Flavor Modulation Innovations for High-Protein Snacks

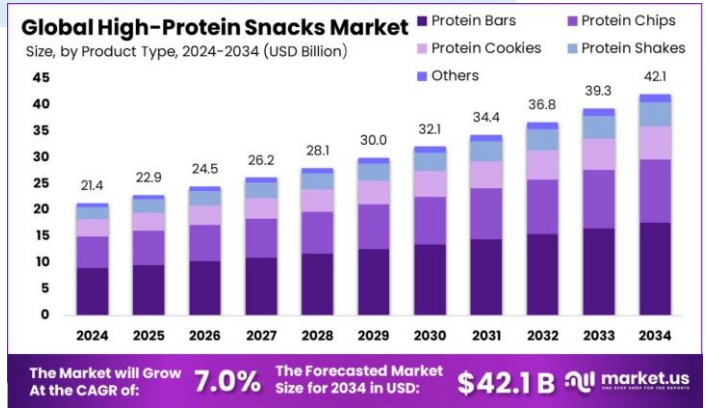
Thanakorn Wongprasert, Ph.D.

School of Food Industry,

King Mongkut's Institute of Technology Ladkrabang

thanakorn.wo@kmitl.ac.th

1 The High-Protein Snacks Introduction



- The global market continues to thrive with a robust CAGR of 8.31%.
- Increasing consumer awareness is driving the demand for snacks that offer more than just basic nutrition specifically high-protein options.

- no longer exclusive to gym-goers or bodybuilders
- new target is busy professional, aging, and weight management population

- Bakery
  Cookies, brownies, and high-protein bread
- Savory Snacks
  Crispy snacks and plant-based/legume chips
- Beverages
  Protein-fortified coffee and fruit juices

https://market.us/report/high-protein-snacks-market/

1 The Tastiness Gap

Surveys show Taste is the primary reason for brand loyalty in functional snacks.

Consumers

Trial

Health benefits
(Protein, Wellness, Nutrition)

Loyalty

only return for sensory satisfaction
(flavor and enjoyment)

consumers will not repurchase a healthy snack if the flavor is disappointing

https://pngtree.com/free-png-vectors/protein-bar
https://proteinpackage.co.uk/products/surreal-protein-cereal-uk-peanut-butter-flavour
https://stayrealfoodinc.com/products/walnut-chocolate-chip-protein-cookie

Stickel, L., Grunert, K. G., & Lähteenmäki, L. (2025). Implicit and explicit liking of a snack with health-versus taste-related information. Food Quality and Preference, 122, 105293.

1 Key Challenges

Physical Barriers

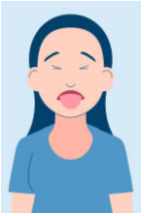
Mouthfeel: sandy, or chalky sensation

- Dryness (astringency) creates a poor eating experience and interferes with how flavor is perceived and released

Sensory Hurdles

Unwanted odors, such as beany, grassy, or sulfurous notes.

- Many protein sources leave a lingering bitterness or metallic aftertaste that masks the intended flavor



https://www.trysnow.com/blogs/news/how-to-get-rid-of-metallic-taste-in-the-mouth
https://www.tiktok.com/discover/foods-with-texture-of-chalk
https://www.reddit.com/r/AskBaking/comments/1ehp0bb/what_gives_italian_bakery_cookies_such_a_sandy/

2 Flavor Chemistry in high protein snacks

Food Proteins

Animal Proteins

Off-flavors

Oxidized
(Cardboard, Soapy)

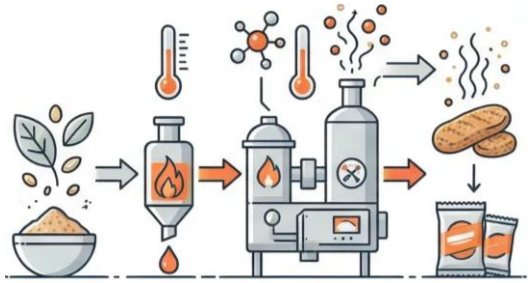
Sulfurous

Plant Proteins

Green
(Beany, Grassy, Earthy)

Flavor-protein interactions

Flavor Interference



Impact on product formulation

Choose right flavor masking or flavor pairing

2 Flavor Binding

- flavor compounds can interact with macronutrients in food such as carbohydrate, fat, and especially protein
- This phenomenon can be occurred in both animal and plant protein
- Lead to flavor loss or imbalanced flavor

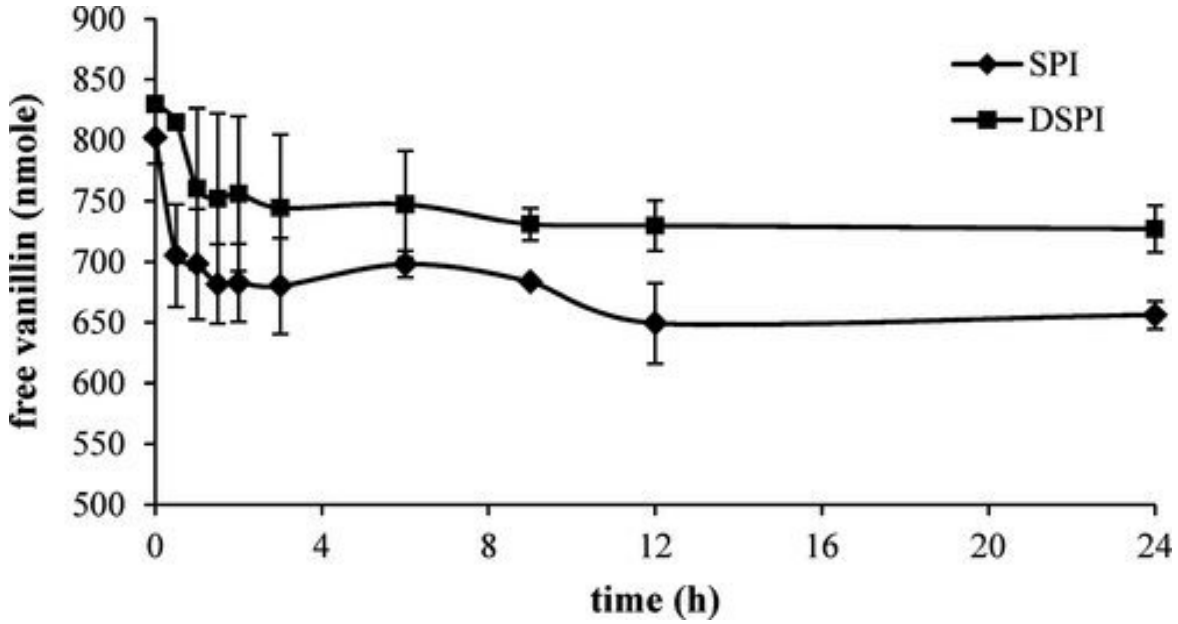


Figure 1. Equilibration curves for binding of vanillin with soy protein isolate (SPI) and deamidated soy protein isolate (DSPI) at 25 °C.

Suppavorasatit, I., & Cadwallader, K. R. (2012). Effect of enzymatic deamidation of soy protein by protein–glutaminase on the flavor-binding properties of the protein under aqueous conditions. *Journal of Agricultural and Food Chemistry, 60(32),* 7817-7823.

2 Flavor Binding

- Mainly hydrophobic or hydrogen bonding (covalent bonding possible)
  - Pea protein with flavor compounds in aqueous system
- Binding affinity/capacity depends on environmental conditions

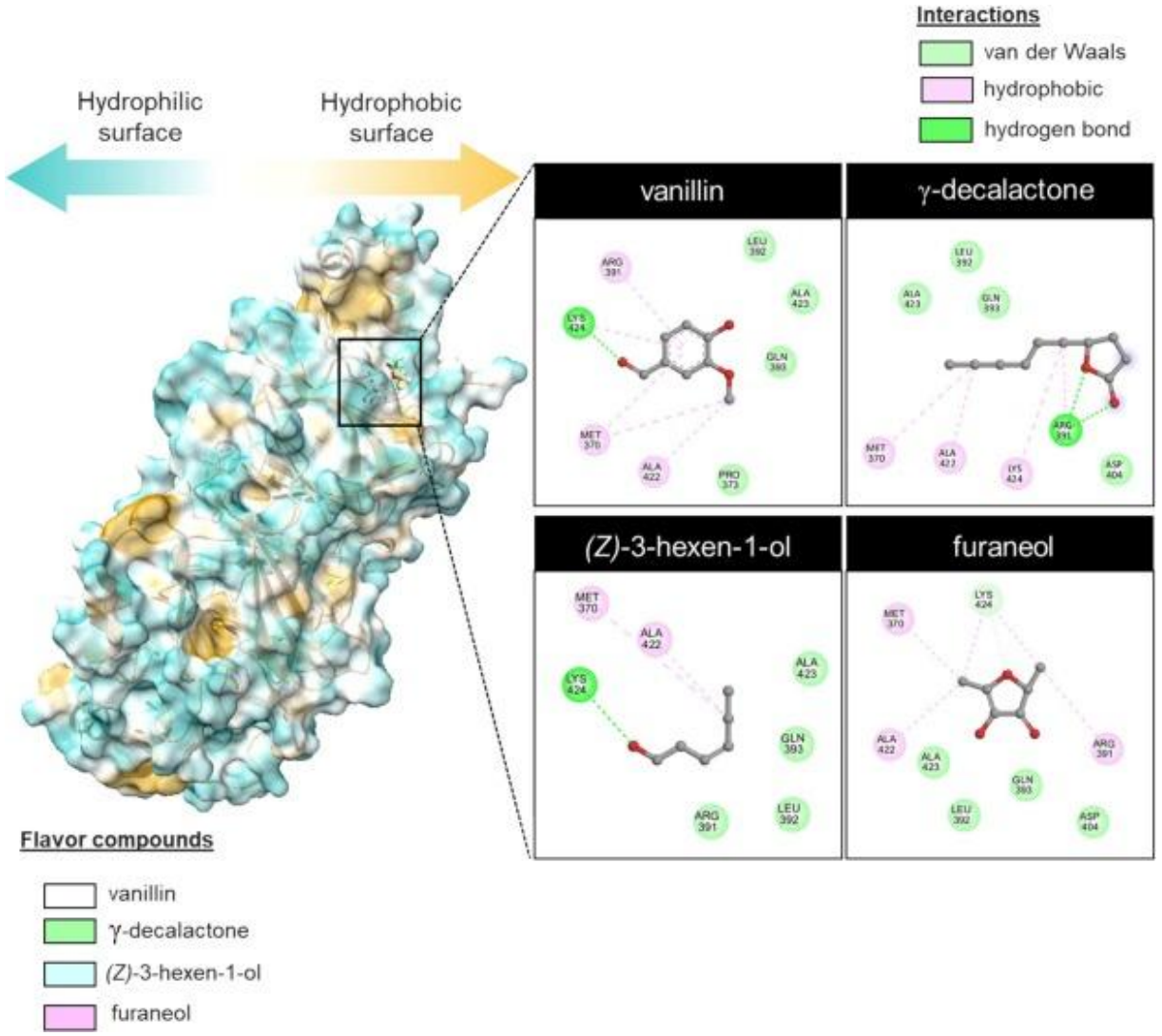
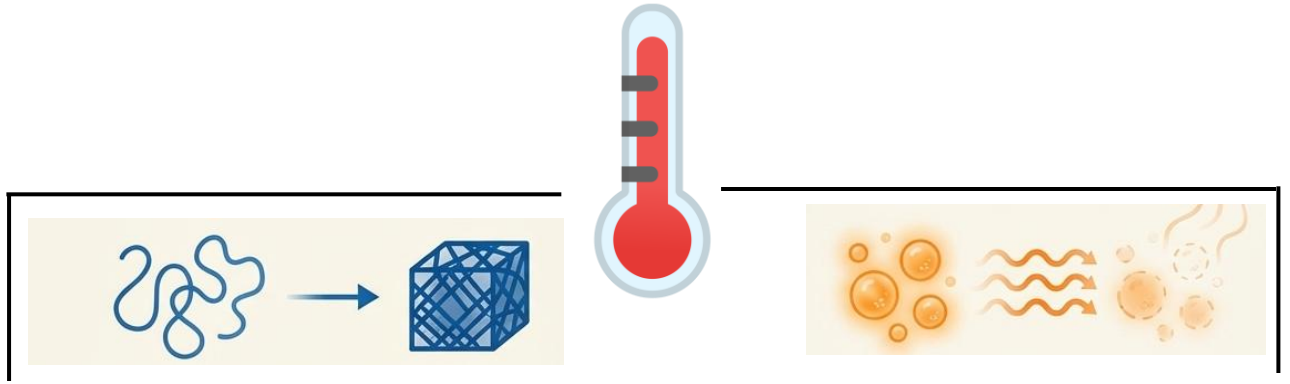


Figure 2. Computational binding results for pea protein with each flavor compound. Representative of the best molecular docking model in 3D diagram (b) 2D enlarged view diagrams of pea protein – each selected flavor compounds.

Wongprasert, T., Mathatheeranan, P., Siripitakpong, P., Vilaivan, T., Suriya, U., Rungrotmongkol, T., & Suppavorasatit, I. (2024). Effect of functional groups in strawberry flavoring on pea protein-flavor interactions: Potential applicable in flavor formulation for plant-based protein aqueous foods. Food Chemistry: X, 23, 101702.

2 Processing impact on flavor compounds



Restructuring of protein

- Thermal denaturation (baking/extrusion) cause unfolding and rapid aggregation
- Under high heat and shear, proteins can form chemical complexes with flavor compounds.

Thermal Degradation

- High temperatures cause sensitive flavor compounds to evaporate (volatilize) before the product is even finished, leading to a bland or weak aroma
- accelerate the mailard reaction, risking burnt or metallic off-notes

Bhandari, B., D'Arcy, B., & Young, G. (2001). International journal of food science & technology, 36(5), 453-461.

2 Product Form and Function

Beverages

- High moisture
  - spoilage concerns
  - viscosity/consistency concerns
- pH restrictions/limitation
- Severe thermal process (UHT)
- Integrated/mobile flavor system
- Ambient or refrigerated storage
  - variable shelf-life
- Difficult to use encapsulated flavors

2 Product Form and Function

Bars/Cereals

- Low moisture/low water activity
  - moisture migration concerns
  - texture concerns
  - possible phase changes
- No or mild thermal process
- Immobile flavor system
- Ambient storage/long shelf-life
- Possibility of using encapsulated flavors
  - will reduce flavor interaction and flavor loss potential

3 Developing a Flavor Solution

Approaches

- Reduction/removal of off-flavors in ingredients
- New/improved processing methods which minimize formation of off-flavors or reduce off-flavors (as a result of a process)
- Better flavoring solutions: addition of masking agents/ specialty formulated flavorings

Cadwallader, K.R. 2015. Flavor challenges in functional beverages. In Handbook of Functional Beverages in Human Health. Shahidi, F. , Alasalvar, C. (Eds.). CRC Press Taylor & Francis Group.

3 Masking agent

- Act to neutralize undesirable aromatics & tastes
- Should be applied before overlaying base with added flavoring (mask first/flavor later)
- Suppression ex. Bitterness suppression, Sweetness suppression, taste inhibition (taste blockers), Flavor potential (Enhancement)

https://www.futuremarketinsights.com/reports/flavour-masking-agents-market
https://www.gminsights.com/industry-analysis/flavor-masking-agents-market

3 Masking agent

Obtaining from most flavor houses

- proprietary or patented technology
- may be custom blended to meet requirement
- try several to find one that works in specific product application

Depending on R & D capability

- provide base to supplier for custom formulation
- trial-and-error (added benefit of proprietary product formulation) – select from numerous offthe shelf products

https://www.rawpixel.com/search/male%20scientist%20png?page=1&path=1522&sort=curated
https://pikbest.com/png-images/a-restaurant-logo-the-flavor-house_11030859.html

3 Partnering with Flavor House

Involve them early in the process

- greatly reduces development time

Provide the composition of your product

- protein, moisture, gums/stabilizers, pH, water activity
- minor components that could impact flavor

  vitamins, minerals, phytochemicals

- levels of sugar, high-intensity sweeteners

Inform them of any process and/or storage variables,

- thermal process conditions
- packaging and storage considerations

https://www.flavorist.com/ultimate-guide-to-flavor-lab-qc-instruments-names-functions-measurement-principles-for-technicians/

3 Flavoring a ‘masked’ product

Use a flavoring that complements residual or lingering aromatics and tastes

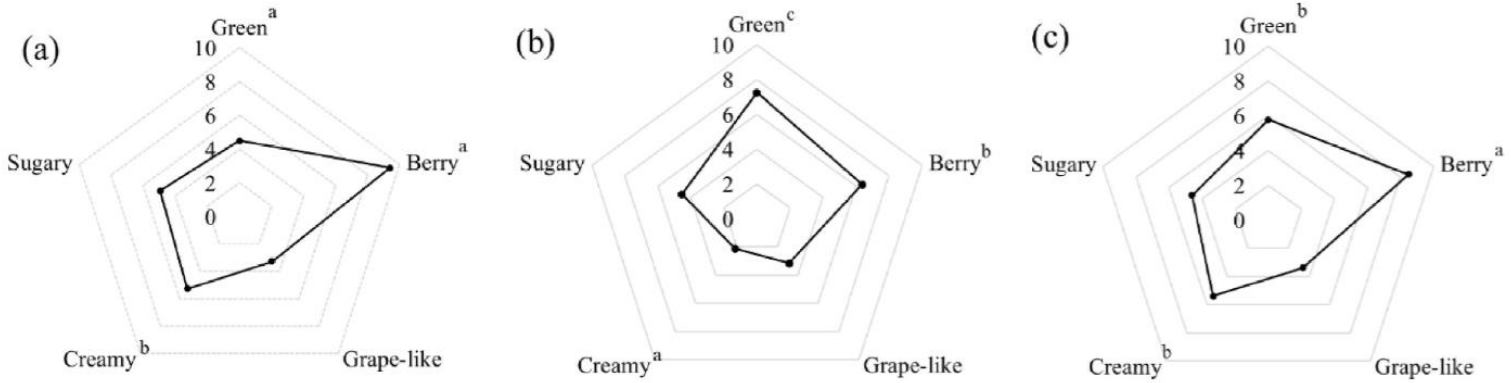
- also known as assimilation masking
- e.g. coffee/chocolate flavors –expect bitterness
- look for synergies (aromatic vs. taste compound)

Shelf-life issues: consider flavor changes that may occur over time

- flavor fade caused by binding of flavors to proteins
- reformulate flavor to account for selective flavor binding (flavor rebalancing)

3 Flavor Rebalancing

- Moving beyond simple masking to recalibrate how the palate perceives protein-derived off-notes.
- Using specific aroma compounds to bridge the gap between the protein base and the desired flavoring
- Re-aligning the flavor impact to match consumer expectations for traditional snacks



Wongprasert, T., Mathatheeranan, P., Siripitakpong, P., Vilaivan, T., Cadwallader, K., & Suppavorasatit, I. (2025). Competitive binding between key aroma components of a strawberry flavoring and pea protein isolate within an aqueous model system. Food Hydrocolloids, 162, 110956.

3 Flavor Rebalancing

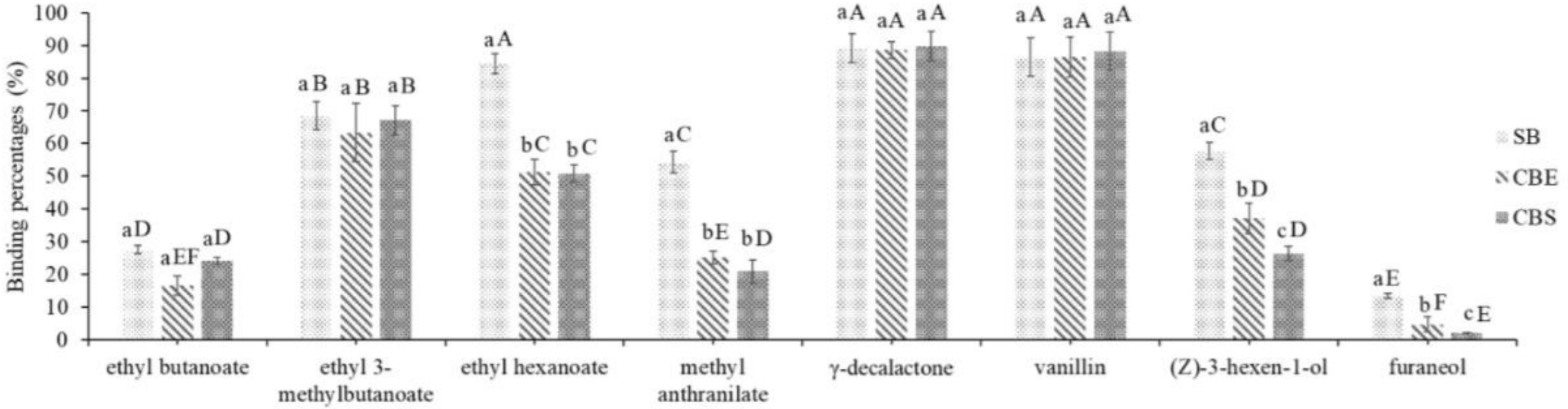


Figure 3. Binding of flavor compounds in 3% (w/v) PPI solutions at different conditions including single binding (SB), competitive binding with an equal concentration of all compounds (CBE), and competitive binding by using different concentrations following flavor profile in strawberry flavoring (CBS); Same lower case letters at same flavor compounds are not significantly different ($p > 0.05$, $n = 3$); same upper case letters within the same condition across different flavor compounds are not significantly different ($p > 0.05$, $n = 3$).

Wongprasert, T., Mathatheeranan, P., Siripitakpong, P., Vilaivan, T., Cadwallader, K., & Suppavorasatit, I. (2025). Competitive binding between key aroma components of a strawberry flavoring and pea protein isolate within an aqueous model system. Food Hydrocolloids, 162, 110956.

3 Flavoring Considerations for High Protein Functional Foods

- Products have intermediate pH (not sour/tart)

  Citrus, berry, grape, etc. flavors are not generally a viable option

- Neutral fruit flavors

  Mango, papaya, banana, peach

- Dairy and indulgent flavors

  Cream, vanilla, chocolate, fudge, coffee/mocha, peanut butter, coconut, cookies & crème, etc.

- Subtle flavors are challenging

3 Final Recommendations

Flavoring of a high-protein specialty foods and snacks is a big challenge

- Products carry off-flavors and may selectively bind (e.g. high protein products) added flavorings
- Be aware of off-flavor ‘potential’ of all ingredients
- Apply masking agents to the complete ‘base’ before adding flavorings
- Use complementary flavoring strategies for finished product

Thank you ☺

Thanakorn Wongprasert, Ph.D.

School of Food Industry,

King Mongkut's Institute of Technology Ladkrabang

thanakorn.wo@kmitl.ac.th