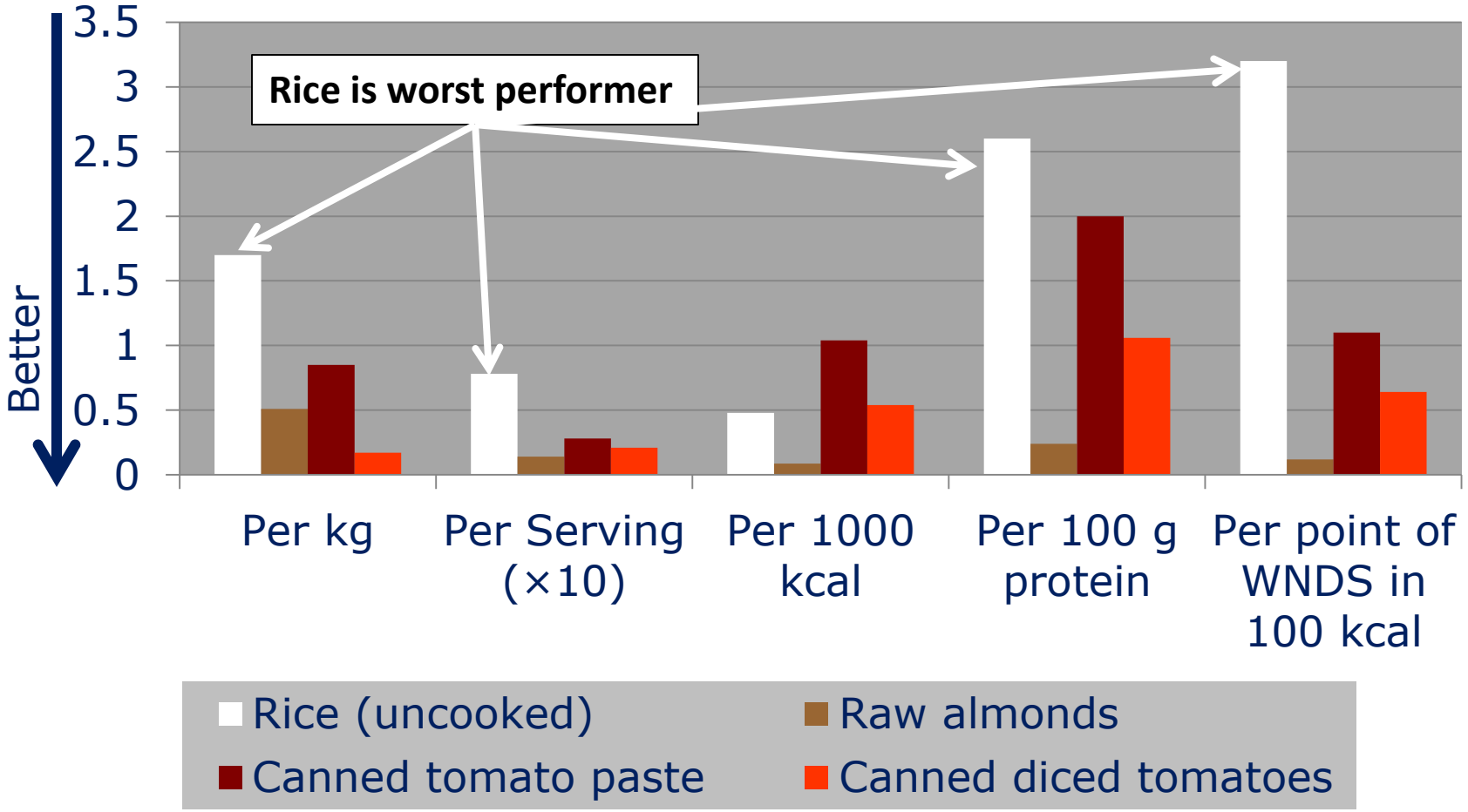
- The weighted nutrient density score (WNDS) (Arsenault et al):

f(↑protein, fiber, unsaturated fat, vitamin C, ↓saturated fat, added sugar, sodium)

Food characteristics



GWP_{100} for the four evaluated products



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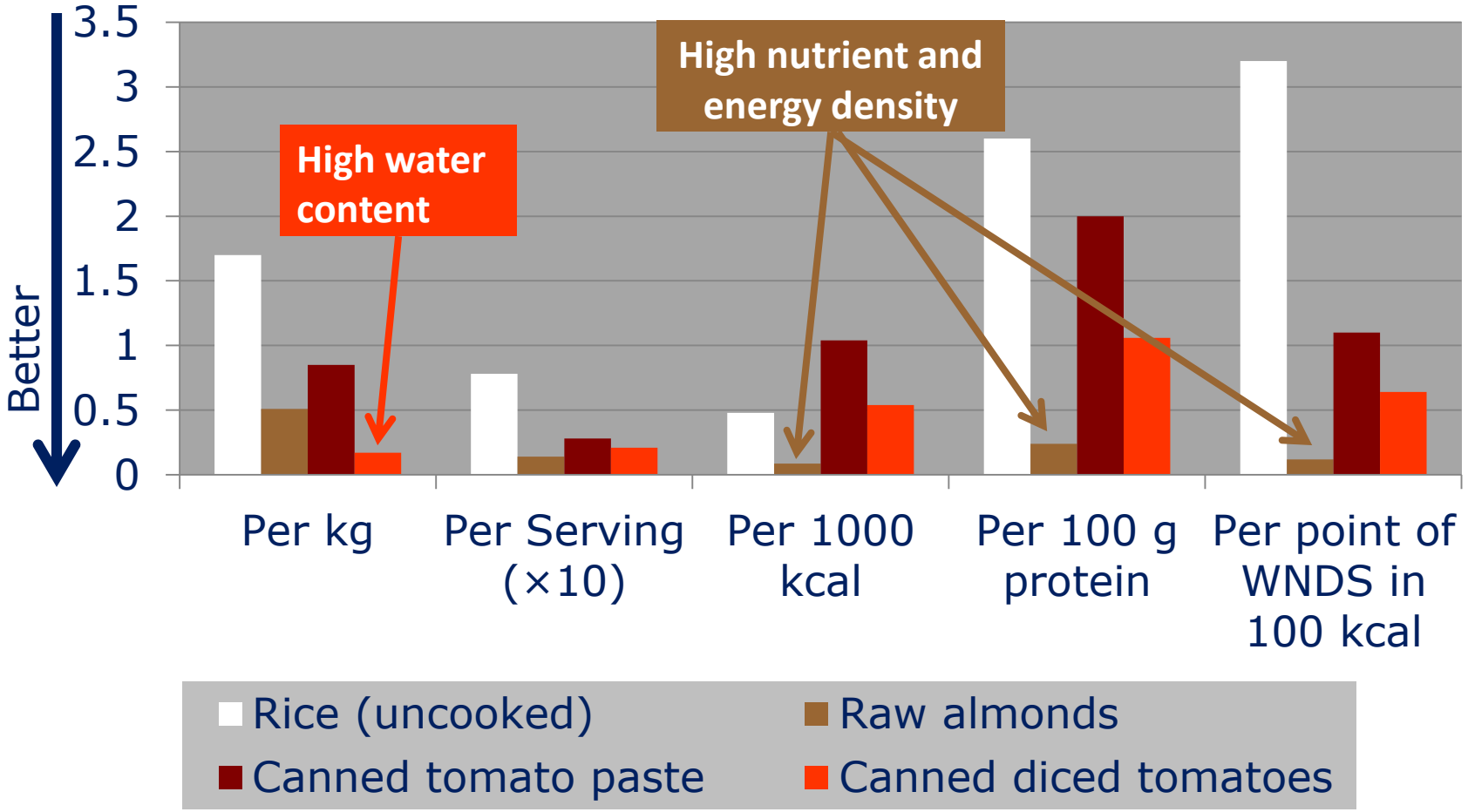
GWP_{100} for the four evaluated products



Composite nutrient indices

- The selection of the index matters
  - Here vitamin C and fiber were important for tomato product performance, for example
  - And nutrient and energy density is largely "good" here, benefiting almonds. But is energy density good?
  - Do these characteristics actually help us compare foods that might be used quite differently in a diet?
- Van Kerbeck et al. (2013) examined composite nutritional indices for use as functional units.
  - Nutritional indices based on diets with and without protein intake caps arrived at different results.

Which product is 'best' from a GWP standpoint

- Almonds performed best in all functional units except mass
- Rice performed worst except on a per-kcal basis
  - Cooking of rice was not included, and compared to the other products probably required more cooking energy
- The level of processing (concentration) for the tomatoes influenced performance, making paste worse than crushed

Recommendations

- Multiple functional units should be explored when foods are compared outside the context of meals and diets
  - though sensitivity and scenario analysis should also be considered in those cases too
- Functional units should include nutrient-based ones (not just kcal and mass)
- In this case the ranking of foods stayed the same for the non-mass, non-kcal functional units

References

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Questions and comments

Alissa Kendall
amkendall@ucdavis.edu

Sonja Brodt
sbbrodt@ucdavis.edu

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Weighted nutrient density score (WNDS)

- $$WNDS = 100 \times (1.4 \times \frac{\text{g protein}}{50} + 3.3 \times \frac{\text{g fiber}}{25} + \mu\text{g calcium} + 2.51 \times \frac{\text{g unsaturated fat}}{44} + 0.37 \times \frac{\text{mg vitamin C}}{60} - 2.95 \times \text{g} \frac{\text{saturated fat}}{20} - 0.52 \times \frac{\text{g added sugar}}{50} - 1.34 \times \frac{\text{mg sodium}}{2400})$$