



## **Fortification of Wheat Based Instant Noodles with Surimi Powder: A Review**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors SC and SN collected the literatures cited here and wrote the first draft, arranged the final manuscript and refined as per the journal guidelines. Author DP helped in collection of literatures. Authors PM, KCD and FHR helped in final refinement of the manuscript. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Noodles, commonly prepared from hard/soft wheat flour, is popular throughout globe due to its versatility, low cost, ease of preparation and nutritional quality. Commercial noodles are rich in carbohydrates, but deficient in essential nutrients, like proteins, dietary fiber and vitamins. Due to scarcity of Essential Amino Acids (EAA) like lysine and methionine in wheat-proteins, incorporation of EAA-rich-protein and fatty-acid-rich-lipids from other sources are important to improve the nutritional quality of noodles. Fish, being an excellent source of high-quality protein, rich in lysine and methionine, omega-3 fatty-acids like eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), along with vitamins like A, D, B<sub>6</sub>, and B<sub>12</sub>, minerals like iron, zinc, iodine, selenium, potassium and sodium, protein enrichment can be achieved by fortification of carbohydrate-rich cereal-based-noodle with dried fish surimi powders. This makes the fortified noodles nutritionally significant and the sensory attributes facilitate greater consumption. Attributes like taste, nutrition, convenience, safety, longer shelf-life and reasonable price have increased global acceptance of noodles and admiration by all generations. Thus, instant noodles are used as space and

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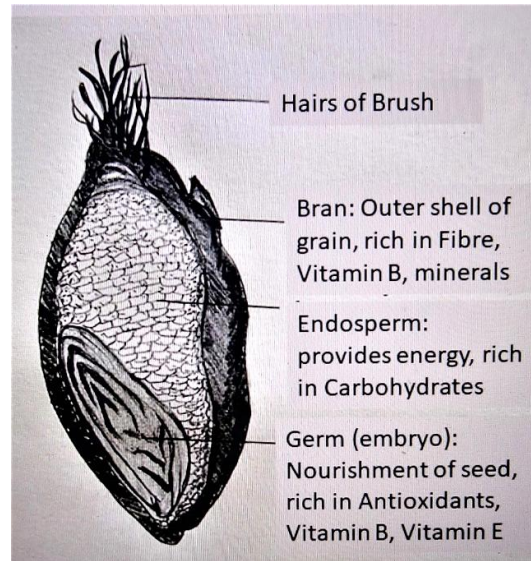
emergency foods. As consumers are becoming health conscious by preferring diet rich in fiber, protein and low fat, readily digestible fish protein incorporated noodles can satisfy their nutritional requirement.

**Keywords:** *Wheat noodles; wheat protein; fortification; fish surimi powder.*

## 1. INTRODUCTION

Cereal grains are the principal component of human diet around the world. The "cereals" belong to members of the Gramineae family and are considered staple food. The different species of cereals include wheat (*Triticum aestivum*), rye (*Secale cereale*), barley (*Hordeum vulgare*), oat (*Avena sativa L.*), rice (*Oryza sativa*), pearl millet (*Pennisetum glaucum*) or common millet (*Panicum miliaceum*), corn (*Zea mays*), sorghum (*Sorghum bicolor*), and triticale which is a hybrid of wheat and rye [1]. Nearly 60% of calories in developing countries are derived directly from cereals, with values exceeding 80% in the poorest nations. By comparison, approximately 30% of calories in the developed world are derived directly from cereals [2]. However, in developed world, livestock form a major part of the diet and cereals contribute to meat production, as they comprise a major livestock feed, thus contributing indirectly to the calories [2]. Additionally, cereals contribute significantly to indirect calories as sweeteners and food starch. Cereal grains are also being used to produce industrial ethanol, which is mostly used as fuels [3]. According to the Food and Agriculture Organization, 2577.85 million tons of cereal crop were produced during 2016. The production of coarse grains (cereal grains other than wheat and rice, primarily used for animal feed or brewing) was 1330.02 million tons. The top cereals produced (in million tons) in the world in 2014 are corn (1253.6), rice (paddy, 949.7), wheat (854.9), barley (146.3), oat (23.2), and rye (15.8) [1].

Wheat, which comes from a type of grass (*Triticum*) is very important cereal due to the fact that the seed can be ground into flour, semolina, etc., which form the basic ingredients of bread and other bakery products, as well as noodles and pasta and thus it presents the main source of nutrients to most of the world population. The whole grain kernel of wheat [Fig. 1] is composed of 2-3% germ, 13-17% bran and 80-85% mealy endosperm (dry matter basis) [4].



**Fig. 1. The whole grain kernel of wheat**

The bran is the outer layer of wheat grain which is rich in B vitamins with high minerals content (7.2%), in addition to fibre components (53%). Protein and carbohydrate each represent 16% of total dry matter of bran. The pericarp and seed coat consists of dead empty cells while the inner bran layer and aleurone layer are made of living cells with protoplasts. The content of certain amino acids like alanine, asparagine, glycine, histidine and lysine are double while arginine is treble in aleurone layer than those in wheat flour [4].

The inner endosperm without the aleurone layer is rich in starch, fats (1.5%) and proteins (13%). The protein fraction contains albumins, globulins and major proteins of the gluten complex i.e., glutenin and gliadins. The contents of minerals (ash) and of dietary fibres are low; 0.5% and 1.5%, respectively. The germ is rich in proteins (25%), lipids (8-13%), mineral (4.5%) and vitamin E. Wheat germ has only one half the glutamine and proline of flour, but the levels of alanine, arginine, asparagine, glycine, lysine and threonine are double [4]. The protein content of wheat grains may vary between 10% - 18% of the total dry matter [5]. In comparison with meat,

plant protein as a source of dietary protein for humans and monogastric livestock, are nutritionally incomplete due to their deficiency in several essential amino acids (EAAs). In general, cereal proteins are low in Lysine (1.5–4.5% vs. 5.5% of WHO recommendation), tryptophan (0.8–2.0% vs. 1.0%), and threonine (2.7–3.9% vs. 4.0%). It is thus of economic and nutritional significance to enhance the EAAs in plant proteins [4]. Due to scarcity of Essential Amino Acids (EAA) like lysine, tryptophan, threonine and methionine [4] and other essential nutrients like dietary fibre and vitamins in wheat-proteins, enrichment with nutritious raw materials containing EAA-rich-protein and fatty-acid-rich-lipids increases the nutritional quality of cereal based products in terms of protein, dietary fibre, vitamins and minerals contents [6].

Literature review reveals that wheat-based bakery products such as bread, cookies, biscuits, and cakes are a large family of popular food products, consumed by a wide range of people all over the world, due to their varied tastes, relatively long shelf-life and low-cost; thus, their enrichment with nutrients is an effective way to prompt the people health. Incorporation of mushroom powder, specifically with best sensory result at 10% infrared-dried-button-mushroom-powder fortification in cake [7], enhances the nutritional profile of bakery products in terms of higher content of vitamins, mineral (calcium, potassium, magnesium, phosphorus, iron, copper, zinc and manganese), polyphenols, crude fibre and protein [8]. Salehi and Aghajanzadeh, [9] also reported that powder of dried fruit and vegetable in cake formulation exhibits benefits of attracting the consumers by improving appearance, texture, nutritional values, sensory properties and shelf life of the cake.

In the bakery products, gums have been used to improve dough performance, bread and cake characteristics, textural and sensorial quality, and extension the products' shelf life. Gums affect gelatinization and retrogradation of starch through a strong association of amylose with gum, resulting in a decrease in the retrogradation of starch. Gums addition increased volume and porosity of the breads and cakes and resulted in softer products [10,11]. One percent wild Sage Seed Gum (*Salvia macrosiphon*) is suggested to use in apple cakes to obtain the cakes with the satisfactory volume, appearance, texture and overall acceptance [12,13].

As fish is a rich source of high-quality protein containing well-balanced essential amino acids required for human nutrition, particularly lysine and methionine, which are relatively poor in cereals; along with omega-3 fatty acids, especially, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) [14]; vitamins like A, D, B<sub>6</sub>, and B<sub>12</sub>; minerals such as iron, zinc, iodine, selenium, potassium and sodium; cereal based snack products such as pasta and noodles offer the possibility for value-addition through fortification with animal protein rich fish mince, surimi and surimi powder to improve the nutritional quality and amino acid profile of such cereal-based food products to satisfy the consumer preference of low-carbohydrate, protein and fiber rich ready-to-cook food products, and thus consumer gets the nutrition from fish.

## 2. WHEAT PROCESSING AND WHEAT FLOUR

Milling represents the principal procedure in the cereal industry and is classified in two categories: dry and wet [1]. In the process of making wheat flour, a major portion of the vitamins (B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub>, folic acid and E), minerals (calcium, phosphorus, copper, zinc, iron), carotenoids and fibre are lost. Dry milling is the separation of the outer fibrous materials and germ from the grain endosperm while the wet milling is used for the production of starch and gluten. The coproducts or by-products of wet milling are steep solids (rich in nutrients valuable for the pharmaceutical industry), germ (intended for the oil-crushing industry) and bran. The milling of grains results in efficient removal of the bran and germ to yield 70% extraction flour. The refined flour is mostly endosperm and contains 80% – 86% starch on a dry basis. The refined flour is characterised with better keeping quality, better sensory appeal due to the bright colour, smooth texture, and flavour, when compared to whole grain products [2].

## 3. NOODLES: THE WHEAT-BASED PRODUCT

Two most popular wheat-based products are pasta and noodles. Pasta products are made from coarse semolina milled from durum wheat (*Triticum durum*) while the noodles are prepared using wheat flour of either hard or soft wheat (*Triticum aestivum*) along with water, salt, and alkaline salts or Kansui (an alkaline salt mixture of sodium carbonate, potassium carbonate and

sodium phosphate) [15]. During noodle manufacturing, the dough is subjected to sheeting and cutting. These processes involve less use of water as compared with other bakery products [16].

It is believed that Asian noodles originated from China as early as 5000 BC [17]. Momofuku Ando invented "Chicken Ramen™," the world's first instant noodle product manufactured by Nissin Foods, Japan, in 1958 [18]. According to the estimates of WINA [19], the global demand of instant noodles stands at 103.6 billion servings in 2018. China and Hongkong together consumed 40,250 million servings in 2018 making them the highest consumers. The attributes of instant noodles like taste, nutrition, convenience, safety, longer shelf life and reasonable price have given them global acceptance and admiration by all generations, thus instant noodles are used as space and emergency foods.

Wheat flour quality appears to have a major influence on noodle eating attributes [20]. Wheat used for noodle manufacturing should be well filled, dry and clean, and have good appearance and not spoiled by weather [17]. Bran color, kernel hardness, protein content, dough strength and starch pasting properties are major quality criteria for noodle wheat [20]. The execution of correct milling procedures is also critical to ensure the resulting noodle flour with bright color, low ash content, a low level of damaged starch and fine particle size. Protein and starch contents are the two principal components in flour which have a major impact on texture. Studies on the protein content of commercial instant noodles show that the protein levels ranged from 8.5% to 12.5% [17]. Wheat flours with low gelatinization temperature are preferred as it results in rapid hydration during cooking [17]. However, increased starch damage during the milling process is not desirable, because it may be associated with high cooking loss, excessive surface swelling and poor noodle color [21].

Commercial noodles are deficient in essential nutrients, such as proteins, dietary fiber and vitamins. Due to this, incorporation of protein and lipids from other sources rich in essential amino acid [22] and fatty acids [23] may be important to improve the nutritional quality of food products like noodles. Three main commercially available instant noodles are instant dried noodles (2–5% moisture, 3% fat), instant fried noodles (8–12% moisture content) and fried noodles (15–20% oil).

Market appearance of instant noodles are either as bag type (with sachet of seasonings packed, boiled in water for three–four minutes before serving) or the cup type noodle (packed in waterproof polystyrene cup with the seasoning sprinkled over, hot water is poured into the bowl and resting for two–three minutes before serving).

### 3.1 Fortification of Wheat-Based Noodles

Fortification of wheat-based noodles can be achieved in two ways. First method is fortification of the flour used to make noodles and the second choice is by fortifying the seasoning consumed with the noodles. Flour is fortified by addition of gluten or other flours, such as soya, oats, barley, and legumes flour. Seasonings can be fortified with micronutrients, including vitamin A, B<sub>1</sub>, B<sub>2</sub>, niacin, folic acid, iron, and iodine. Fortification of the seasoning is considered advantageous as the fortificants are not exposed to processing conditions such as heat during noodle preparation. In addition, the fortificants are better protected being packed in a sachet [18]. Apart from fortifying noodle with vitamins and minerals, it is important to incorporate protein, especially the amino acids that are deficient in the refined wheat flour used for noodle making.

Animal proteins, especially the fish proteins can be used for fortification of instant noodles. Fish is a rich source of high-quality protein containing well-balanced essential amino acids required for human nutrition, particularly lysine and methionine, which are relatively poor in cereals [24]. Moreover, incorporation of fish protein can enhance the sensory properties of an otherwise bland diet, thus facilitating and contributing to greater consumption. As consumers are becoming health conscious by preferring diet rich in fibre, protein and low fat, fish protein incorporated noodles can satisfy their nutritional requirement. Fish proteins are effectively more readily digestible than those of plant protein, thus cereal products can be fortified with fish proteins to reduce glycemic impact and provide a balanced nutritional profile for human being [25,26].

## 4. SURIMI AND SURIMI POWDER

The protein fortification of noodles can be accomplished by the addition of dried meat powders, such as fish surimi powders [27,28].

Surimi, a product of Japanese origin, refers to concentrated myofibrillar protein extracted from fish flesh by washing minced meat that has been separated from bones, skin, and guts [29]. This isolated myofibrillar protein is then mixed with cryoprotectants such as sugar or an alcohol, which are required to retain the functional properties of surimi [30]. The cryoprotectant generally used in the surimi industry is a 1:1 mixture of sucrose and sorbitol at a concentration of 8%. Surimi is generally frozen in a block form at -40°C and is kept in frozen storage (-18°C).

Traditionally, the fish species, Alaska pollack is used for preparation of surimi. Now, a range of species are utilized as raw material for 'Surimi' which include hoki, whiting, white hake, cod and Atlantic croaker [5,31,32]. Many fishes of marine origin such as thread fin bream (*Nemipterus japonicus*), ribbon fish (*Trichiurus lepturus*) and lizard fish (*Saurida tumbil*) are also being used for surimi production [33]. However, with the continuous decrease in marine catch followed by scarcity of raw material for surimi production, freshwater fish such as tilapia has now become an attractive raw material for surimi processing [34].

Surimi powder is the dried form of frozen surimi, which is advantageous as it does not require frozen storage and can be stored conveniently. Surimi powder also offers advantages of easy handling, low distribution cost and can be applied in dry mixes for preparation of value-added products [34]. Surimi is dried using various drying methods like freeze drying, spray drying, oven drying, solar drying, and mechanical drying [35]. The cryoprotectants usually added to surimi, such as sugar or polyols to retard protein denaturation during freezing and frozen storage, also acts as dryoprotectant in surimi powder. Dryoprotectant prevents protein denaturation in surimi powder during drying process. The protective action is important to maintain the functional properties of fish protein, such as solubility, gelation, water-holding capacity, emulsion, foaming property and color. Park and Lin [28] indicated that the nutritional value and physicochemical properties of surimi powder make it ideal for producing formulated seafood and other food products. Till date a number of researches were done focusing on the application of surimi powder in food products, including rice-fish snacks [36], fish crackers [37], fish balls [38], corn-fish snacks [39] and fish cutlet mixes [40].

## 5. PREPARATION OF PROTEIN FORTIFIED NOODLES

Several authors have studied the fortification of noodles using dried minced fish like *Nemipterus* sp. and *Oreochromis mossambicus* [41]. The supplement of wet minced fish and surimi from *Decapterus macrosoma* and *Congresox talabon* [42] was also attempted. Huda et al. [37] reported that the noodles with fortified levels of fish surimi powder (0%, 5%, 10%, 15% and 20%) showed a trend of significantly increased ( $p<0.05$ ) value of ash, protein, fat, lightness, redness, yellowness, stickiness and cooking yield as the incorporation levels of surimi powder increased. Higher concentrations of surimi powder in the noodles reduced the acceptance of the color score, taste, aftertaste, hardness and elasticity as well as the overall acceptance. Finally, a value of 5% surimi powder was considered the maximum concentration acceptable for incorporation into the noodles [37].

## 6. TYPES OF INSTANT NOODLES

Instant noodles are categorized in two groups based on the method of moisture removal, namely instant dried noodles and instant fried noodles [18]. The frying in oil reduces the moisture content of noodles to about 2–5%, while hot air drying reduces the moisture content to about 8–12% in the noodles. The heat applied during the process of frying or hot-air-drying results in gelatinization of the starch and the noodles attain a porous texture. This porous texture of the noodles helps in rehydration process during the cooking. Instant fried noodles are preferred more due to better texture and more than 80% of instant noodles are fried. Hot air-drying adversely affects the texture of the finished noodles due to uneven drying. As a result, air dried noodles require extended time for cooking and lacks the distinctive flavor introduced by deep frying. However, fried noodles contain about 15–20% oil as compared with a maximum of 3% fat in hot air-dried noodles, which makes the former more susceptible to oxidation resulting in rancidity. Moreover, the higher fat content in fried noodles creates health issues as well. The frying temperature and time are usually varied from 140 to 160°C, for 60 to 120 seconds, respectively [18]. Mamat et al. [43] found that temperature between 100°C to 110°C need only 45 minutes to dry the wet noodle but results in darkened

color. While temperature between 60°C to 70°C, perfectly dry the noodle in 80 minutes.

Instant noodles are available either as bag type or the cup type noodle. Bag type noodles comes with a sachet of seasonings packed within and generally cooked in constantly boiling water for three–four minutes duration before serving. Cup noodles are packed in a waterproof polystyrene cup with the seasoning sprinkled over the noodles. Cup noodles are prepared by pouring hot water into the bowl and resting for two–three minutes before serving.

### 6.1 Additives Used in Instant Noodles

The commonly used additives in noodle preparation are polyphosphates, hydrocolloids, emulsifiers, antioxidants, and starches. Additives are primarily used to improve noodle quality. Polyphosphates are used as chelating agents which influences the dough processing properties and reduce the discoloration process of fresh noodles. They are dissolved in water and added to the flour mix before dough preparation. Addition of polyphosphates, typically at the rate 0.1% of flour weight, improves noodles elasticity, texture and chewing properties by promoting gluten bonding. Polyphosphates are known to facilitate starch gelatinization during cooking, allowing more water retention in the noodle and reduces water cloudiness during cooking process [44].

Additives such as guar gum, locust bean gum, alginates, and carboxy methyl cellulose (CMC) are some hydrocolloids used in instant noodle processing. Choy et al. [45] reported that acetylated potato starch (APS) and CMC used in combination can affect the hardness and adhesiveness of instant noodles. Shiau [46] demonstrated the use of emulsifiers like glycerine fatty esters, sucrose fatty ester and lecithin to prevent starch retrogradation, improve texture and structure, and improve cooking quality. Enzymes like transglutaminase, lipases, oxidoreductase and amylases are reported to increase break strength and firmness; reduce stickiness and cooking loss [20]. Antioxidants such as BHA, BHT, PG and TBHQ inhibit or interfere with the chain reaction mechanisms that produce compounds responsible for rancidity [17].

### 6.2 Quality Criteria of Instant Noodle

The important quality factors for instant noodles are color, flavor, texture, cooking quality,

rehydration rates (during final preparation), and the extent of rancid taste after extended storage. A bright and light-yellow color is desirable for instant noodles [15,47]. Color scale such as  $L^*$  (noodle brightness or lightness),  $a^*$  (noodle redness) and  $b^*$  (noodle yellowness) are widely accepted parameters for noodle color and is usually measured by spectro-colorimeter (like Hunter Lab colorimeter).  $L^*$  of instant noodles positively correlates with the flour protein content and negatively correlates with processing factors like steaming, frying or drying and oil absorption [48]. Protein quality parameters also exhibit a significant relationship with  $b^*$  of instant noodles [48]. Alkaline additives also give a yellowish appearance to the noodle color.

Kubomura [47] described the texture of instant noodles as rubbery, firm or smooth. Sensory and instrumental methods (by simple compression and texture profile analysis or TPA and tensile tests) are used to evaluate noodle texture parameters such as smoothness, softness, hardness/firmness, stickiness, cohesiveness, elasticity, chewiness and gumminess [49]. The noodle texture is influenced by the quality of flour and water absorption. Other ingredients like salt or alkaline reagents also influence the texture. The processing parameters like sheeting, steaming and dehydration are found to influence the texture of noodles as well.

Cooking quality is generally measured based on the rehydration rate, cooking time, and cooking loss. The cooking quality of instant noodles depends on the content and quality of protein, ash and starch. Thickness of noodle strands and frying conditions also influences the cooking quality. Protein content and amylose content was reported to correlate positively and negatively respectively, with the optimum cooking time of noodles [48].

## 7. CONCLUSION

Wheat plays an important role as global commodity due to its gluten-forming proteins, which are capable of having extensibility and elasticity required for bakery products, noodles and pasta. Noodles prepared from wheat flour forms the staple food in Asian countries like China, Japan, and Korea. Instant noodles are currently the most important convenience food preferred by consumers globally due to their excellent flavour, convenience and ease of preparation. A number of studies are reported on production of instant noodles from wheat grain

fortified with various protein sources, especially with fish meat flour and surimi powder. Surimi protein can be used for fortification of noodles with high nutritional properties, well-balanced amino acid and acceptable flavor. The unsaturated fatty acids, such as linoleic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) present in surimi reduce the risk of coronary heart disease, decrease triglyceride, blood pressure and improve endothelial function. As consumers are becoming health conscious by preferring diet rich in fibre, protein and low fat, fish protein incorporated noodles can satisfy their nutritional requirement. Fish proteins are effectively more readily digestible than those of plant protein, thus cereal products can be fortified with fish proteins to reduce glycemic impact and provide a balanced nutritional profile for human being.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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