CAPSTONE EXPERIENCE 2015
Balanced Bar: Programming and Process Development

PURDUE UNIVERSITY

Agricultural & Biological ENGINEERING

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Introduction

Problem Statement & Background

The overall goal of The Salad Bar project is to use all-natural ingredients to produce a healthy, meal-supplement bar that is manufactured on a local farm by a student-run plant.

Market Research

The **market is moving towards bars with higher nutritional standards** in the form of hearty, healthy, organic bars [2].In fact, the "nutritional" bar segment of the bar industry is growing while the more **traditional "snack" bar segment is steadily declining** [1]. According to Mintel, the typical snack bar consumer **ages 18-37**, **making Purdue's campus an ideal consumer market** for our product [1].

Linear Programming Approach

A user-interface, Starting Point, which utilizes linear programming, was developed to maximize the nutritional value of products. We wanted the **bar to contain as close to 20% of the daily value for all macronutrients**. Thus we chose to minimize the sum of squared errors between the calculated percent daily value for fiber, lipid, carbohydrate and protein and 20%.

$$OBJ = [F_i - 0.2]^2 + [L_i - 0.2]^2 + [C_i - 0.2]^2 + [P_i - 0.2]^2$$

Where F_i, L_i, C_i, and P_i are the calculated percent daily value of fiber, lipid, carbohydrate, and protein for the i^{th} combination of ingredients.

Bar Formulation

Figure 1 reflects the balanced nutritional value of the Salad Bar. Table 1 summarizes the balanced recipe for an 80gram, of solids, bar.

Nutrition Facts

Serving Size 1 1 BAr (1g)
Servings Per Container 1

Amount Per Serving	
Calories 290	*Calories from Fat* 88
	% Daily Values*
Total Fat 9.82g	21%
Saturated Fat 0g	N/A
Trans Fat 0g	
Sodium 0mg	N/A
Total Carbohydrate 49.12g	35%
Dietary Fiber 10.12g	24%
Sugars 0g	
Protein 11.39g	20%

*Percent Daily Values are based on a 2,000 calorie diet.

Figure 1. (left) Salad Bar nutrition label.
Table 1. (below) Salad Bar ingredient formula and each respective composition of total bar.

Ingredient	Composition (%)
Almond	20
Bell pepper	0.8
Black bean	20
Brown rice	20
Carrot	19.2
Corn	20

Experimental Methods

Binding Agent Determination

A suitable binding agent was experimentally determined based on binding ability. Cornstarch and tapioca starch were considered at 6%wt, 14%wt and 18%wt concentrations. Considering the ideal product, it was apparent the 6wt% tapioca starch was best, which makes the binding agent 18% of the bar mass.

Particle Size Evaluation

A sensory experiment tested textural qualities based upon vegetable particle size. In this experiment, dehydrated banana chips were ground within a food processor into three separate particle size samples ($\frac{1}{4}$", $\frac{1}{8}$" and $\frac{1}{16}$"). A 6%wt tapioca starch solution was added to each sample then baked for 15 minutes at 350˚F. Each bar texture was analyzed and ranked based on preference. With a perfect score, the smallest particle size was rated as the favorite.

Vegetable Dehydration Investigation

This third experiment was designed to determine suitable vegetable dehydration rates. Moisture content was recorded at various time increments for carrots, corn, and bell pepper samples as they dried in a dehydrator at 150 °F.

Figure 2. (left) Dehydrated bell peppers, carrots and corn along with hydrated black beans and almonds.

Salad Bar Trial

With an understanding of key bar characteristics, scale processing of the Salad Bar occurred. After all ingredients were properly prepared, 6wt% tapioca starch solution wad added to the combined components and the bar was baked at 350ºF for 25minutes.

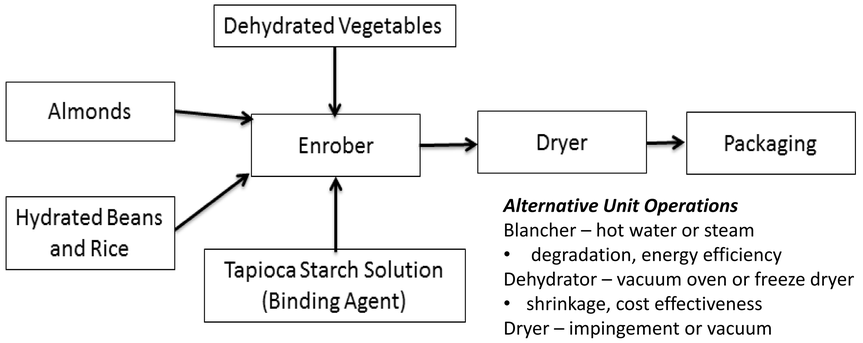
Figure 3. Salad Bar from test processing

Semi-Batch Process: Vegetable Dehydration

Fresh Vegetables:
- Corn
- Carrots
- Bell Peppers

→ Cut Vegetables → Blanch Vegetables → Dehydrate Vegetables → Store Dehydrated Vegetables

Continuous Process: Assimilation to Packaging



Alternative Unit Operations

Blancher – hot water or steam
- degradation, energy efficiency

Dehydrator – vacuum oven or freeze dryer
- shrinkage, cost effectiveness

Dryer – impingement or vacuum
- continuous, market prevalence

Economic Evaluation

The **capital investment** of this project is **$346,500 in working capital and $2,310,000 in equipment, land, and building**. Once production begins**, $713,000 of annual profit** will be made for a bar **price of $**1, return on investment of **45%** and a **production rate of 183,000kg/year** will meet anticipated demand.

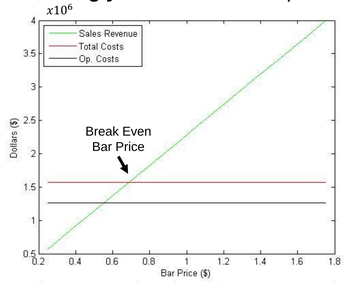


Figure 4. Various bar prices compared to revenue and total costs

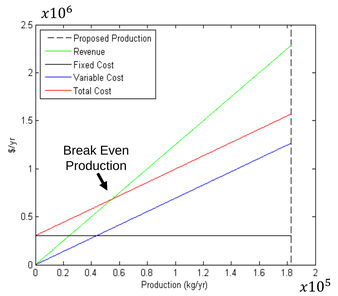


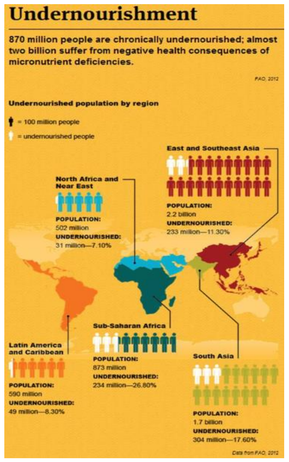
Figure 5. Salad Bar production (kg/yr) compared to fixed, total and variable costs.

Impact

Sustainability

The Salad Bar enables sustainable farming as it's ingredients are all **natural, wholesome Indiana farm produce**. Our product is organic and local which will not perpetuate the use of harmful chemicals and pollutants.

Societal and Global



- The software, Starting Point, could facilitate **long term food planning**. Families could plan weekly meals to that meet their dietary needs and **prevent diet related diseases**.
- To demonstrate versatility, we used the software to balance pizza and nacho recipes.
- Starting Point, could bring better nutrition to developing countries. First, the program develop **affordable, shelf stable food products**. Second, the program could **optimize** what crops a country needs **to meet nutritional demand**.

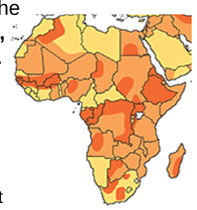


Figure 6. (left) Undernourishment infographic published by the Food and Agriculture Organizations of the United Nations [4]. **Figure 7. (right)**Prevalence of micronutrient deficiency in developing countries [4].

Conclusion

Overall, the Salad Bar is the perfectly balanced, nutritious snack. Meeting **one-fifth the daily requirements of protein, carbohydrates, lipids, and fiber**, this treat will satisfy health-conscious consumers. Moreover, the user-interface, Starting Point, could be adapted to **optimize the nutrition of a variety of food products**. This would certainly be useful for dieticians and food scientists alike looking to offer nutritionally-balanced recipes to their clients. In particular, we feel that Starting Point could be particularly valuable for food companies looking to tweak their current recipes to bring healthier food products to market.

References

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Sponsor:
Dr. Martin Okos, Professor
Agricultural & Biological Engineering

Acknowledgements:
- This project was supported by the Biological Engineering and Food Science departments.
- A special thanks to all faculty whom supported our work.

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