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Standardization of Drying Temperature and Time for Surimi Powder Fortified Pasta

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ABSTRACT: Pasta, prepared from wheat or semolina flour, has gained worldwide popularity due to its ease of preparation, affordability and nutritional benefits. However, it often lacks specific amino acids, namely lysine and methionine, as these components are limited in the cereal proteins present in wheat. Therefore, enhancing the nutritional profile of pasta may necessitate the inclusion of proteins from alternative sources that are abundant in essential amino acids. Fish, known for its richness in lysine, methionine, omega-3 fatty acids, as well as vitamins such as A, D, B6, and B12, along with minerals like iron, zinc, iodine, selenium, potassium and sodium, emerges as a promising option. Dried surimi powders, derived from fish, can be conveniently utilized to fortify the protein content of carbohydrate-rich pasta made from cereals. As the conventional method for preparing and storing fish protein-enriched pasta faces limitations, the aim of this study was to establish a standardized drying temperature and duration for 10% Tilapia surimi powder fortified pasta. The nutritionally enriched, low- carb, low calorie raw pasta was dried at different temperatures (60°C, 70°C and 80°C) to standardize the time and temperature for drying before storage in ambient temperature. Moisture content (11.54±0.47%) was achieved after 64 minutes of drying at 70°C followed by 'best' overall acceptability (4.10±0.42) by 30 expert sensory panellist members. Therefore, based on highest protein content (21.68±0.38%) and significantly ($p<0.05$) lowest carbohydrate content (60.53±0.45%) followed by sensory evaluation, 10% Tilapia surimi powder fortified pasta dried at 70°C for 64 minutes was chosen to be the optimum drying temperature and time.

Keywords: Tilapia surimi powder, value- added fishery product, cereal-based pasta.

INTRODUCTION

Pasta, made from durum wheat, is the most consumed Italian style of extruded paste-product such as spaghetti or lasagna (Shelke, 2016). Antioxidants present in sprouted wheat, particularly in the form of carotenoids (beta-carotene), catalytic elements, mineral salts, calcium, magnesium, potassium, sulphur, chlorine, arsenic, silicon, manganese, zinc, iodine, copper, vitamin B and vitamin A. Pasta is a traditional food product that dates back to the first century and is enjoyed all over the world for its affordability, adaptability, convenience, palatability and nutritional value. It is often prepared from wheat flour or semolina flour (Foschia *et al*., 2015). The composition of wheat flour includes protein, starch, moisture, ash, fiber and minerals; a high protein flour content is crucial for the hard texture of pasta. Cereal proteins (rice, wheat, barley and maize) are low in lysine and methionine, often referred to as limiting amino acids thus, their protein concentrations are lower than those of the reference protein (Gobbetti and Ganzle 2023). Consequently, it might be crucial to add protein and fats from additional sources that are high in essential amino acids (Nogueira and Steel 2018) and fatty acids (Rodriguez *et al.*, 2018) in order to enhance the nutritional value of pasta derived from cereal. The concept that proteins containing essential amino acids from different sources should be fortified in order to increase the nutritional value of cereal products and thus make food items more beneficial from the fact that cereal proteins, especially wheat protein, are inadequate in meeting our nutritional needs. The nutritional value of fortification with proteins and lipids is dependent not only on the quantity of protein and lipid incorporated but also the quality of such proteins and lipids used, their potential digestibility, ability to form a complex with other food ingredients and the subsequent bioavailability. The quality of pasta is determined based on the cooking properties like optimal cooking time (OCT), cooking loss (CL), water absorption index (WAI) and swelling index (SI) (Ficco *et al*., 2016) and textural parameters. Samaan *et al*. (2006) opined that the quality of pasta such as firmness, elasticity and its cooking characteristics like cooking loss are dependent upon the protein-starch network of the pasta product. Thus, the raw material composition used for the preparation of pasta is a very important factor that affects the physical, chemical and textural properties of pasta (Lu *et al*., 2016; Patel *et al*., 2022).

The composition of durum wheat semolina can be divided into 3 main constituents, the main fraction being starch, varying between 70 and 80 % of the total weight, followed by proteins, reaching up to 15 % of the total weight and the remaining part is composed of small amounts of fibre, lipids, vitamins and minerals (Petitot *et al*., 2010). The most simple and common method to produce pasta is formation of homogenous dough through cold extrusion where the semolina flour is mixed with 30-35% of water (Brennan *et al*., 2004) followed by extrusion under high pressure through a die to obtain desirable pasta shape. Protein coagulation and starch gelatinization occurs during cooking; the ultimate cooking and texture quality of the pasta is determined by the strong interactions and formation of a gluten network between the protein molecules (Bustos *et al*., 2015). The major protein fractions in the semolina are glutenin and gliadin. Gluten is responsible for the development of dough during mixing and extrusion, entrapping the starch granules in its network. During processing of pasta, these proteins interact with each other and form intra- and inter-molecular disulphide (SS) bonds that will help to develop the strong viscoelastic gluten network (Lamacchia *et al*., 2010), which restricting starch swelling, maintaining the structure of pasta during cooking and preventing cooking loss.

Fish is an excellent 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 (Lee *et al.,* 2009; Hasselberg *et al.,* 2020) and contains omega-3 fatty acids, especially, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Kris-Etherton *et al*., 2002) along with vitamins like A, D, $B_{6,}$ and B_{12},minerals like iron, zinc, iodine, selenium, potassium and sodium etc.Fish protein can therefore be added to a mixed diet to improve the protein content and coincide with the amino-acid pattern, such as fish surimi powders or fish protein concentrates (Park and Lin, 2005). Surimi refers to concentrated myofibrillar protein extracted from fish flesh by washing minced meat, separated from bones, skin and guts with added cryoprotectants such as sugar or alcohol (most used cryoprotectant in the surimi industry is 1:1 mixture of sucrose and sorbitol at a concentration of 8%), finally stored in frozen condition in block form. According to recent research, surimi could be converted into powdered form, which has several benefits for the food industry, including ease of handling, reduced transportation costs, more convenient storage and application in dry mixes (Majumder *et al.,* 2017). This makes surimi powder ideal for making formulated seafood and other food products. It can also be stored without freezing. The use of surimi powder in food products has been the subject of numerous studies conducted to date. These studies include those on rice-fish snacks (Pansawat *et al.,* 2008), fish crackers (Huda *et al.,* 2001), fish balls (Huda *et al.,* 2003), corn-fish snacks (Shaviklo *et al.,* 2010), and fish cutlet mixes (Shaviklo *et al.,* 2011). Therefore, adding fish surimi powder to cereal-based pasta could have important nutritional benefits.

Several studies have been done on successful incorporation of fish flesh or fish powder into starch-based materials and legumes fortification to produce consumer-acceptable nutritious products (Desai *et al*., 2018). Studies on protein enrichment in wheat-based foods were scarce, despite the fact that much research has been done on enhanced cereal-based diets. Snacks like noodles and pasta available in present market are rich in carbohydrate and deficient in proteins and amino acids. These are unable to fulfil the World Health Organization recommended daily protein intake (33 g) for average men and women with moderate physical activity (Wu, 2016). Furthermore, adding fish proteins to meals is an excellent approach to promote consumption of fish in nations where consumers purchase more fast-food and processed products that are rich in nutrients but low in calories. Moreover, literatures on standard procedure to prepare and store ready-to-cook protein fortified pasta, especially fish protein enriched pasta, are limited. Thus, the objective of the present study was to standardize the drying temperature and time for pasta fortified with Tilapia surimi powder.

MATERIAL AND METHODS

A. Preparation of dry surimi powder

Fresh tilapia (*Oreochromis mossambicus*), bought from Garia fish market, Kolkata by simple random sampling were transferred to the laboratory within an hour from the market in iced condition and processed immediately for conducting the present study. Surimi powder was prepared by the method as described by Majumder *et al*. (2017) (Fig. 1 and 2) and finally stored in airtight plastic packs under 4^{O}C refrigeration till further processing.

B. Preparation of Pasta using surimi powder

The pasta was prepared according to the method of Desai *et al*. (2018) with slight modifications. Semolina flour was collected from the local market. Analyzing prior research, the inclusion of 10% Tilapia surimi powder (T10) was employed as fortification in pasta preparation (Ikbal *et al*., 2023). Initially, semolina was quantified by using a flour measuring mug and then placed into the plastic basin within the pasta maker machine. Water (approximately 60% of the total weight) was added to make the dough in the basin. Mixing was carried out for 20 min followed by switching on the machine to function 2 (extrusion). For each batch of pasta, 500g of dry ingredients and 170 ml of water (room temperature) were added to the extruder. The resultant long, uniformly thick strands (measuring 3.5 mm) were gathered on a plastic food tray and subsequently sliced into 10–12-centimeter lengths using a stainless-steel knife. Now the raw pasta was dried at different temperatures (60°C, 70°C and 80°C) until the moisture content reached below 12% to standardize the time and temperature for drying of pasta before storage in zip lock bags in ambient temperature of 24^{O}C in ready-to-cook condition.

C. Proximate composition analysis

To standardize the time and temperature for drying of Tilapia surimi powder fortified pasta, proximate composition of the experimental samples was determined that includes protein, fat, ash and moisture content. The moisture content of the experimental samples was measured by Moisture Balance (Precisa, Dietikon, Switzerland). Total nitrogen was estimated by the Kjeldahl method (AOAC, 1995). Crude protein value was calculated by multiplying the total nitrogen value by a factor of 6.25. Estimation of total lipid was done by the method as described by Bligh and Dyer (1959). The ash content was measured by the method of AOAC (1995). All the results were expressed on a wet weight basis.

D. Quality analysis of fortified pasta: Analysis of Cooking properties

Following cooking properties were estimated to standardize the time and temperature for drying of Tilapia surimi powder fortified pasta**.** 10 g of pasta was cooked in 300 ml of boiling water at an optimal cooking time for estimation of water absorption index (WAI, g/100 g) (Foschia *et al*., 2014) and was determined as Water absorption capacity (WAC). WAI = (Wc -Wr)/Wr × 100, where Wc is the weight of cooked pasta (g) and Wr is the weight of uncooked pasta (g). The cooking yield was determined as described by Alesson-carbonell *et al*. (2005) as follows: Cooking Yield (%) = (Weight of pasta after cooking/Weight of pasta before cooking) × 100. 10 g of pasta were placed into 300 ml of boiling distilled water in a 500 ml beaker. After cooking for 7-9 min the samples were taken from the beaker and weight for cooking yield. The residue was determined by weighing the solid materials in cooking water after drying in an oven at 130^{O}C overnight to a constant weight. Results were recorded as follows: Cooking loss (%) = Weight of residues in cooking water/Weight of uncooked sample × 100 (Olfat *et al*., 1993). The cooking time is the minimum time necessary to gelatinize the starch. Pasta strands (20 g) were cut into equal lengths of 40 mm and cooked in 300 ml of boiling water. During cooking the optimal cooking time was evaluated by taking a sample strand of pasta every 30 second and observing the time of disappearance of the core of pasta, by squeezing it between two transparent glass side, according to the AACC approved method 66-50 (AACC, 2000). The time at which the core completely disappeared was taken as the optimal cooking time (Jalgaonkar *et al*., 2018). The swelling index (SI) of cooked pasta (g water/g dry pasta) was determined according to the procedure described by Cleary and Brennan (2006) by weighing 10g of pasta after cooking followed by drying at 105^{O}C to a constant weight. SI = (Wc – Wd)/ Wd, where Wc is the weight of cooked pasta (g) and Wd is the weight of pasta after drying (g).

E. Quality analysis of fortified pasta: Texture Profile Analysis, Analysis of pH, Bulk Density and Sensory Evaluation

Texture Profile Analysis (TPA) of 10% Tilapia surimi powder fortified pasta were conducted using a TA-XT plus texture analyzer (Stable Micro System, Surrey, UK) equipped with a 5 kg load cell and cylindrical probe (p/75 mm) by taking the mean value of five test samples. The attributes evaluated were hardness, cohesiveness, springiness, gumminess, chewiness, and resilience as described by Jalgaonkar *et al*. (2018) with following settings: Mode: TPA 2 (return to start); Pre-Test Speed: 3 mm/s; Test Speed: 1 mm/s; Post-Test Speed: 10 mm/s; distance: 50% in compression mode; Time: 1 s; Data acquisition rate: 200 pps. From the TPA curve. pH was determined by the method described by Benjakul *et al*. *(*1997) using a pH meter (Metrohm, 713ph Meter-Herisau Switzerland) after centrifuging 0.5g of pasta sample in 4.5 ml of distilled water for 1 min at 1800 rpm. Bulk density (kg/m^3) was calculated as described by Badwaik *et al*. (2014), Bulk density = Weight of sample/ Volume occupied by pasta. Sensory evaluation was performed by a sensory panel composed of 30 experienced members by evaluating color& appearance, flavor, taste, texture and overall acceptability of the oven dried fortified pasta samples after cooking in boiling water to become light brown in color using a 5-point Hedonic rating scale (Devi *et al*., 2013). All the data were checked for normal distribution with normality plots prior to analysis of variance (ANOVA) to determine significant differences among means at α =0.05 level, using statistical tools of Microsoft Office Excel (2007) and R software (Version 2.14.1).

RESULTS AND DISCUSSION

In the present study, cereal based semolina flour pasta is fortified with 10% Tilapia surimi powder for protein enrichment, thus increasing the nutritional profile. Now the nutritionally enriched, low- carb, low calorie raw pasta was dried at different temperatures (60°C, 70°C and 80°C) to standardize the time and temperature for drying before storage in ambient temperature under easy-to-prepare status.

The pasta was dried at 60°C, 70°C and 80°C until the moisture content reached below 12% with significant variation ($p<0.05$) in drying time among the drying temperatures. Fig. 3 shows that, despite the fact that it took less time to reduce the moisture content by 12% as the drying temperature increased. There were no significant variations ($p>0.05$) in the moisture content of dried pasta samples was observed as the final moisture was maintained around 12% and the respective time was recorded. Moisture content of 11.54±0.47% was achieved after 64 minutes at 70°C. Changes in protein, lipid, ash and carbohydrate content of pasta after drying in different temperature (60°C, 70°C and 80°C) are given in Fig. 4-7 respectively. The highest values of ash (1.90±0.23%) were observed at 70°C (Fig. 6). Ash was found to vary significantly ($p<0.05$) among the samples dried at 70°C and 80°C while lipid recorded a significant variation ($p<0.05$) within the samples dried at 60°C and 70°C. No significant differences ($p>0.05$) was recorded in protein content of fortified samples among all the temperatures with the highest value (21.68±0.38%) at 70°C (Fig. 4). Significantly ($p<0.05$) higher and lower values

(66.33±0.44% and 60.53±0.45%) in carbohydrate content was observed at 60°C 70°C respectively (Fig. 7).

Changes in water absorption index (WAI), cooking yield (CY), optimal cooking time (OCT), cooking loss (CL) and swelling index (SI) of fortified pasta after drying in different temperature (60°C, 70°C and 80°C) are given in Table 1. No significant differences ($p<0.05$) was recorded in WAI, CY, OCT, and SI of pasta samples among all the temperatures. The highest WAI value (62.72±0.30) at 70°C, the highest cooking yield value (162.45±2.55%) at 70°C, the highest optimal cooking time (9.40±0.17 min) at 80°C and the highest swelling index (1.91±0.12) at 70°C was obtained. A significant variation ($p<0.05$) in cooking loss exists among all the drying temperatures, values ranging from 4.81±0.17% (60°C) to 5.98±0.20% (70°C) were all within the limit of acceptability of 8% as suggested by Smatanova *et al*. (2014).

The texture profile analysis (TPA) of dried pasta samples under three different temperatures (60°C, 70°C and 80°C) are given in Table 2. The hardness values at 60°C and 80°C were a bit higher (179.05±58.59 g and 177.85±33.84 g) than at 70°C (143.84±49.42 g). Similar trends were observed for springiness, gumminess, chewiness and resilience values. On the contrary, fracturability values are lower at 60°C and 80°C (15.49±1.44 g and 17.04±0.15 g) to that of 70°C (63.67±68.52 g). No significant differences ($p>0.05$) were found among the samples dried at different drying temperature.

The lowest and highest pH values were observed in 60°C (5.56±0.16) and 80°C (5.78±0.20) respectively. No significant differences ($p>0.05$) in pH were found among the samples dried at different drying temperature. Likewise, the lowest and highest bulk density values were observed in 60°C (294.98±0.53) and 80°C (297.25±0.41) respectively. The pH and bulk density values at 70°C were 5.66±0.18 and 295.37±0.30 respectively.

Sensory evaluation reveals that 10% Tilapia surimi powder fortified pasta dried at 70°C was rated the best as evaluated by expert sensory panellist members with a mean overall acceptability score of 4.10±0.42 (Fig. 8). Therefore, based on the highest protein content (21.68±0.38%) and significantly ($p<0.05$) lowest carbohydrate content (60.53±0.45%) followed by the overall acceptability scores, 10% Tilapia surimi powder fortified pasta dried at 70°C was chosen to be the best drying temperature.

Table 1: Cooking properties of pasta (After drying).

Treatment	WAI	Cooking Yield (%)	Optimal cooking time(min)	Cooking Loss (%)	Swelling Index
T10(60°C)	57.27±0.50	157.27±1.94	9.12±0.11	4.81±0.17	1.89±0.13
T10(70°C)	62.72±0.30	162.45±2.55	9.20±0.14	5.98±0.20	1.91±0.12
T10(80°C)	58.49±0.39	158.50±1.50	9.40±0.17	5.70±0.29	1.84±0.09

*Results are mean of five determinations (n=5) with s.d.
Values of mean for particular column do not vary significantly ($p>0.05$) except in cooking loss (%) among the treatments

Table 2: Texture profile analysis of pasta after drying.

Treatment	Hardness (g)	Fracturability (g)	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
T10(60°C)	179.05±58.59	15.49±1.44	0.97±0.01	0.74±0.05	131.08±35.04	126.80±33.18	0.48±0.00
T10(70°C)	143.84±49.42	63.67±68.52	0.91±0.06	0.78±0.02	112.31±40.88	103.57±44.06	0.53±0.05
T10(80°C)	177.85±33.84	17.04±0.15	0.98±0.01	0.78±0.04	136.74±18.39	134.05±16.68	0.50±0.02

*Results are mean of five determinations (n=5) with s.d.
#Values of mean within the same column do not vary significantly ($p>0.05$) among the treatments

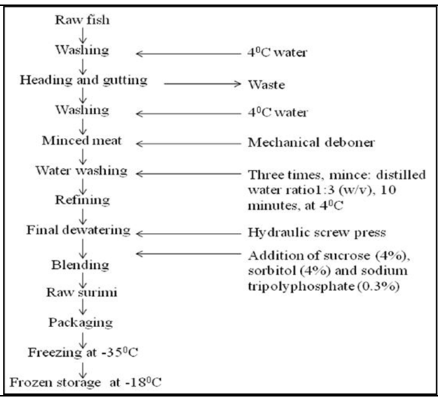

Fig. 1. Flow diagram of surimi processing.

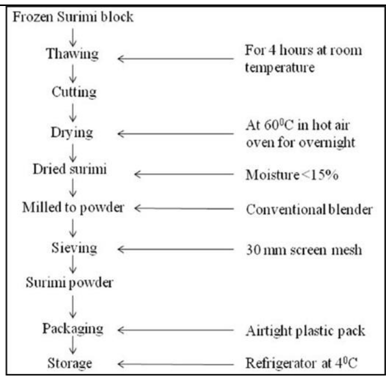

Fig. 2. Flowchart of surimi powder preparation.

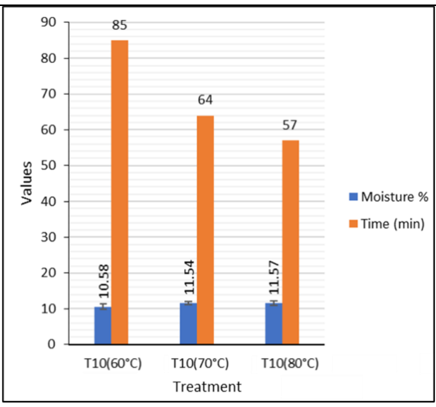

Fig. 3. Changes in the moisture of pasta after drying in different temperature (60°C, 70°C and 80°C) at varying times.

*Results are mean of five determinations (n=5) with s.d.
#[1]Values of mean for moisture content do not vary significantly (p>0.05) among the treatments
#[2]Values of mean for drying time vary significantly (p<0.05) among the treatments

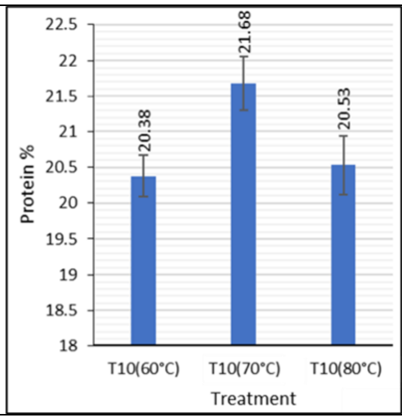

Fig. 4. Changes in the protein of pasta after drying in different temperature (60°C, 70°C and 80°C).

*Results are mean of five determinations (n=5) with s.d.
#Values of mean do not vary significantly (p>0.05) among the treatments

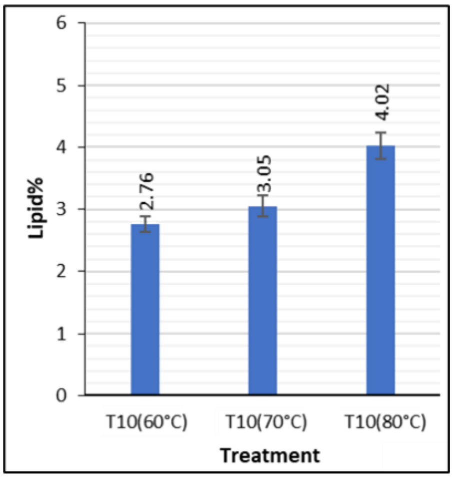

Fig. 5. Changes in the lipid of pasta after drying in different temperature (60°C, 70°C and 80°C)

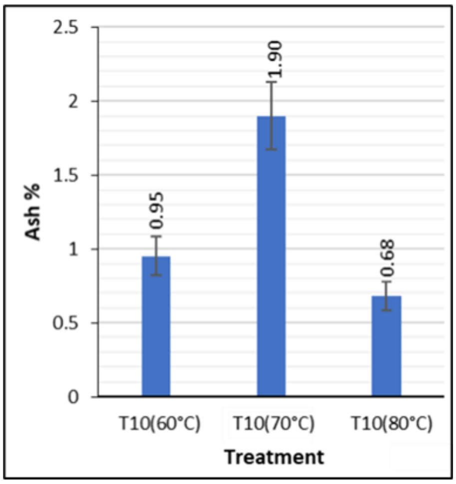

Fig. 6. Changes in the ash of pasta after drying in different temperature (60°C, 70°C and 80°C)

*Results are mean of five determinations (n=5) with s.d.
#Values of mean vary significantly (p<0.05) among the treatments

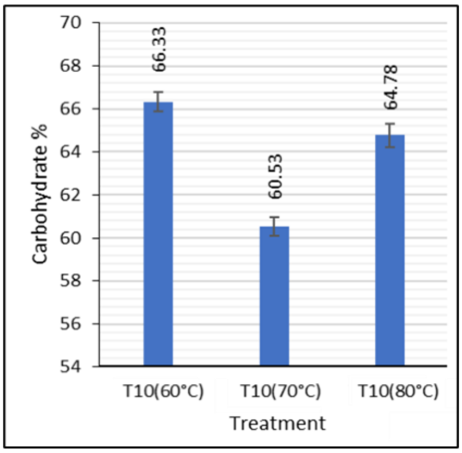

Fig. 7. Changes in carbohydrate of pasta after drying in different temperature (60°C, 70°C and 80°C).

*Results are mean of five determinations (n=5) with s.d.
#Values of mean vary significantly (p<0.05) among the treatments

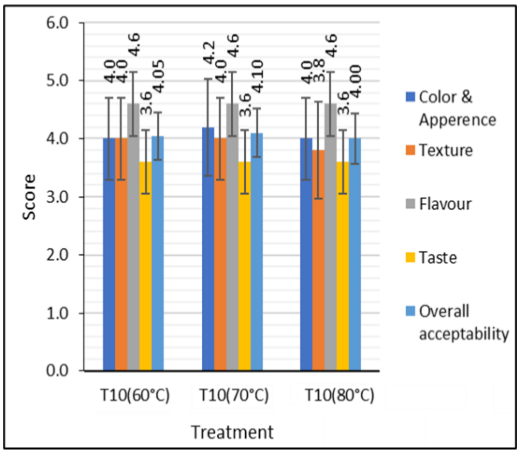

Fig. 8. Changes in sensory evaluation of pasta after drying at different temperature (60°C, 70°C and 80°C).

*Results are mean of thirty determinations (n=30) with s.d.

CONCLUSIONS

To standardize the drying temperature with time of 10% Tilapia surimi powder fortified pasta, from the above quality analysis it is evident that after 64 minutes of drying at 70°C, the residual moisture content was 11.54±0.47% with the highest protein content (21.68±0.38%) and significantly ($p<0.05$) lowest value of carbohydrate content followed by mean overall acceptability score of 4.10±0.42 by expert sensory panellist members. This pasta was designated as best after sensory evaluation. Thus, it can be inferred that the optimum drying temperature for drying of 10% Tilapia surimi powder fortified pasta is 70°C for a period of 64 minutes.

FUTURE SCOPE

The research of this tract was centered mainly on illustrating the current scenario of fortification in cereal based food products. Yet, much more research works are required to fill numerous breaks of knowledge**.** Experiments can also be done to improve the nutritional quality of traditional staple foods like noodles, pasta etc. and to evaluate the bioavailability of iron, zinc, calcium, magnesium and other trace elements incorporated in cereal based products. Tracing of glycemic index to control the blood glucose level can be an important area of research.

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Conflict of Interest. None.

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