Product Challenges in the Development of Protein and Keto-Friendly Food Products

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Overview

- Brief history of the Ketogenic diet
- Types of Ketogenic Diets
- Benefits and risks
- Case Study: Developing a Keto-friendly food
  - Business risks to consider
  - Platform choice
  - Protein regulations and quantification
  - Alternative sweeteners
  - Dietary fiber
  - Using dietary fiber for product structural functionality

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Origins of the Ketogenic Diet

500 BC
Fasting used to treat epilepsy – Hippocratic Collection

1920
Ketogenic diet developed to mimic metabolism of fasting for treating epilepsy

1994
NBC’s Dateline television program reported the case of Charlie Abrahams, son of Hollywood producer Jim Abrahams.

2019

Keto-diet reduces epileptic seizures

- Used for almost 100-yrs to reduce epileptic seizures.
  - Primarily intended for children not responsive to seizure medications.
    - Dietary compliance is an issue for adults.
    - Modified Atkins recommended for adults.
  - Helpful in treating the following conditions:
    - Infantile spasms
    - Tuberous sclerosis complex
    - Dravet syndrome
    - Doose Syndrome
    - Glut-1 Deficiency

- Potential side effects:
  - Constipation
  - High cholesterol
  - Ketoacidosis
  - Kidney stones

Benefits of a ketogenic diet beyond epilepsy

• Weight loss (primarily)

Possibly,

• Reduced Acne
• Improved blood sugar control
• Lower triglycerides
• Reduced Inflammation
• Reduced Brain tumors
• Reduced Breast cancer
PET (Positron Emission Tomography) Scan

fluorodeoxyglucose (\(^{18}\text{F}\))
\(((2S,6R)-6\text{-meth},-2\text{-ol})\)
Obesity increases cancer risks

Dot size is proportional to relative risk.

Figure modified from United Kingdom Dept. of Health and Social Care brochure
Weight Management as a driver of consumer demand and need

• More than 2/3 of US adults are overweight or obese.
• Demand for weight management foods and plans remains high.
• Diet plans have generally low long-term compliance.
### Four types of Ketogenic Diets

<table>
<thead>
<tr>
<th>Standard ketogenic diet (SKD)</th>
<th>Targeted keto diet (TKD)</th>
<th>Cyclical keto diet (CKD)</th>
<th>High-Protein Keto Diet (HPKD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Macronutrient Ratio:</strong></td>
<td><strong>Macronutrient Ratio:</strong></td>
<td><strong>5-days &quot;ON&quot;</strong></td>
<td><strong>Macronutrient Ratio:</strong></td>
</tr>
<tr>
<td>75% fat</td>
<td>65-70% fat</td>
<td>75% fat</td>
<td>60-65% fat,</td>
</tr>
<tr>
<td>15-20% protein</td>
<td>20% protein</td>
<td>15-20% protein</td>
<td>30% protein,</td>
</tr>
<tr>
<td>5-10% carbs</td>
<td>10-15% carbs</td>
<td>5-10% carbs</td>
<td>5-10% carb</td>
</tr>
<tr>
<td>Carbs consumed at exercise times.</td>
<td></td>
<td>2-days &quot;OFF&quot;</td>
<td>Primarily used by bodybuilders.</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

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Risks of starting a ketogenic diet

- The "keto flu"
- Diarrhea
- Constipation
- Reduced athletic performance
- Ketoacidosis
- Weight regain
- Less muscle mass
- Decreased metabolism
- Increased risk of heart disease and diabetes

Lack of dietary fiber; Irritable bowel
Business risk considerations

- Benefits of keto-diet for healthy individuals still under study.
- Known risks of keto-diet may be significant.
- Diet compliance is an issue.
- Ketosis is highly individualized state (variable consumer results).
- No validated health claims.

Conclusion:
- Focus on “Keto-friendly”.
- Advise use with a Keto diet only under physician supervision.
- Make good, nutritious food that stands on its own regardless of diet.
Choosing a platform for a Keto-friendly food product

Considerations:
- natural
- high fat
- high protein
- low carb or high fiber
- locally sourced (California)
- existing consumer health aura
- well studied for health and safety
- healthy food regardless of diet plan
Chosen Platform: Nut Butters (almonds)

- Almonds: locally grown and manufactured.
- Composition is close to Keto diet.
  - 51% fat
  - 21% protein
  - 20% carbs (13% dietary fiber)
- Wide range of secondary foods and platforms possible.
- Well accepted and high liking by consumers.
Flexibility of Almonds for Protein and Oil sourcing

- 51% fat
- 21% protein
- 20% carbs (13% dietary fiber)

Expeller pressed almonds + MCT Oil or Coconut Oil

Almond Oil

Almond Protein Powder

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Correctly quantifying almond protein

- NCF of 5.18 assigned in 1896.
- Based on nitrogen of purified Amandin (storage protein).
- Significant other proteins present.
- Limiting amino acids (PDCAAS) shown to change with oil extraction.
- Factor not specified for Dumas method.

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Su et al. (2017) Food Research Int’l 100, 87-95.
Sweetening (Artificial or Natural?)

- Any sugar content has a negative perception by most keto dieters.
- Sugar within the accepted keto diet limits provides a more clean label.
- Alternative sweeteners needed for toolbox.
  - Sugar alcohols
  - Stevia
  - Other?.....Allulose
Bioactive Sweeteners: Allulose

- Monosaccharide
- Stereo chemical isomer of fructose (3-position)
- 70% of the sweetness of sucrose
- 0 to 0.4 calories per gram
- Inhibits intestinal alpha-glucosidase
- Physiological benefit of Fiber: Glycemic response reduction
  - Reduced digestion of co-consumed starch!
Citizen Petition for Alternative Calories Granted

FDA Issues Draft Guidance Regarding the Declaration of Allulose on the Nutrition Facts Label

- Allulose to count as 0.4 calories per gram
- Does not need to be included Total Sugars
- Does not need to be included in Added Sugars
- Does need to be included in Total Carbohydrates
• Keto diets typically lack dietary fiber.
• Complications of both constipation and diarrhea can result.
• Reduced digestion and absorption.
• Reduced mineral uptake.
• Negative impact to gut microbiome and intestine.
Mucosal layer in a Fiber-rich vs Fiber-free diet

Dietary Fiber Consumption Falls Short Worldwide

“Today, the benefits of a high-fiber diet are emphasized by all major international health agencies.”


Physiological benefits of dietary fiber

- Lower Triglycerides
- Reduced Glycemic Response
- Mineral uptake/retention
- Lower Blood Pressure
- Lower Cholesterol
- Laxation
- Weight Loss
- Satiety
Weight Management with Viscous Fiber

- Complements weight management equity of Keto-diet.
- Viscous dietary fiber provide a feeling of fullness and satiety.
- Reduced caloric intake.
- Peer-reviewed clinical support.
- Existing EFSA affirmed health claim.
Using viscous dietary fiber to modify rheology

![Graph showing viscosity (cP) over time (min) for Control Chocolate Almond Butter, Supplier 1 - Fiber in Chocolate Almond Butter, and Supplier 2 - Fiber in Chocolate Almond Butter.](image-url)
Better product characteristics with select dietary fibers

60-Day 22°C Storage

13.0% (v/v) Oil Separation
Control

0% (v/v) Oil Separation
Test
Control + Dietary Fiber
Oil separation in a fiber stabilized almond butter

![Graph showing oil separation over days of storage at 22 °C]

- Control
- Test - (Control + Specific fiber)
Advantages of fiber stabilized nut butters

• Greater consumer appeal
  – Oil separated nut butter highly unappetizing.
  – Does not completely reincorporate with mixing.
  – Viscous nut butter similar to commercial peanut butter rheology.

• No use of ingredients with negative consumer perception:
  – No hydrogenated fats
  – No Palm oils
  – No Emulsifiers

• Intellectual property available to capture – patent pending.
Summary

• Keto diets benefits are primarily weight loss (Weight Management)
• Benefits and risks of the Keto diet are still under study
• Disclaimers regarding diet highly recommended
• Keto-friendly foods can fit the Keto-diet or stand on their own
• When developing a Keto-friendly food, consider:
  – composition of source ingredient
  – the NCF used for protein
  – which sweetener is most compatible with intended consumers
  – dietary fiber content
  – innovating and capturing intellectual property
Thank You for your time!

Questions?
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Introduction: Dave Plank

- Managing Principle of WRSS-Food & Nutrition Insights
- Senior Research Fellow, Dept. of Food Science and Nutrition, U of M
- 35+ years of Research and Development Experience
  - 27 U.S. and International patents
  - 15 peer-reviewed journal articles
- Research areas:
  - Dietary Fiber
  - Protein Quality
  - Trans fat replacement technology
  - Enzyme analysis methodologies
  - Analytical method development
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