Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 06, Issue: 06 (NOV-DEC, 2026)
Available online at http://www.agriarticles.com
©Agri Articles, ISSN: 2582-9882

Peas as an Emerging Raw Material for Healthy Snack Development

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Peas (*Pisum sativum* L.) offer considerable potential for developing value-added snacks because their protein, starch and dietary fibre contribute both nutritional value and processing functionality. Pea flour, protein concentrates, isolates and starch-rich fractions can support diversified products, particularly expanded snacks and composite cereal-pulse formulations. However, successful development requires more than increasing protein concentration. Pea ingredients influence melt behaviour, expansion, hardness, flavour release and storage stability, creating trade-offs between nutritional improvement and sensory quality. Recent research identifies crispness and puffiness as important acceptance drivers, whereas pronounced pea and green flavours can reduce liking. Extrusion optimisation, ingredient blending, fermentation and targeted flavour management therefore provide complementary development strategies. This article reviews pea-based snack development, flavouring and seasoning technologies, protein-rich formulations, consumer acceptability and market potential.

Keywords: Pisum sativum, pea protein, extrusion, healthy snacks, flavour management, consumer acceptability.

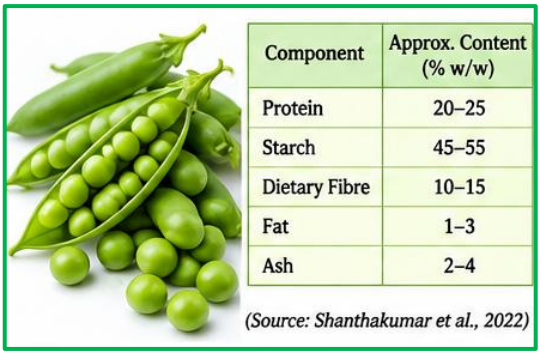
Introduction

Snack development increasingly combines convenience with improved nutritional composition. Within this context, peas provide an alternative to formulations dominated by refined cereal starch. Their relevance extends beyond protein enrichment: pea starch contributes to structure formation, fibre modifies hydration and texture, and proteins provide water-binding, emulsifying and gel-forming properties. Consequently, pea ingredients can function as structural components rather than merely nutritional supplements. Shanthakumar *et al*. (2022) described these functionalities as important foundations for expanding pea applications across cereal-based and other formulated foods. Nevertheless, adding peas does not automatically produce a healthy or acceptable snack. Nutritional performance depends on the complete formulation, including oil, salt, other ingredients and serving size. Likewise, a protein-enriched product may fail commercially when excessive hardness, poor expansion or undesirable flavour outweigh perceived nutritional benefits. In a direct investigation of high-plant-protein snack balls, Saint-Eve *et al*. (2019) found that texture strongly influenced liking, while pea-related flavour could become a barrier to acceptance. Healthy snack development should therefore treat nutritional composition and eating quality as connected design objectives.

Nutritional and Functional Significance

Dry peas generally contain approximately 20–25% protein, together with substantial starch and dietary fibre. Their proteins are rich in lysine but relatively limited in sulphur-containing amino

acids. Consequently, cereal–pea combinations offer a useful basis for complementary protein formulations. Pea proteins also provide hydration, emulsification, viscosity and gel-forming properties, making them structural ingredients rather than merely nutritional additives (Lu *et al*., 2020; Shanthakumar *et al*., 2022). Ingredient form determines the balance between nutrition and functionality. Whole or dehulled flour retains starch and other seed components; concentrates provide greater protein enrichment; and isolates enable higher protein inclusion with less accompanying carbohydrate. Nevertheless, protein purity alone does not predict performance. Extraction and drying can change protein conformation, solubility and flavour, influencing the suitability of an ingredient for a particular snack (Boukid *et al*., 2021). Genotype and milling characteristics also deserve attention (Ren *et al*. 2021) found that cooked wrinkled-pea flours contained 17.2–22.2% resistant starch on a dry basis, compared with 7.9–11.4% in round-pea flours. These results identify opportunities for differentiated ingredients, but they do not establish that an extruded snack will retain the same resistant-starch concentration or produce a lower glycaemic response. Finished-product testing remains necessary.



Component	Approx. Content (% w/w)
Protein	20–25
Starch	45–55
Dietary Fibre	10–15
Fat	1–3
Ash	2–4

(Source: Shanthakumar et al., 2022)

Fig.1: Nutritional Profile of Peas

Development of Value-Added Pea Snacks

Ingredient selection and fractionation

Dry fractionation produces protein-rich ingredients without the extensive water use and drying operations associated with wet extraction, although protein purity is generally lower. Wet extraction provides more purified isolates but can change native functionality. Selection should therefore consider protein concentration, flavour, water absorption, processing history and cost rather than assuming that isolates are always superior (Shanthakumar *et al*., 2022). A fraction-based development strategy can use pea protein for enrichment and pea starch for structure. Saldanha *et al*. (2019) demonstrated expanded snacks produced from pea starch, pea protein-rich fractions and oat fibre-rich fractions. This approach supports broader utilisation of crop components while allowing nutritional and physical properties to be adjusted through formulation and extrusion conditions.

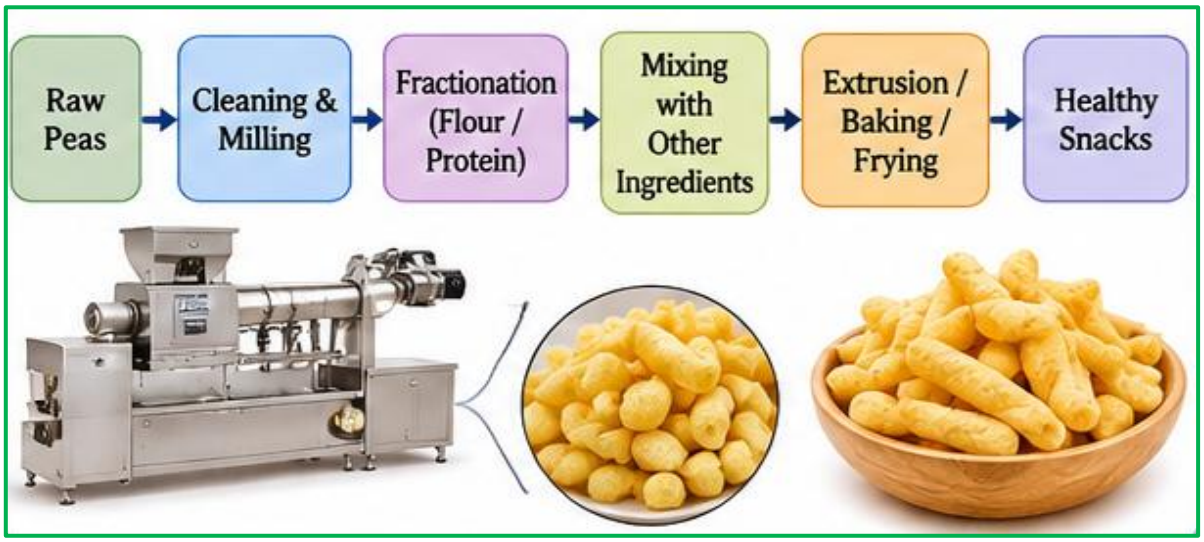


Fig.2: Process Flow for Pea-Based Snacks

Extrusion and structural development

Extrusion combines heat, pressure and shear to transform hydrated ingredients into shaped products. Expansion occurs as pressure decreases at the die exit, but final structure depends on whether the melt can retain its expanded form during cooling. Protein addition therefore affects

both bubble formation and subsequent structural stability (Beck *et al*., 2017; Philipp *et al*., 2018). The relationship between pea content and expansion is not simply linear. Philipp *et al*. (2017) reported the highest expansion at 10% pea protein isolate in their rice-starch system. In a separate investigation, Philipp *et al*. (2018) found the greatest final expansion at 20% isolate; although 30% produced high initial expansion, subsequent shrinkage reduced the final benefit. These findings show why published optimum inclusion levels cannot be transferred uncritically between formulations. Protein and fibre must also be evaluated together. Beck *et al*. (2018) investigated their combined incorporation into rice-starch extrudates, illustrating the need to optimise a multicomponent matrix rather than adjust protein alone. Broader legume-extrusion evidence similarly shows that moisture, temperature, screw configuration and ingredient composition interact to determine nutritional and physical quality (Pasqualone *et al*., 2020).

Flavouring and Seasoning Technologies

Controlling the source of undesirable flavour

Pea ingredients can exhibit beany, green, grassy and bitter characteristics. These sensations arise from different volatile and non-volatile components, so eliminating one aroma compound does not necessarily remove bitterness or astringency. Flavour improvement should therefore distinguish prevention of undesirable-compound formation, removal, masking and generation of desirable aromas (Lao *et al*., 2024). Raw-material selection is an important first step (Manouel *et al*. 2024) demonstrated that cultivation location and harvest year influenced pea-protein flavour-related characteristics. A consistent seasoning system cannot fully compensate for inconsistent starting ingredients; protein content should therefore be supplemented with flavour and functionality specifications.

Thermal treatment and fermentation

Pre-roasting can modify pea-protein structure and functionality, making it relevant to ingredient preparation, although its suitability depends on the intended application (Lao *et al*., 2023). Fermentation offers another route: Zipori *et al*. (2024) investigated selected lactic acid bacteria and yeasts for acidification and off-flavour reduction in pea-protein suspensions. These studies support ingredient-treatment opportunities, but results must be confirmed after incorporation into the complete snack. Thermal processing also generates desirable aromas. Goncuoglu *et al*. (2026) found that pea-protein inclusion and extrusion temperature influenced pyrazine formation in corn-based extrudates. Under their tested conditions, formulations containing up to 50% isolate offered a practical balance of physical properties and aroma development, whereas 70% caused less desirable structural changes. This was an experimental optimum, not a universal formulation limit.

Seasoning design

Seasoning should complement the snack's intrinsic flavour rather than merely increase flavour intensity. Savoury, roasted, herbal, spicy or tangy profiles are reasonable development options, but no single profile can be described as optimal without consumer testing. Saint-Eve *et al*. (2019) identified pea and green flavour perceptions as barriers to liking, demonstrating the importance of evaluating the complete flavoured product. Pea proteins can also act as emulsifying or encapsulating materials, offering potential for flavour-delivery systems. However, these general functionalities do not establish the performance of a particular commercial snack coating (Shanthakumar *et al*., 2022). A standardised vocabulary is equally important: Chigwedere *et al*. (2022) developed a pulse sensory lexicon and wheel to improve consistency in describing taste, aroma, flavour and trigeminal sensations. Such terminology helps distinguish a seasoning imbalance from an underlying ingredient defect.

Protein-Rich Formulation Strategies

A successful protein-rich formulation balances protein enrichment against starch availability, fibre effects and desired texture. Protein can compete with starch for water and modify melt behaviour; increasing inclusion may therefore reduce puffing or change fracture characteristics. Beck *et al*. (2017) and Philipp *et al*. (2018) demonstrated that protein transformation and melt properties are central to this relationship.

Three formulation principles follow from the evidence:

1. Establish a realistic protein target alongside a defined texture benchmark.
2. Compare flour, concentrate and isolate rather than choosing solely by protein purity.
3. optimise ingredient proportions and extrusion conditions together.

These are synthesis-based development principles, not a validated universal recipe. Their foundation is the documented dependence of pea functionality on processing history and matrix composition (Boukid *et al*., 2021; Beck *et al*., 2018). Nutritional assessment should extend beyond crude protein. Arribas *et al*. (2017) investigated nutritional composition, dietary fibre and *in vitro* digestibility in rice–pea–carob snacks, providing an example of evaluating multiple nutritional outcomes. Gas-assisted extrusion also offers an alternative physical-processing route: Koksel and Masatcioglu (2018) investigated nitrogen-assisted production of puffed yellow-pea snacks. Together, these studies illustrate opportunities to improve either the formulation or the expansion process rather than relying exclusively on higher isolate addition.

Consumer Acceptability and Market Potential

Consumer acceptance depends on eating quality, not nutritional composition alone. Saint-Eve *et al*. (2019) identified crispness and puffiness as positive attributes in high-plant-protein snacks. Philipp, Buckow, *et al*. (2017) likewise found that highly expanded samples were described as crisp, whereas less-expanded samples were perceived as hard, crunchy and non-crisp. Thus, "crunchy" and "crisp" should not be treated as interchangeable texture targets.

Instrumental methods can accelerate screening, but consumer testing remains necessary. The strong correlations between mechanical hardness and sensory hardness, and between acoustic measurements and sensory crispness, support their use in formulation studies. Nevertheless, these measurements do not establish purchase intention or repeated-consumption acceptance (Philipp, Buckow, *et al*., 2017). Market potential is supported by broader acceptance of pulses as alternative proteins. In a systematic review covering 91 articles, Onwezen *et al*. (2021) identified taste, health motives, familiarity, attitudes and food neophobia as recurring acceptance drivers. Pulses and plant-based alternatives showed comparatively favourable acceptance among the alternative-protein categories examined. However, this evidence does not provide a pea-snack market valuation or guarantee acceptance in a specific country or consumer segment.

The strongest commercial proposition is therefore a familiar, enjoyable snack with a demonstrable nutritional improvement—not a product marketed on pea content alone. The accompanying development flowchart summarises this integrated approach, from ingredient selection to finished-product validation.

Conclusion

Peas provide a credible platform for developing value-added, protein-enriched snacks, particularly through cereal blending and extrusion. The central challenge is to obtain nutritional improvement without compromising expansion, crispness or flavour. Recent evidence supports ingredient-specific optimisation, controlled flavour modification and combined instrumental–consumer evaluation. Claims concerning protein quality, resistant starch or health benefits should be based on the finished snack rather than inferred from the raw ingredient. Commercial progress will depend on consistent raw materials and balanced product performance, not maximum pea inclusion.

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