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DEVELOPMENT AND NUTRITIONAL EVALUATION OF AMARANTH-BASED FUNCTIONAL PORRIDGE FOR ATHLETES

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Abstract

This study presents a formulation-based assessment of an amaranth porridge designed for physically active adults. Four dry mixtures containing 0, 20, 30 and 40% nonfat dry milk were compared using reference food-composition values and ingredient mass balance. The purpose was to identify a practical cereal-based meal that supplies carbohydrate together with a meaningful quantity of protein. The estimated protein content increased from 13.56 to 22.60 g per 100 g of dry blend, while the calculated energy content remained approximately 367–371 kcal. The blend containing 60% amaranth and 40% milk powder provided the largest protein contribution among the formulations investigated. A proposed cooking process and a quality-validation plan are presented. These findings represent theoretical formulation estimates rather than laboratory measurements or evidence of improved athletic performance. The product may be considered a candidate for further development as a post-training meal.

Keywords: amaranth grain, sports nutrition, functional porridge, protein enrichment, carbohydrate, food formulation, recovery meal.

Introduction

A meal intended for athletes must be evaluated not only by its energy content but also by the amount of nutrients delivered in an acceptable portion. Training schedules often create a need for meals that are easy to prepare, affordable and adaptable to individual energy demands. Conventional grain porridges provide carbohydrate, but their protein contribution may be insufficient when they are eaten without complementary foods. A formulation that combines a pseudocereal with a concentrated food protein offers one route to improving the nutrient profile without introducing specialized sports supplements.

Amaranth is of interest because it combines starch, protein, dietary fibre and lipid in a small edible seed. Its amino acid distribution, including lysine, differs from that of many conventional cereals [1,2]. However, the nutritional characteristics of the raw grain cannot alone establish the effectiveness of an amaranth meal in athletes. The

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composition of the finished recipe, portion size, processing conditions and individual tolerance must also be considered.

Materials and Research Methods

The work was designed as a desk-based food formulation study. No samples were manufactured, no athletes were recruited and no laboratory determinations were performed. Reference nutrient data for uncooked amaranth grain and regular nonfat dry milk were obtained from USDA food-composition records [3]. The formulation variable was the mass fraction of milk powder, which replaced an equivalent mass of amaranth. Water was excluded from dry-blend calculations and treated separately in the proposed cooking process.

Table 1. Reference composition of ingredients per 100 g

Ingredient	Protein (g)	Carbohydrate (g)	Fat (g)	Fibre (g)	Energy (kcal)
Amaranth	13.56	65.25	7.02	6.70	371
Nonfat dry milk	36.16	51.98	0.77	0.00	362

Source: USDA FoodData Central, SR Legacy records 170682 and 170877 [3].
Carbohydrate by difference includes dietary fibre. The energy values are database values, not recalculated by applying a single set of conversion factors.

Table 2. Proposed formulation of dry porridge mixtures (g)

Ingredient	A0 (control)	A20	A30	A40
Amaranth grain	100	80	70	60
Nonfat dry milk	0	20	30	40
Total	100	100	100	100

For each nutrient, the amount in the dry blend was obtained from the weighted sum of the reference ingredient concentrations:

$N = (m_a \times N_a + m_m \times N_m) / 100$

Here, N is the amount of nutrient in a 100 g blend; m_a and m_m are the ingredient masses in grams; N_a and N_m are the respective nutrient amounts per 100 g of each ingredient. The same mass-balance principle was applied to database energy values. A0 was selected as an unfortified reference, while A20, A30 and A40 were selected to examine progressively greater protein enrichment. The screening criterion was a calculated protein content of at least 20 g in a 100 g dry serving; this is a formulation target, not a regulatory nutrition claim or proof of protein quality [4].

The comparison is deterministic. Therefore, standard deviations, significance levels and confidence intervals were not assigned. The effect of water addition was assessed through a nominal cooked yield of 350 g from 100 g dry mixture and 250 g retained water, with no nutrient losses assumed. Actual cooking yield and nutrient retention should be measured during pilot trials.

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Proposed manufacturing technology

Food-grade amaranth grain should be inspected for foreign matter, cleaned and washed using potable water. Grain may be used whole or lightly milled, depending on the desired texture. The milk powder should be obtained from an approved supplier and examined for packaging integrity, moisture-related caking and expiry date. Ingredient quantities are weighed according to Table 2.

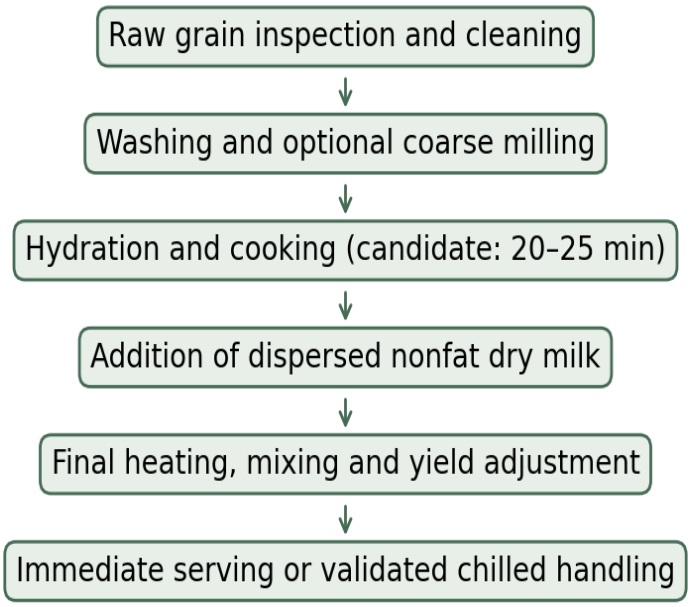


Figure 1. Proposed technological sequence for amaranth porridge.

During cooking, water penetrates the grain and promotes starch swelling. The resulting consistency depends on particle size, hydration, temperature and the amount of solids. Milk powder can be dispersed separately in a portion of water to reduce lump formation. The mixed porridge should receive adequate final heating under a validated time–temperature procedure. The proposed cooking period is a starting condition for experiments, not a confirmed optimum.

For immediate consumption, the recipe may be prepared in a saucepan or a jacketed kettle. For centralized production, controlled mixing and calibrated weighing are required to reduce batch variability. Finished product yield should be recorded because evaporation alters the nutrient concentration per 100 g of cooked porridge. A separate shelf-life study would be necessary before marketing a refrigerated ready-to-eat product.

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Results and discussion

Table 3. Calculated nutrient composition per 100 g dry blend

Blend	Protein (g)	Carbohydrate (g)	Fat (g)	Fibre (g)	Energy (kcal)
A0	13.56	65.25	7.02	6.70	371.0
A20	18.08	62.60	5.77	5.36	369.2
A30	20.34	61.27	5.14	4.69	368.3
A40	22.60	59.94	4.52	4.02	367.4

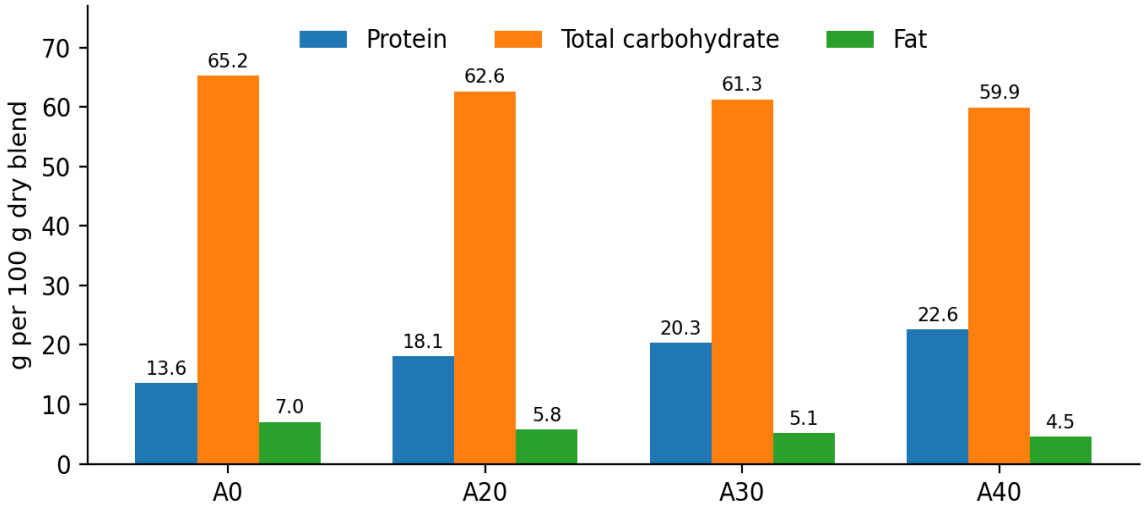


Figure 2. Calculated macronutrient composition of the four formulations.

The protein concentration increased progressively as milk powder replaced amaranth. In A40, the estimated protein amount was 22.60 g, compared with 13.56 g in A0. This represents an increase of 9.04 g, or approximately 66.7%. The total carbohydrate content decreased to 59.94 g, and the fat content decreased to 4.52 g. The change reflects the composition of the ingredients rather than an effect of processing. No statistical differences can be inferred from these modeled values.

Although enrichment increases the protein fraction, it also reduces the amount of grain-derived fibre. A40 contains an estimated 4.02 g fibre compared with 6.70 g in the control. This trade-off may be useful for athletes who prefer a less fibre-rich meal near a training session, although gastrointestinal tolerance must be assessed individually. The calculated energy difference between the control and A40 is only 3.6 kcal per 100 g dry blend. Thus, the recipe modifies the distribution of macronutrients while retaining a similar energy supply.

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Suitability for sports nutrition

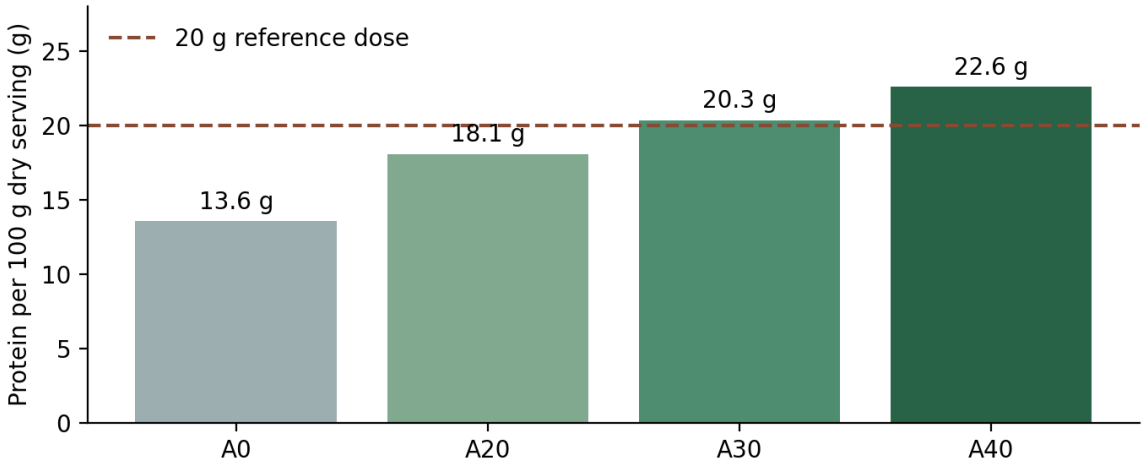


Figure 3. Calculated protein per dry serving relative to a 20 g reference dose.

A30 and A40 exceed the selected 20 g screening threshold. A40 was retained as the leading candidate because it provides the greatest protein quantity within the defined formulation range. This selection is conditional on the recipe being acceptable in taste, consistency and cost. Sports nutrition guidance indicates that protein requirements depend on training load, body mass, overall diet and protein quality [4,5]. A mixed porridge can contribute to these requirements but cannot replace a balanced daily diet.

Table 4. Estimated nutrient delivery of the A40 formulation

Nutrient	100 g dry serving	100 g cooked product*
Protein (g)	22.60	6.46
Total carbohydrate (g)	59.94	17.13
Fat (g)	4.52	1.29
Fibre (g)	4.02	1.15
Energy (kcal)	367.40	104.97

*Assumed cooked yield: 350 g per 100 g dry blend. Actual yield and losses were not measured.

For a 70 kg athlete, one A40 serving supplies approximately 0.32 g protein/kg body mass and 0.86 g total carbohydrate/kg. These figures illustrate the contribution of the meal, not an individualized prescription. Rapid glycogen restoration after demanding exercise may require additional digestible carbohydrate, especially when another training session is scheduled soon [5,6]. The porridge can be accompanied by fruit or other foods, with the additional nutrients calculated separately. Amaranth is naturally gluten-free, but a gluten-free claim requires controlled sourcing and prevention of cross-contact. A40 contains milk proteins and lactose and is unsuitable for individuals with milk allergy; lactose tolerance also needs consideration.

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Experimental validation and quality control

The next stage should compare at least three independently prepared batches of each formulation. Moisture, protein, fat, ash and dietary fibre should be determined using validated methods suitable for the matrix. Protein may be determined using Kjeldahl or Dumas nitrogen analysis with an explicitly justified conversion factor. The final product should be examined for viscosity at a specified temperature and shear condition, cooking yield, water separation and sensory acceptability. A randomized coded sensory evaluation could assess appearance, aroma, taste, texture and overall liking. Microbiological testing and storage conditions should be defined in accordance with applicable food safety requirements. Human performance or recovery outcomes would require a separate ethically approved study. Until such evidence is available, the porridge should not be described as clinically proven to accelerate recovery.

Conclusion

1. Amaranth and nonfat dry milk were combined in four proposed formulations for a grain-based sports meal. The mass-balance approach enabled comparison without presenting unmeasured experimental data as observations.
2. The A40 mixture (60% amaranth and 40% nonfat dry milk) yielded an estimated 22.60 g protein, 59.94 g total carbohydrate and 367.4 kcal per 100 g dry serving. Its protein content was approximately 66.7% higher than that of the unfortified reference.
3. A40 is recommended for pilot-scale technological and sensory evaluation. Verification of composition, digestibility, microbial safety and athlete acceptability is necessary before commercial introduction or performance-related claims.

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