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Development of Marketable, Shelf-Stable and Affordable Nutrient-Dense Mealtime Products for Backpackers Hiking Multi-Day Trips

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Development of Marketable, Shelf-Stable and Affordable Nutrient-Dense Mealtime Products for Backpackers Hiking Multi-Day Trips

Introduction

The scope of practice for this project will be to research nutrition requirements, establish and test recipes, produce a prototype, and research guidelines for product development, food safety and regulations to market the products in the retail space. Backpackers confront incredible scenery, wild and dangerous animals, endless adventure, and many injuries during grueling months of walking for hundreds, and sometimes thousands, of miles. As the sport becomes more popular, innovations have been made in many segments of care. Gear has been established that is lighter and more durable, gadgets have been cultivated to maintain a sense of safety, trails have been etched deeper for a clearer path. However, the development of a nutrient dense and reliably affordable food option has yet to be created. Backpackers find themselves with a large array of over-priced meal options or 50 cent ramen noodles, with very little opportunity in-between. The purpose of this project is to close that gap, and develop a marketable, shelf-stable and affordable nutrient-dense mealtime product for backpackers hiking and backcountry camping through multiple days, weeks and months in the wilderness.

Overview: Long distance backpackers

A stride is split into two phases, stance and swing. Stance phase is experienced from the heel strike to the toe off. The remainder of the motion is swing phase, when the foot releases the ground and swings forward to heel strike again. Through the forward motion of the stance phase, 85% of the generation of muscular force is found.¹

Long distance backpackers hike an average of approximately ten miles per day at a rate of 2.5 miles per hour. Backpacking is a highly active sport, requiring close to or more than 30,000 to 40,000 steps per day. There is a wide range of ages on the trail, but the majority are between ages 20-25.² In 2017, nearly 60% of backpackers were in this age range, with 20% between the ages of 26 and 29.² In the past 20 years, the age of backpackers over 30 has increased by 5%.² With an increase in popularity, and the development of better technology and more comfortable and lighter equipment, this style of travel has opened itself up to a wider crowd. This is an attainable activity to an older group. The number of 30+ individuals could continue to increase with the proper provision of nutrition and training for aging athletes.
Backpackers typically carry a load of 30% of their body weight. This 30% increase in weight corresponds to an increase in metabolism by approximately $47 \pm 17\%$ above the unloaded rate.\textsuperscript{1} Through the 2011 compendium of physical activities, the following metabolic increase was calculated for backpackers at weights ranging from 120 to 210 pounds.\textsuperscript{3} Basal metabolic rate was tracked through weight in kilograms times twenty-five to account for the broadest approximation of individuals. Metabolic Equivalent (Met) at 8 and 8.3 allowed for a range of possible caloric recommendations dependent on the backpacker’s route. Additional kilocalories were determined with the following calculation: kilocalories = MET × weight in kilograms × duration in hours. BMR was added to the total to determine caloric requirements for the day.

**Figure 1.** Increased caloric requirement of individuals backpacking 10 miles/day on uneven terrain.

<table>
<thead>
<tr>
<th>Per hour</th>
<th>MET at 8</th>
<th>MET at 8.3</th>
<th>BMR</th>
<th>10 m/d - Male</th>
<th>10 m/d - Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 (54.5kg)</td>
<td>436</td>
<td>452</td>
<td>1363</td>
<td>3107 – 3171</td>
<td>2890 – 2949</td>
</tr>
<tr>
<td>150 (68.2kg)</td>
<td>546</td>
<td>566</td>
<td>1705</td>
<td>3889 – 3969</td>
<td>3617 – 3691</td>
</tr>
<tr>
<td>180 (81.8kg)</td>
<td>654</td>
<td>679</td>
<td>2045</td>
<td>4661 – 4761</td>
<td>4335 – 4428</td>
</tr>
<tr>
<td>210 (95.5kg)</td>
<td>764</td>
<td>793</td>
<td>2386</td>
<td>5442 – 5558</td>
<td>5061 – 5169</td>
</tr>
</tbody>
</table>

MET – Metabolic equivalent, MET at 8.0 – 25-49 pound load, upstairs; MET at 8.3 – climbing hills with 21-42 pound pack, BMR – Basal metabolic rate, M/d – Miles per day

This is a surprising increase in calorie requirements. In all instances, calorie needs have more than doubled. Women often have a metabolic rate 5-10% lower than males of the same height and weight due to an increase in skeletal muscle mass on men.\textsuperscript{4} This measurement has been factored above at a decreased range of 7%, but is greatly dependent on the individual.
Nutrition requirements and deficiencies

Deficiencies found commonly in athletes include exhaustion, gastrointestinal distress, diarrhea, constipation, muscle cramps, heat stroke, dehydration, ankle strain, back pain, lower extremity fractures, ligament damage, sleeping issues, headaches, and in certain cases, altitude sickness and hypothermia. Many of these deficiencies can be rectified through proper diet and adequate rest pre, during and post hike. Often, backpackers do not properly hydrate or intake nutrients due to the restraints of weight, cost and lack of knowledge. The following are medical nutrition suggestions to prevent or fight the most common injuries found in backpackers.

- **Exhaustion** – Calories in and hydration.

- **Gastrointestinal distress** – Potassium such as bananas, apricots, peach nectar, potatoes, fish and meat. Drinking fluids between meals. Eating small amounts of food frequently. Avoiding fatty foods. Increasing intake of zinc to restore epithelial barrier function. Zinc can be found in meat, shellfish, legumes (such as chickpeas, lentils and beans), seeds, nuts, dairy and eggs.

- **Diarrhea** – Similar to gastrointestinal stress, small frequent meals are beneficial to ease liquid bowel movements. Limited fried and fatty foods, minimal sugary foods and foods that are high in soluble fiber like oatmeal and oat bran. Look for low fat cheese, eggs, lean fish, beef, pork and skinless poultry. Increase intake of zinc to decrease fluid secretion to the intestinal lumen.

- **Constipation** – To relieve constipation, consume fruits with skin intact for dietary fiber, unsalted seeds and nuts such as pumpkin, sunflower, flax, chia seeds, and vegetables like green peas, broccoli, sweet potato, winter squash and pumpkin. Consume whole grains and increase intake of water.

- **Muscle cramps** – These develop most often due to fatigue, salt loss and dehydration. Consume ¼ teaspoon of table salt in a 16-20 oz beverage. Magnesium is often used as a remedy because of its function in oxygen uptake, energy production and electrolyte balance, but evidence of effectiveness is limited. In fact, most studies report that Magnesium is no more effective than a placebo. In Maor et al, a randomized double blind trial of 94 participants found magnesium oxide supplementation no better than placebo for night cramps. However, study participants did report magnesium as being more effective regardless of statistically significant outcomes. Magnesium is found in almonds, cashews, peanuts, spinach, and soy milk. For bioavailability, vitamin D should also be adequate. This is as simple as spending fifteen to forty minutes in direct sunlight.

- **Heat Stroke** – Increase water intake slowly. In animals, heat stroke has been shown to shift energy metabolism toward carbohydrate use and reduced lipid oxidation. Diets that promote glucose may benefit those who experience heat
Nutritional supplementation such as lipoic acid (red meat, carrots, beets) and chromium (vegetables such as broccoli, potatoes and green beans) improve insulin sensitivity and play a key role in glucose metabolism.¹³

- Dehydration – Slow hydration from clean water, as well as intake of fruits and vegetables if available to you. Drink water until urine is dilute.

- Back pain – Anti-inflammatory foods such as nuts, lean protein, kale, spinach and broccoli work to reduce swelling.¹⁴

- Lower extremity fractures – Low calcium intake, low serum vitamin D and vegetarian diets lead to a greater risk of stress fractures.¹⁵ During extended and strenuous exercise, it is important to replenish with adequate protein, calcium and vitamin D.¹⁵

- Ligament Damage – Collagen forms the major extracellular protein in tendons, muscle and ligaments.¹⁶ A diet deficient in calories and/or protein lead to less collagen production.¹⁶ Proteins, and specific amino acids arginine, glutamine and branched-chain amino acids leucine, isoleucine and valine, are included in whey protein, which has been found to significantly increase tendon strength in the patellar and quadriceps tendon.¹⁶ Vitamin C is necessary for collagen synthesis and transcription.¹⁶ Similarly, vitamin D deficient diets have been shown to slow tendon healing in the rotator cuff.¹⁶ Curcumin (found in turmeric) reduces inflammation in tenocytes, or tendon cells.¹⁶ Lastly, omega-3 fatty acids, such as eicosapentaenoic acid, is found to enhance collagen formation.¹⁶

- Sleeping issues – Avoid refined carbohydrates, which cause spikes and crashes in blood glucose levels that have been linked to an increased risk of developing insomnia.¹⁷ Low glycemic index foods raise blood sugar levels more slowly. Adherence to the DASH diet of whole grains, nuts, low and nonfat dairy and fruits and vegetables is associated with lower odds of insomnia.¹⁷

- Headache – An imbalance of fluid and electrolytes can cause a dehydration headache.¹⁹ Replace lost fluid with an oral rehydration solution. A simple solution could contain 6 teaspoons sugar and ½ teaspoon salt to alleviate this symptom.¹⁹

- Altitude Sickness – Hydration decreases risk of frost bite and fatigue. At altitude, respiratory water losses, increased fluid loss at rest, and hypoxic-induced diuresis increase the body’s need for water, even exceeding 4 liters of water per day.²⁰ Iron availability is crucial in hypoxia.²⁰ The move from sea level to altitude increases iron acquisition and erythropoiesis.²⁰ Fish such as mussels, oysters, canned sardines and salmon, as well as chicken, turkey, ham and veal are all good sources of heme iron.²⁰ Though research is ongoing, it is possible that a high carbohydrate diet is the best macronutrient distribution in altitude.²⁰ Fat may not be tolerated as well at altitude and can worsen symptoms of acute mountain sickness.²¹ Fat requires more oxygen for metabolism than carbohydrates by 8-
For cold weather, energy bars, oatmeal with dried fruit, pancakes, pasta, rice and even sports drinks with sodium can be helpful. Eating enough protein, fat and carbohydrates, with an emphasis on carbohydrates, will be beneficial in higher altitudes.20

- Hypothermia – This may be caused by malnutrition and a lack of fat, resulting in less insulation and more heat loss.22 The best course of action is to find a way to warm the individual. Nutritional therapy includes an increase in caloric intake through frequent feedings to support essential body functions for heat generation.22 Maintaining warmth overnight may suggest an increased percentage of fat in evening meals, which will metabolize more slowly through the night.

The following is a summary of the vitamins and minerals listed above, their recommended dietary allowance (RDA) or adequate intake (AI), as well as examples of food sources for each.

Potassium – 3,500-4,700mg
Examples: White beans, potatoes, sweet potatoes, parsnips, spinach, swiss chard, tomato sauce

Zinc – 8-11mg
Examples: Meat, shellfish, chickpeas, lentils, beans, seeds, nuts, dairy, eggs, whole grains

Fiber – 25-32g

Lipoic Acid – no daily recommendation
Examples: Red meat, carrots, beets, spinach, broccoli, and potatoes

Chromium – 25-35mcg
Examples: Meat, whole wheat

Arginine, glutamine and branched-chain amino acids leucine, isoleucine and valine – 144mg/kg
Examples: Meat, dairy, legumes

Vitamin C – 65-90mg
Examples: Tomatoes, tomato juice, potatoes, red green peppers, broccoli, brussels sprouts

Vitamin D – 1000-4000IU
Examples: Cod liver, salmon, swordfish, tuna fish, sardines, beef liver

Omega 3 – 2-2.5g
Examples: Mackerel, salmon, cod liver oil, flax seeds, chia seeds

Curcumin – 150-250mg
Example: Turmeric

Heme Iron – 17 – 18.9mg
Examples: Beef, chicken liver, poultry
Analysis of the market

The market is saturated with backpacking meals. Six main companies have been chosen as the most popular brands. The majority of company products are freeze dried, with a few choosing dehydration. The following is a breakdown of cost, features and nutrients of the most popular meals of each of the six companies.

**Figure 2.** Analysis of the market for shelf stable dinner products available for backpackers.

<table>
<thead>
<tr>
<th></th>
<th>Mountain House</th>
<th>Good to go</th>
<th>Backpackers Pantry</th>
<th>Alpine Aire</th>
<th>Peak Refuel</th>
<th>Firepot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$10</td>
<td>$14.25</td>
<td>$10</td>
<td>$12</td>
<td>$13</td>
<td>$13</td>
</tr>
<tr>
<td>Method</td>
<td>Freeze dried</td>
<td>Dehydrated</td>
<td>Freeze dried</td>
<td>Freeze dried &amp; dehydrated</td>
<td>Freeze dried</td>
<td>Dehydrated</td>
</tr>
<tr>
<td>Weight</td>
<td>4.2 oz</td>
<td>6.6 oz</td>
<td>8.1 oz</td>
<td>6.0 oz</td>
<td>5 oz</td>
<td>7 oz</td>
</tr>
<tr>
<td>Calories</td>
<td>480</td>
<td>770</td>
<td>930</td>
<td>540</td>
<td>810</td>
<td>550 – 835</td>
</tr>
<tr>
<td>Protein</td>
<td>23g</td>
<td>20g</td>
<td>40g</td>
<td>42g</td>
<td>41g</td>
<td>50g</td>
</tr>
<tr>
<td>Carbs</td>
<td>23g</td>
<td>112g</td>
<td>131g</td>
<td>96g</td>
<td>50g</td>
<td>75g</td>
</tr>
<tr>
<td>Added sugar</td>
<td>19g</td>
<td>5g</td>
<td>10g</td>
<td>0g</td>
<td>8g</td>
<td>12g</td>
</tr>
<tr>
<td>Fat</td>
<td>4.5g</td>
<td>28g</td>
<td>33g</td>
<td>4g</td>
<td>46g</td>
<td>5.6g</td>
</tr>
<tr>
<td>Sodium</td>
<td>1420mg</td>
<td>1010mg</td>
<td>1550mg</td>
<td>1180mg</td>
<td>950mg</td>
<td>2700mg</td>
</tr>
<tr>
<td>Notable features</td>
<td>Gluten free, Recyclable packaging, no artificial preservatives</td>
<td>Vegan, gluten free, made by an award winning chef</td>
<td>Facility powered by solar energy Organic non-GMO textured soy protein. BPA free</td>
<td>Gluten free “all natural” (minimally processed)</td>
<td>Targeted to men. Claim to have double protein? “Real meat”</td>
<td>Gluten free, lactose free, regular and extra large</td>
</tr>
</tbody>
</table>

Oz – ounces; G – gram; Mg – milligram

Product delivery and gaps in the market

The average cost of a backpacking product ranges from between $10 to $15. That means if an athlete is interested in going on a two week hike, he would be spending $140 to $168 on dinner. This would not take into account breakfast, lunch and snacks which may be the reason why so many backpackers choose to eat low-cost dinners that lack nutrient value, such as ramen noodles and powdered potatoes. There does not seem to be an option for backpackers to choose a nutrient dense and affordable meal. The nutrition found within the expensive meals on the market contain high amounts of added sugar and sodium. Many are lacking in calcium and fiber. With constipation and diarrhea being two of the most often mentioned symptoms of backpacking illnesses,
fiber should be emphasized. Additionally, with the prevalence of strains to bones and muscles, calcium, vitamin D and complete proteins with additional emphasis on amino acids that make up collagen would be recommended. Reviews on the flavor of certain recipes are great. However, many of the reviews of meals are considered tasteless and overly salty. These issues could be remedied with careful recipe development and the addition of certain nutrients to prevent current and long-term injuries. This would also entail an ability to cultivate meals at an affordable price to make them accessible to the younger generation of athletes who make up the bulk of backpackers.

Marketing new products to the retail space

A new product requires 35% more attention and time than an established product. Much of this time is spent educating the customer on the product. Face-to-face meetings have been shown to provide the best results. In order to properly market a new product like a backpacker's meal, one must establish meetings with large companies that sell to consumers. Examples include REI, Walmart, sporting goods stores, outdoor outfitters, and companies that specialize in running and biking. Small and large businesses buy in bulk and sell to consumers. One can also market directly to consumers online. To convince a company to pick up a new product can be challenging. Resistance to sales typically occurs later in the process for new products. As the buyer learns more, he or she becomes more hesitant to abandon the status quo or to spend money on a product that does not have known success in the market. At first, the customer might think the salesperson is not revealing something important about the product. Then, they might fear open-ended situations, which raise doubt and uncertainty, and begin to worry about disruption to their established budget. As the sale becomes more serious, more people get involved in decision making with additional opinions and concerns. Customers focus on risk and regret. For the salesperson, this translates to initial interest by the potential buyer and then very little to show for effort when many potential buyers find reason to pull out. Ways in which this can be mitigated is to spend more time upfront investigating good prospects and targeting a smaller group of customers who are most likely to successfully buy. If the salesperson can promise the company a profit, they will be much more likely to invest in the product.

Food packaging should include form, function, beauty and simplicity. It should also include benefits clearly stated on the packaging such as protein amounts, time to prepare, whether it is gluten-free, vegan, organic, and/or calories per pouch. In order to attain minimal cleanup for the demographic and easy “pack in pack out” accessibility, backpacking meal containers must be able to hold boiling water. Mylar pouches are commonly used for their strength and durability. They are vacuum or heat sealable for long term storage. They reflect light, are puncture and tear resistant, and provide a moisture and oxygen barrier.
**USDA/FDA guidelines for production**

There are four main methods for producing shelf stable meals that are nutrient dense and safe for consumption without refrigeration. These methods are retorting, freeze drying, dehydrating, and vacuum drying.

Retort pouches are commonly seen in military rations and are defined as flexible pouches for low-acid foods that are thermally processed in a pressure vessel (called a retort) and made of three to five layers; polyester, aluminum foil, nylon, polyethylene and polypropylene. The inner most layer, polyethylene, is aseptic. The meal is placed in the pouch, sealed and then retorted at extremely high temperatures and rapidly cooled to the ambient temperature. Commercial sterilization occurs at temperature of greater than 212° F. In most cases, temperatures reach 240° to 250° F. After this process is complete, the retort package will be shelf stable for months. The cooler the climate, the longer the food retains its stability.

To freeze dry, frozen food is placed in a special vacuum cabinet. There, ice changes from a solid state directly to a vapor state without first becoming a liquid. This process is called sublimation, and eliminates 98% of the moisture from the original food. To use freeze-dried foods, they must be rehydrated with water and must be packaged in moisture-proof, hermetically sealed containers like mylar. Freeze dried food can last on a shelf from 6 months to 25 years. Typically, it will be the lightest weight option, and the option that retains 97% of the nutrients in the original meal. It should also hold its flavor and texture.

Dehydrating is the most affordable method of food preservation. This method has been around for hundreds of years, when one would simply lie food out and allow the sun to dry it overtime. First, food preparation is required so that the elements of the meal are sliced in uniform thickness and dry as a unit. Food is dried at 110° to 160° F, depending on the item, until pliable. This will take anywhere from 6 to 36 hours. The best way to dehydrate is to make batches of one item at a time so the drying process is identical. Even herbs are a great option for dehydrating and adding flavor to a meal that must be rehydrated. With meat, the USDA recommends first heating raw meat to 160° F and then dehydrating at a steady temperature of 145° F to kill bacteria.

Vacuum oven drying facilitates drying under reduced pressure to reduce the boiling point of substances. This allows evaporation of the unwanted materials from food without burning. The air tight vessel uses vacuum pumps to reduce pressure and humidity within the machine, so that the materials dry more quickly by contacting the heated walls indirectly. The attached vacuum pump expels air and moisture from the system, and the reduced pressure changes moisture into vapor which is removed again via the pump. This process should be quick, allowing conservation of energy and a quick production process. Pans must be placed directly on the metal shelves to conduct heat. The process of determining time depends on many variables, such as the surface area per unit weight, the total moisture and nature of the food, and the concentration of sugars.
Methods of Product Production

Prior to developing the product, nutrient requirements were determined for a typical hiker during the day. The age range for the adult hiker commonly falls between 18-30 years old. The approximate caloric requirement per day is between 3,000 and 5,000 calories, and therefore, a dinner portion for optimal nutrient replenishment should fall between 1,200 and 1,500 calories. The following daily menu was created wherein items which are lightweight, and shelf stable provide adequate energy, and are timed appropriately to fuel an athlete who is walking in uneven terrain with a backpack at approximately 30% of their total weight for four hours. This meal includes a breakfast with protein and complex carbs to promote muscle growth and sustain energy, two snacks and lunch that utilize simple carbohydrates for replenishing glycogen stores, and a recovery dinner that provides omega-3 long-chain fatty acids to enhance recovery of muscular performance and reduce soreness post-exercise.

Full Day of Eating

Breakfast: 1 16 oz cup coffee, 1 cup oats with 2 tbsp peanut butter powder and 3 tbsp granola soaked in water.

Snack: 1 cup dried fruit, ½ cup trail mix with chocolate & unsalted nuts

Lunch: 2 StarKist tuna pouches (148g) wrapped in two 8” white tortillas

Snack: 2 oz beef jerky, ½ cup dried fruit

Dinner: Surf & Turf Pesto Pasta

Dessert: ½ cup dried fruit, 2 tbsp granola, 2 oz dark chocolate, 1 cup herbal tea

Energy: 4210kcal
Protein: 181.1g x 4 = 724 = 17%
Net Carbs: 540.8g x 4 = 2163 = 51%
Fat: 148.2g x 9 = 1334 = 32%

Additional notable nutrients are Fiber (57g), Sodium (3.6g), Potassium (5.6g), Vitamin D (43mcg), Calcium (669mg), Iron (34mg), Omega 3 (4g), Vitamin C (156mg), Zinc (21mg), Leucine (8.5g), Isoleucine (4.5g), Valine (5g), Chromium in beef, and whole wheat; Heme iron in beef; Lipoic acid in beef, spinach and broccoli.

The following meal was developed to be a packaged, dried product for backpackers. The recipe includes a series of ingredients that would provide efficient calories, as well as important macronutrients and micronutrients to promote recovery, replenish muscle glycogen, and avoid deficiencies that can result in injury on the trail. In addition, the steps required to process the product prior to drying are presented.
Surf and Turf Pesto Pasta

**Ingredients**
- Beef steak, chuck, 4 oz
- Salmon, 3 oz
- Pasta, whole wheat, dry, 2 cups
- Pesto sauce, see sub recipe
- Cod liver oil, 1 tsp
- Red bell peppers, chopped, 0.5 cups
- Spinach, 1 cup
- Broccoli, chopped, 0.5 cups
- Olive oil, 1/2 tbsp
- Salt, 1/4 tsp
- Pepper, 1/8 tsp

**Pesto Sauce Ingredients**
- Pine nuts, 1 tbsp
- Olive oil, 1 tbsp
- Parmesan, grated, 2 tbsp
- Basil, 0.5 cups
- Lemon juice, 1 tsp

**Instructions**
- Add 4 cups salted water to a pot. Place over high heat until boiling and add pasta.
- Add pesto ingredients to a blender and blend until smooth. Set aside.
- In a separate pan, sauté oil over medium high heat
- Add beef and salmon. Let cook until browned/golden then flip sides. 4-5 minutes.
- Remove from heat. Add red bell peppers and broccoli and sauté until fork easily pierces, approximately 5 minutes. Add spinach and cook until wilted. Top with cod liver oil.
- Combine in bowl with pesto and mix thoroughly.

**Nutrition Facts**

<table>
<thead>
<tr>
<th>Amount per serving</th>
<th>Calories 1290</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Daily Value*</td>
<td></td>
</tr>
<tr>
<td>Total Fat 53g</td>
<td>68%</td>
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<tr>
<td>Saturated Fat 11g</td>
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<tr>
<td>Trans Fat 0g</td>
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</tr>
<tr>
<td>Cholesterol 155mg</td>
<td>52%</td>
</tr>
<tr>
<td>Sodium 860mg</td>
<td>37%</td>
</tr>
<tr>
<td>Total Carbohydrate 139g</td>
<td>51%</td>
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<tr>
<td>Dietary Fiber 10g</td>
<td>36%</td>
</tr>
<tr>
<td>Total Sugars 10g</td>
<td></td>
</tr>
<tr>
<td>Includes 0g Added Sugars</td>
<td>0%</td>
</tr>
<tr>
<td>Protein 71g</td>
<td></td>
</tr>
</tbody>
</table>

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Additional notable nutrients are Omega 3 (3g), Vitamin C (137mg), Zinc (7mg), Arginine (3g), Glutamic acid (7g), Leucine (4g), Isoleucine (2g), Valine (2g), Chromium in beef, and whole wheat, Heme iron in beef, Lipoic acid in beef, spinach and broccoli.
Meal production process via freeze-drying, vacuum drying in oven, and dehydrating

The process of preparing the food included cooking in batches, weighing and separating between eight containers, and refrigerating overnight. The next morning, the food was brought to the lab. Four servings were frozen for freeze drying. Two additional servings were laid out for vacuum drying. Two were spares in case of unforeseen incidents.

Freeze drying: Freeze drying was a long but ultimately successful process. It took 2-3 hours to cool to the appropriate temperature of -35°C. Four servings were placed in the freeze dryer. They were frozen at a max temperature for 3 hours. Then, slowly the temperatures rose until the heating process at 40°C was maintained for 4 hours. The freeze drying process took a total of 19 hours. However, in the first attempt, the meat was not completely dry by the end. Because of this, the meat was thinned manually, and the entire process was repeated. By the end of the second drying process, all of the samples were dry and placed in bags with oxygen packets. Utilization of a vacuum sealer allowed the meals to be protected from degradation over time. If the vacuum sealer had still contained nitrogen, the bag would have been injected with this nontoxic gas to give it a more appealing product value.

This method provided the best rehydrated product in taste and nutrient density, and was determined to be the best recipe to utilize in product development. A standardized recipe for freeze drying is established as follows:

Thinly slice the meat and spread the meal on a freeze dryer metal tray so that the ingredients are evenly spaced apart. Place the product in the freezer for several hours until it is frozen through at -35°C. Insert the trays into the freeze dryer. Place a probe in the thickest piece of the meat to determine internal temperature and set the process so that the initial freeze shelf setpoint is -35°C for 2 hours, the primary dry increases by 5°C every hour for ten hours, the secondary dry shelf setpoint is set at 40°C for 3 hours and the final probe reads that the product temperature is 20°C. Then, place the product in a thick, food grade mylar bag with an oxygen absorber. Utilize a vacuum sealer to remove oxygen in the bag and seal the product inside. Finally, inject the bag with non-toxic nitrogen gas to provide product appeal.

Vacuum Oven: The oven was heated to 75°C for 4 hours. After preheating, the vacuum turned on at 20 in/mercury. Heat was raised to 87°C and left it to dry overnight. At 9:30AM the following day, the food was removed and the meat was tested. The water activity meter read the beef index at 0.768A_w. The machine that calculated this determines unbound water vapor pressures to find microbial spoilage, chemical and physical stability. Any reading below 0.85A_w is considered reasonably shelf stable. Because the beef held the most moisture of all the elements of the sample, it was concluded that the product was shelf stable. However, the color was browned and blackened in some places, the food was no longer distinguishable, and it held very little appeal. While the food still tasted okay, it was no longer particularly appetizing and should not be provided to customers.
Dehydrating: Each element of the meal was placed into the dehydrator individually. Pesto was spread thin and dried at 122°F for 12 hours. Unfortunately, because of the high fat content, it carried a lot of oil after drying. This may lead to a reduced shelf life. For future reference, creating a pesto without as much oil will be beneficial for longevity. Beef was dried at 158°F for 5.5 hours, salmon at 134° for 8 hours, and the heartier vegetables, red bell peppers and broccoli, went in at 122°F for 12 hours. Spinach dried for 12 hours at 113°F and pasta at 140° for 10 hours. The use of multiple machines would reduce the time needed to dry. Vacuum sealing directly after production would increase shelf life.

**Taste analysis after rehydration**

Freeze Drying: This process was by far the most effective. Two-thirds of a cup of boiling water was placed into the mylar bag, the meal was stirred, and sat to soak up liquid for 15 minutes. Below are photos of the finished product. The meal tasted nearly identical to its flavor at freshness. The pesto held a nice strong flavor. The only thing to note was that the salmon had lost some of its appeal upon rehydration.
Vacuum Oven Drying: No attempt was made to rehydrate this meal. It had been severely burnt in the drying process (see below) and would not have been edible. While the elements were safe for long term storage, the flavor was completely gone.

Dehydrating: One cup of boiling water was placed in the mylar bag to rehydrate the product. The bag was shaken thoroughly, resealed, and set aside. After 15 minutes, the meal was ready to eat. The texture of the meat and fish was not as digestible or appealing as that of the freeze dried version. The meat was hard and over cooked, the salmon was dry and fairly tasteless. The vegetables and noodles heated up nicely, and tasted very good.
Future aims and practical application

Recipe: The response to the recipe has had heavily mixed reviews. To some, it sounds tasty, to many it sounds unappealing. The first change would be to remove the cod liver oil from the recipe. Even though the taste is unintelligible, the idea does not illicit a positive response. The next change would be to remove the salmon. While this decreases the nutrient value, at the end of a long hike, dehydrated fish is not attractive to most, and the addition of tuna packets for lunch will provide some omega 3s to the daily intake of the backpacker. A hiker is seeking comfort over nutrient density. These changes would bring down the cost of the meal. Third, how does it truly differ from what Mountain House and other large suppliers offer? Without the elements previously expressed, it could be provided at a cheaper cost, but overall, there would not be enough differences to pull ahead in a saturated market. While freeze drying is the best option to dry food, it would be a high cost to start. It would also take several years to become a profitable business with good success. Moving forward, if the choice was made to pursue this field, production would consist of comfort foods that hit the key points of nutrient necessity; macronutrient density in efficient percentages and high caloric value, which could be produced affordably and would appeal to the mass population of backpackers, bringing comfort after a long day on the trail. These recipes would include beef and potatoes with nourishing gravies, pastas with cheese sauce like macaroni and cheese, pork ramen, sesame chicken and rice, Pad Thai, lentils and rice, or hearty soups like minestrone, and beef stew.

### Buffalo Chicken Mac N Cheese

**Development cost - $4.01**

**Nutrition Facts**

<table>
<thead>
<tr>
<th>Serving size (566g)</th>
<th>Amount per serving</th>
<th>Calories</th>
<th>% Daily Value*</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1400</td>
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</tr>
<tr>
<td>Total Fat 42g</td>
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</tr>
<tr>
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<tr>
<td>Trans Fat 0g</td>
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<tr>
<td>Cholesterol 160mg</td>
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<tr>
<td>Sodium 1040mg</td>
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</tr>
<tr>
<td>Total Carbohydrate 172g</td>
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</tr>
<tr>
<td>Dietary Fiber 1g</td>
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<tr>
<td>Total Sugars 8g</td>
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</tr>
<tr>
<td>Includes 0g Added Sugars</td>
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</tr>
<tr>
<td>Protein 37g</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Nutrition Facts**

- Total Fat: 50g (27%)
- Saturated Fat: 16g (25%)
- Trans Fat: 1g
- Cholesterol: 130mg (1%)
- Sodium: 500mg (20%)
- Total Carbohydrate: 73g (27%)
- Dietary Fiber: 8g (20%)
- Total Sugars: 7g (0%)
- Includes 0g Added Sugars (0%)
- Protein: 43g

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

### Mince & Tatties

**Development cost - $3.07**

**Nutrition Facts**

<table>
<thead>
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<th>Serving size (731g)</th>
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<th>Calories</th>
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<tr>
<td></td>
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<td>Trans Fat 1g</td>
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<tr>
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</tr>
<tr>
<td>Total Sugars 7g</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| Includes 0g Added Sugars (0%)
| Protein 43g          |                     |          |                |

*The % Daily Value tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.*
Branding: The title of the company, Upstream, was developed through reflection on phrases that invoke the essence of the backpacker lifestyle. Similar to a salmon swimming upstream, people seek out this journey for the adventure and excitement that awaits them, and because of the hardship it presents, it rarely makes sense to an outside perspective. Words which evoke the essence of this brand would be peace, solitude, excitement, adventure, thrill, and anticipation. In the packaging, a sticker would be included in each bag which would help spread the word and provide a small gift for the buyer. Larger companies like REI, Mountain High, High Country, and even Walmart would be contacted and provided samples in order to start a conversation about providing this product in their stores.

Logo:
Federal and State Regulations: Water activity in foods must be below 0.85 to prevent bacterial growth.$^{27}$ This is the ratio that represents water available for a microorganisms.
growth, not to be confused with moisture content, or the total amount of water in a food.\textsuperscript{27} To sell food, registration is required under section 415 of the Federal Food, Drug and Cosmetic Act.\textsuperscript{27} To package and hold dried commodities, the Current Good Manufacturing Practices of 21 CFR Part 117, Subpart B must be followed.\textsuperscript{27} Operating temperatures and humidity of equipment and produce must be monitored.\textsuperscript{27} A food safety plan may need to be written which includes hazard analysis, preventative controls, supply-chain program, a recall plan, monitoring procedures, and corrective actions.\textsuperscript{27} Validation documents for process preventive controls should also be included.\textsuperscript{27} Subpart B includes disease control and cleanliness, plant construction and design, as well as grounds maintenance, sanitary operations, facilities, and control of disposal, equipment and utensil use, processes and controls, warehousing and distribution to protect against allergen cross-contact, and defect action levels.\textsuperscript{28} 21 CFR Part 117, Subpart B may be provided upon request.

Production: On average, warehouse space is $0.85 per square foot per month. The smaller the space, the higher the cost per square foot. There is a warehouse in Cumming, GA at $1.08 per sq ft per month at 1,400 sq ft.\textsuperscript{29} The average cost would be $1,442/month or $17,302/year. The cost of an eight rack freeze dryer would be approximately $4,100.\textsuperscript{30} To start, purchasing four freeze dryers would require a one-time payment of $16,400. Walk in freezers cost approximately $10,000, and energy to operate a walk-in freezer at 8,000kW a year is $1,200.\textsuperscript{31} Four freeze dryers at $2/day/unit would cost approximately $2,920, totaling an energy cost of ~$4,120/year.\textsuperscript{30} The cost of 5,000 labeled mylar bags would be $1,985.\textsuperscript{32} Cost of the meal is ~$6.47. With four freeze dryers, 64 meals could be produced and packaged every 2 days. If business was successful, at 9,216 meals per year, total cost of the first year of meals would be $59,627.52. Total costs of production would be ~$107,450. If the product is sold at $8 per meal, 13,431 products would need to be sold to break even the first year. With only four freeze dryers running six times a week, that goal could not be reached, even if demand was high enough.

As enjoyable as the learning process has been in pursing the development and supply of a dehydrated backpacking meal, the expectation of this project was not reached. While the meal is nutrient dense, the idea of eating the meal has been received with mixed reviews, the cost is very high, and the product would need to be provided at a similar price point to competitors to retain any possibility of breaking even. Providing meals that are much cheaper to produce could eventually lead to a profit margin, and allow for a smaller price point to customers. While $8 is cheaper than all other products on the market, the cost is not quite low enough to bring enough popularity in the first year to successfully sell 37 meals per day every day during the first year. Moving forward, the next steps would be cooking and drying a low cost product with high caloric density and a good macronutrient ratio for recovery and setting the price point at $5 or $6 to be highly competitive in the market place. The gap has not been closed on nutrient dense and highly affordable backpacking meals. However, for someone willing to put in the time, effort, cost, and ultimate risk, comfort driven and nourishing products could be developed at a much more affordable rate than what the current market provides.
REFERENCES:


Development of Marketable, Shelf-Stable, and Affordable Nutrient-Dense Mealtime Products for Backpackers Hiking Multi-Day Trips

Alana Ahrens

PANEL
Jessica Todd, MS, RD, LD
Professor William Kerr, Ph.D
Mackenzie White, MS, RD, CSSD, CSCS

Committee Chair
Committee Member
Committee Member
Agenda

1. Backpacking: An Overview
2. Backpacking Nutrition
3. Market Analysis
4. Production Options
5. Methods for Production
6. Food Prep Process
7. Marketing Plan
8. Future Aims
<table>
<thead>
<tr>
<th>Nutrient Dense</th>
<th>Broadly Palatable</th>
<th>Affordable</th>
<th>Profitable</th>
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</thead>
<tbody>
<tr>
<td></td>
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Backpacking: An Overview
Backpacking Nutrition
Kilocalories = MET × weight in kilograms × duration in hours

**Increased caloric requirement of individuals backpacking 10 miles/day on uneven terrain.**

<table>
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<tr>
<th>Per Hour</th>
<th>MET at 8</th>
<th>MET at 8.3</th>
<th>BMR</th>
<th>10m/d Male</th>
<th>10m/d Female</th>
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<tbody>
<tr>
<td>120 (54.5kg)</td>
<td>436</td>
<td>452</td>
<td>1363</td>
<td>3107 - 3171</td>
<td>2890 - 2949</td>
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<tr>
<td>150 (68.2kg)</td>
<td>546</td>
<td>566</td>
<td>1705</td>
<td>3889 - 3969</td>
<td>3617 - 3691</td>
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<tr>
<td>180 (81.8kg)</td>
<td>654</td>
<td>679</td>
<td>2045</td>
<td>4661 - 4761</td>
<td>4335 - 4428</td>
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<tr>
<td>210 (95.5kg)</td>
<td>764</td>
<td>793</td>
<td>2386</td>
<td>5442 - 5558</td>
<td>5061 - 5169</td>
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</tbody>
</table>

MET - Metabolic equivalent, MET at 8.0 - 25-49 pound load, upstairs; MET at 8.3 - climbing hills with 21-42 pound pack, BMR - Basal metabolic rate, M/d - Miles per day
| Common Injuries
<table>
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<tbody>
<tr>
<td>Exhaustion</td>
</tr>
<tr>
<td>Sleeping issues</td>
</tr>
<tr>
<td>Heat Stroke</td>
</tr>
<tr>
<td>Dehydration</td>
</tr>
<tr>
<td>Headache</td>
</tr>
</tbody>
</table>
Breakfast: 1 cup coffee, 1 cup oats with 2 tbsp peanut butter powder, and 3 tbsp granola soaked in water.

Snack: 1 cup dried fruit, ½ cup trail mix with chocolate & unsalted nuts

Lunch: 2 StarKist tuna pouches (148g) wrapped in two white tortillas

Snack: 2 oz beef jerky, 1/2 cup dried fruit

Dinner: Surf & Turf Pesto Pasta

Dessert: 1/2 cup dried fruit, 2 tbsp granola, 2 oz dark chocolate, 1 cup herbal tea

Energy: 4210kcal
Protein: 181.1g x 4 = 724 = 17%
Carbs: 540.8g x 4 = 2163 = 51%
Fat: 148.2g x 9 = 1334 = 32%
Market Analysis
## Comparison

<table>
<thead>
<tr>
<th></th>
<th>Mountain House</th>
<th>Good to go</th>
<th>Backpackers Pantry</th>
<th>Peak Refuel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cost</strong></td>
<td>$10</td>
<td>$14.25</td>
<td>$10</td>
<td>$13</td>
</tr>
<tr>
<td><strong>Method</strong></td>
<td>Freeze dried</td>
<td>Dehydrated</td>
<td>Freeze dried</td>
<td>Freeze dried</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>4.2 oz</td>
<td>6.6 oz</td>
<td>8.1 oz</td>
<td>5 oz</td>
</tr>
<tr>
<td><strong>Calories</strong></td>
<td>480</td>
<td>770</td>
<td>930</td>
<td>810</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>23g</td>
<td>20g</td>
<td>40g</td>
<td>41g</td>
</tr>
<tr>
<td><strong>Carbs</strong></td>
<td>23g</td>
<td>112g</td>
<td>131g</td>
<td>50g</td>
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<tr>
<td><strong>Added Sugar</strong></td>
<td>19g</td>
<td>5g</td>
<td>10g</td>
<td>8g</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
<td>4.5g</td>
<td>28g</td>
<td>33g</td>
<td>46g</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>1420mg</td>
<td>1010mg</td>
<td>1550mg</td>
<td>950mg</td>
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</tbody>
</table>
Production Options
Retort Pouches
Retort Pouches

Vacuum Oven Drying
Retort Pouches

Freeze Drying

Vacuum Oven Drying

Dehydrating
Methods of Production
Surf & Turf Pesto Pasta
Additional notable nutrients are Omega 3 (3g), Vitamin C (137mg), Zinc (7mg), Arginine (3g), Glutamic acid (7g), Leucine (4g), Isoleucine (2g), Valine (2g), Chromium in beef, and whole wheat, Heme iron in beef, Lipoic acid in beef, spinach and broccoli.
<table>
<thead>
<tr>
<th></th>
<th>Mountain House</th>
<th>Good to go</th>
<th>Backpackers Pantry</th>
<th>Peak Refuel</th>
<th>Upstream</th>
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<tbody>
<tr>
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<td>$14.25</td>
<td>$10</td>
<td>$13</td>
<td>$8</td>
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<td>Method</td>
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<td>Freeze dried</td>
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<tr>
<td>Weight</td>
<td>4.2 oz</td>
<td>6.6 oz</td>
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<td>6 oz</td>
</tr>
<tr>
<td>Calories</td>
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<td>770</td>
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<tr>
<td>Protein</td>
<td>23g</td>
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<td>40g</td>
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<td>71g</td>
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<td>23g</td>
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<td>19g</td>
<td>5g</td>
<td>10g</td>
<td>8g</td>
<td>0g</td>
</tr>
<tr>
<td>Fat</td>
<td>4.5g</td>
<td>28g</td>
<td>33g</td>
<td>46g</td>
<td>53g</td>
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<tr>
<td>Sodium</td>
<td>1420mg</td>
<td>1010mg</td>
<td>1550mg</td>
<td>950mg</td>
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</table>
Food Prep Process

Freeze Drying
Food Prep Process

Freeze Drying  Vacuum Oven
Food Prep Process

- Freeze Drying
- Vacuum Oven
- Dehydrating
Freeze Drying Instructions:

Thinly slice meat and spread meal on freeze dryer metal tray so that ingredients are spaced apart.

Place in freezer for several hours until frozen through at -35° C. Insert trays into Freeze Dryer, place probe in thickest piece of meat to determine internal temperature, and set process for the following:

- **Initial Freeze**: Shelf Setpoint set at -35°C for 2 hours
- **Primary Dry**: Increase °C by 5 every hour for ten hours
- **Secondary Dry**: Shelf Setpoint set at 40°C for 3 hours
- **Final**: Probe reads product temperature is 20°C

Place in a thick, food-grade mylar bag with an oxygen absorber. Utilize vacuum sealer to remove oxygen and seal. Inject with non-toxic nitrogen gas to provide product appeal.
Federal Regulations

- Water activity in food must be below 0.85Aw
- **Section 415 of the FD&C Act (21 U.S.C. 350d)**
  - Requires domestic and foreign facilities that manufacture, process, pack, or hold food for human or animal consumption in the United States to register with FDA.
- **Current Good Manufacturing Practices of 21 CFR Part 117, Subpart B**
  - Operating temps
  - Food safety plan
  - Validation documents
  - Disease control & cleanliness
  - Plant construction & design
  - Grounds maintenance, sanitary operations
  - Protection against allergen cross-contact
Marketing Plan
SURF & TURF
PESTO PASTA

FUELING FOR SUCCESS

One 10 mile hike carrying a 30lb backpack across uneven terrain can burn an additional 2000-5000kcal above your resting energy expenditure.

Exercise of this caliber requires nutrients to recover your brain and body. Consistently under fueling leads to common injuries.

Never take a zero again with the proper sustenance, carefully formulated to align with recovery and accelerate performance on the trail.

PREPARATION

- Remove and discard oxygen absorber
- Add 2/3 cup (160mL) boiling water
- Stir and reseal
- Let sit for 15-20 minutes
- Stir one more time, and enjoy directly from the pouch!

INGREDIENTS:
Whole wheat pasta, beef, salmon, spinach, broccoli, red bell pepper, parmesan, olive oil, cod liver oil, pine nuts, basil, lemon juice, salt, pepper
Cost: Year One
Whole Sale Cost $59,628
Warehouse Rent $17,302
Freeze Dryer $16,400
Walk-in Freezer $10,000
Electricity $4,120
Mylar Bags $1,985

Total: $107,450
To break even: 13,431 sold
Future Aims

• Compare 1, 5, 10, 20 years
  ◦ Consider inflation
  ◦ Factor in changes in technology
• Discuss with other companies the length of time before profitability
• Plant visits
• Product testing
  ◦ Vegetarian options
  ◦ Dietary restrictions
  ◦ Customization based on future market research and client feedback
Future Aims

- Less concentration on nutrients
- Fishless options
- Be wary of too much fiber
Future Aims

- Less concentration on nutrients
- Fishless options
- Be wary of too much fiber
- Focus on taste & macros
- Affordable, comfort meals
<table>
<thead>
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<th>Total Carb (g)</th>
<th>Total Sugars (g)</th>
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<td>Mince &amp; Tatties</td>
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<td>52</td>
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References

Thank You!