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Physio-chemical analysis of spinach paste fortified instant noodles

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Abstract
An investigation was carried out to study the physical chemical, cooking and sensory qualities of instant noodles fortified with spinach paste as main ingredient. Instant noodles were developed by using wheat flour with some minor ingredients and spinach paste at three different combinations with two types of spinach paste (Raw spinach paste and blanched spinach paste). Totally six variations were formulated viz. RSP 15%, 25%, 30% and BSP 10%, 20%, 30% for the study. They were evaluated for color, texture, taste, flavor, and overall acceptability. Statistically significant difference was observed in moisture, ash, fiber, fat, carbohydrate and iron content of the raw spinach paste and blanched spinach paste. The moisture content was significantly higher (P<0.05) for the blanched paste compared to the raw spinach paste. Statistically significant difference in the protein and calcium content was observed between the RSP and BSP. Mean sensory scores revealed that instant noodles were best accepted at 15% level of RSP and 20% BSP incorporation. Physical properties of instant noodles were affected significantly with the increase in the level of incorporation of spinach. Increment of spinach paste from 0 to 30% increase colure value and cooking loose and decrease cooking time, good flavor. The result of chemical and nutritional quality characteristics of Instant noodles revealed that statistically significant difference (P<0.05) was observed between the control sample and spinach fortified instant noodles. The protein, fat, ash, were higher in spinach fortified instant noodles compared to control. There was a decreasing trend of sensory scores for colour texture taste flavour and over all acceptability for control raw spinach paste and blanched spinach paste incorporated instant noodles. During shelf life study and significant difference was found between. The treatments and duration for all the sensory characteristics.
The findings of the present study strongly support that the blanched spinach paste can be successfully incorporated in instant noodles as it enhances the nutritional quality of instant noodles, a "little known" food is highly nutritious and delivers a powerhouse of health supporting nutrients which is either thrown away.

Keywords: spinach paste; instant noodles; ash; fat protein

Introduction
Asian noodles are believed to have originated from Northern China as early as 5000B.C. The introduction of noodles to other Asian countries, different types of products developed due to varying regional preferences. Noodles are a traditional food widely consumed throughout Asia. In the past, they were made within the home for consumption by the household. Today they remain a staple of Asian diets and, with improved food technology, offer variety, versatility and high nutritional quality. Noodles are readily available and can be purchased in a variety of forms including fresh, cooked or processed for longer shelf life. Due to their ease of preparation, noodles are now considered as a convenient fast food.
There are many approaches used to classify noodles but the most common ways are either based on a processing methods or raw materials used. Depending on the processing methods adopted, noodles can be categorized as fresh, dried, boiled, steamed and instant types. For all of these noodles, the primary steps are similar, involving mixing of ingredients (wheat flour, salt and water), resting, sheeting and cutting. Noodles that are sold directly after being processed in this way are known as fresh noodles. These are usually dusted with starch or fine flour immediately after the cutting process to prevent the strands from sticking to each other during handling and transportation. Noodles can also be processed further by drying, boiling, steaming and frying. Dried noodles are produced from raw wet noodles that have undergone a controlled drying process, whereas boiled noodles are precooked in boiling water. Steamed noodles are produced by treating fresh noodles with steam. “Instant” type noodles are prepared first by steaming the noodles and

there after dehydrated and this typically is achieved by a deep frying process.

The processes involved in manufacture of different types of noodles alternatively, noodles can be classified on the basis of the raw materials used and two types have been widely recognized in the literature: WSN and YAN. The main difference between these is the use or presence of alkaline salts in the formulation. In the case of alkaline noodles, solutions of sodium carbonate, potassium carbonate, sodium bicarbonate or sodium hydroxide, commonly known as lye water or "kan sui" are added (Crosbie & Ross, 2004). Therefore, depending on the presence or absence of alkaline salts, noodles can be classified as non-alkaline (WSN or commonly known as "udon" in Japan) or alkaline.

I) White salted noodles (WSN) - Japanese noodles: Among the types of Asian noodles which are prepared without alkaline ingredients, udon is an example of a popular form of WSN. These are generally prepared from a dough made using flour and water with 2-8% salt (based on flour weight). Cooked WSN typically have a bright, creamy colour and a smooth, glossy surface appearance. The noodles are soft, with slight surface firmness and are elastic. Wheat quality requirements for Japanese udon include medium dough strength, high swelling starch and a wheat protein level of around 10.5% to yield a flour typically having 9.0-9.5% protein.

II) Yellow alkaline noodles (YAN) – Chinese noodles: The use of alkali in noodles originated in the Canton and Hokkien provinces of southern China. The weather in that region is typically hot and humid, and the alkaline salts in the noodle formula serve to extend noodle shelf life by inhibiting mould growth. YAN are prepared from a mixture of flour, water, sodium chloride and alkaline salts(such as sodium and potassium carbonates as well as sodium hydroxide). Alkaline noodles have a characteristic aroma and flavor, a clear yellow color and firm, elastic texture as well as smooth surface. These noodles are yellow in color due to the detachments of flavone-*C*-diglycosides from starch under alkaline pH (Asenstorfer, Wang & Mares, 2006). The principal factors governing the eating quality of YAN are protein content, dough strength and starch paste viscosity. Other researchers have also studied the effects of starch pasting and protein quality along with the effect of various alkaline conditions on the rheological properties of wheat flour dough.

III) Instant Noodles: Momofuku Ando invented "Chicken Ramen TM," the world's first instant noodle product manufactured by Nissin Foods, Japan, in 1958. Another achievement was the introduction of cup noodles by Nissin in 1971. Instant noodles are widely consumed throughout the world and it is a fast growing sector of the noodle industry (Owen, 2001). The world instant noodle market is projected to reach 158.7 billion packs by the year2010 (Anonymous, 2008). Instant noodles are consumed in more than 80 countries and have become internationally recognized food. Noodle industry supplies 95.4 billion servings annually to consumers throughout the world, and the demands are on the rise. Worldwide, China ranks first in the consumption of noodles followed by Indonesia Japan, and Vietnam according to the world instant noodle association (WINA, 2011) Although consumption of noodles in India had been low, it has increased appreciably in the past five years, i.e., by more than five times as reported by WINA (2011), with current consumption of 2940 million packets (bags/cups) This is because instant noodles are convenient, easy to cook, low cost and have a relatively long shelf-life. Asian noodles are not made exclusively of wheat many are made from rice, buckwheat, and starches derived from the mug bean and potato for example. Noodles based on wheat are prepared mainly from three basic ingredients; flour, water, and salt. Asian noodles and Italian pasta differ in raw materials and processing methods.

Types of instant noodles

Instant noodles are further classified into two types on the basis of methods used for the removal of moisture, i.e., instant dried noodles and instant fried noodles. Instant dried noodles are produced in a fully automatic production line similar to the type used for steamed and deep-fried noodles, except that a continuous drying chamber replaces the deep fryer, using hot air as the drying medium. Frying the noodles in oil decreases the moisture content of noodles to about 2–5%, where as in hot air dried noodles, it is about 8–12%. The heating during frying or hot air drying further gelatinizes the starch and the noodles attain a porous texture, which facilitates rehydration process while cooking the product. Frying is the preferred method of drying and more than 80% of instant noodles are fried because hot air drying results in uneven drying that adversely affects the texture of the finished noodles, requires a longer cooking time, and lacks the distinctive flavor introduced by deep frying. The disadvantage of frying, however, is that fried noodles containa bout 15–20% oil (compared with a maximum of 3% fat in hot air-dried noodles), are more susceptible to oxidation resulting in rancidity, and have health issues due to higher fat content. The use of antioxidants, however, prolongs the shelf life of fried instant noodles. Instant noodles based on their commercially packaged form available are bag type and the cup type noodles. Bag type noodles are available with the sachet of seasonings packed within and usually cooked in constantly boiling water for about three–four minutes before serving.

Among them Indians mainly depend on cereal based foods which have poor bioavailability of micronutrients leading to of iron-deficiency, anaemia and vitamin 'A'. Some green leafy vegetables are a rich source of β-carotene, a precursor of vitamin 'A' and grown more in India. Though there are more than 25 varieties of green-leafy vegetables are available in India. (Premavalli *et al*. 2001). The Indians used leafy vegetables are spinach, fenugreek, drumstick leaves, coriander and curry leaves etc. Since these have short life, suitable processing and preservation can prevent wastage and increase availability in the diet during off season. In this context spinach has a prominent role among all leafy vegetable because of its nutitional value, medicinal benefits etc.

Spinach has been consumed for thousands of years. It is believed that spinach made its way into Indian and Asian cooking through Arab traders who carried it to Asia from the Middle East. It has been used in salads, soups, in baked dishes with cheese, yogurt, and in tortellini. With the development of canning and freezing, the popularity of spinach increased world-wide. Indian spinach is the most cultivated in Africa. This is probably due to good environmental factors such as high temperature conditions, high rainfall and moist fertile soils with high organic matter observed in the African continent (Procher MH, Ken F). Spinach has high concentration of vitamin A, E, C, and K, and also folic and

oxalic acids. Along with these chemicals are various minerals are present in the spinach such as magnesium, manganese, calcium, phosphorus, iron, zinc, copper and potash. (Mehta and Belemkar, 2014) [23]. Leafy green vegetables such as spinach provide more nutrients than any other food, when compared calorie for calorie. Its nutrients include a range of vitamins and minerals (micronutrients), which can prevent deficiency diseases and are essential for normal physiological function, as well as phytochemicals thought to help prevent chronic health problems such as cancer and heart disease, as well as other health problems associated with ageing. Spinach also contain an immense variety of bioactive nonnutritive health promoting factors as antioxidants, phytochemicals, essential fatty acids and dietary fiber.

In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever increasing human population. Spinach leaves have remained underutilized due to lack of awareness and popularization of technologies for utilization (J Hum Ecol *et al*). People's diet offers a greater and more diverse group of plant bioactive than do drugs, and they often do not realize that many drugs are derived from the compounds originally discovered in plant foods. They play an important part in maintaining general good health owing to the presence of nutritional and phyto chemical property. All these substances help to protect the body from disease and regulate the body process on which vitality and good health depend.

Therefore, in the present investigation, an attempt was made to develop instant noodles by incorporating spinach paste and to test the shelf life of the developed products.

Material and Methods

Raw materials: Spinach leaves were obtained from vegetable market at uppal Hyderabad. Refined wheat flour was obtained from local market. Salt (sodium chloride), was purchased from the local market

Processing: Fresh and undamaged leaves were separated, and thoroughly washed under running water to remove foreign matter such as dust, dirt, chaff. The recovery of usable portions of spinach leaf was found. Washed matured leaves are dried under fan cooling and blanched for few minutes to remove anti nutritional factors such as oxalates present within the leaves. Fine mixer is used to grind spinach leaves to make fine paste.

Dried instant noodle processing: Noodles were prepared according to the procedure followed by the (Kim. 1996). Basic ingredients used for making instant dried noodles were flour, water, salt, starch, guar gum oil (refined palm oil). Control dried noodles were prepared from 100% wheat flour, three additional dried noodle samples were prepared by substituting wheat with 10%, 20%, 30%, of spinach paste. The different formulations were processed into noodles using manual mixing and a small spaghetti maker (Imperia brand, Italy) consisting of two rolls with adjustable gap settings and a cutting roll attachment. In brief, salt, and gum were dissolved in the water and this solution was added. After that, the resultant dough had a crumbly consistency. Then this dough was allowed to rest in zip plastic bag at room temperature for 15 minutes. The dough was formed into a dough sheet by a process of folding and passing the crumbly dough through the rollers of the noodle machine several times. The sheet was cut into strands 1.8 mm wide using the cutting roll attachment of the noodle machine. The noodle strands were then cut to 15cm in length before steaming over boiling water for 15 min. Subsequently, the steamed noodles were dried in an oven at 100 °C for a total drying time of 30 minutes.

Chemical analysis: Moisture content (oven dry method) was determined by AOAC (1990) [3]. The protein content of samples was determined by Kjeldahl procedure described in AOAC (2005) [6]. Whereas Fat content in the sample was estimated by Soxhlet extraction process method. Procedure was followed for ash determination in the noodles. The per cent carbohydrates were calculated by subtracting the sum of moisture, protein, fat, ash and fiber from 100%.

Cooking property: Cooking stage, small parts of instant noodles will be separated from the noodle itself and suspended in water. By this method, noodles becomes weaker and less slippery, while the cooking water becomes cloudy and thick. This is usually quantitative described by the term ''cooking loss" (Chen *et al*., 2002). During cooking or keeping in water the starch noodles absorb water innstantly and the starch noodle will become swollen. This is normally quantified by ''swelling index" or ''cooked weight". The cooking loss and cooked weight of instant noodles were measured by the following method. Noodles (5 g) were cut into 5 cm lengths and cooked in 200 mL of boiling distilled water for 1 min more than the optimum cooking time. The optimum cooking time was determined by crushing cooked noodles between a pair of glass plates until the white hard core in the noodles strand disappeared. The cooked noodles were then filtered through a nylon screen, rinsed with distilled water, and drained for 5 min. Cooking loss was determined by evaporating the combined cooking water and rinse water to dryness at 110 ºC and expressed as the percentage of solid loss during cooking. Cooked weight (CW) was calculated as a percentage of dry cooked noodle weight prior to cooking.

Noodle color analysis: The color of the dried noodles were measured with a Chroma-meter (Color Quest, XE Hunter Lab, USA) equipped with a D65 illuminant using the CIE L*a*b* system. The L*, a* and b* readings were obtained directly from the instrument and provided measures of lightness, redness and yellowness, respectively. All measurements were performed in triplicate.

Sensory evaluation: All instant noodle samples prepared were analyzed for sensory evaluation by panel members. The samples were boiled using mineral water for the optimum cooking time, optimally cooked noodles with soup were evaluated for appearance, flavor, taste, texture and over all liking of the samples by 14untrained panelists using nine-point hedonic scales, where9 = extremely like and 1 = extremely dislike. Each panelist evaluated three samples in a balanced sequential order. The optimal ratio of spinach paste in the noodles was investigated using sensory qualities in comparison to the control noodles.

Statistical analysis: All the result was statistically analyzed to test the significance of the results using percentages, means, standard deviations and analysis of variance.

Results and Discussion

Nutritional quality characteristics of spinach: Nutrient composition of raw spinach paste (RSP) and Blanched spinach paste (BSP) samples are shown in Table 1. The

Moisture content was 81 and 88%, protein content was 3.3 and 2.7%, ash content was 4.3 and 3.73%, fat content was 1.5 and 1.3% and carbohydrate content was 3.5 and 3.1%, calcium content was 256 and150 (mg/100g) and iron content was 74 and 68% in Raw spinach paste and Blanched spinach paste respectively. The moisture value was significantly higher (P<0.05) for blanched spinach paste (88%) compared to the raw spinach paste (81.3%). Significant small difference was found in the protein and calcium, Iron content between the raw spinach paste and blanched spinach paste. Statistically significant difference was observed in moisture, ash, fiber, fat, carbohydrate and iron content of both RSP and BSP.

Sensory quality characteristics and Mean sensory scores of instant noodles

Instant noodles prepared with combination of wheat flour, raw spinach paste and blanched spinach paste were evaluated for organoleptical evaluation by semi trained panel of judges. The mean scores of sensory evaluation for the products are given in Table.2.

Sensory rating of instant noodles for color showed that control (C) got maximum score (8.35) while treatments T5 (6.5) and T2 (7.04) obtained the lowest score followed by T1 (7.64), T3 (7.35), T4 (7.78) & T6 (7.14) got fairly high score which showed that color was decline from 8.35 to 6.50 with increasing level of incorporation of raw spinach paste and blanched spinach paste. The color of instant noodles turned from light green to dark green, leading to lower acceptance.

Table 1: Nutritional quality characteristics of Spinach paste

Nutrients	RSP	BSP	CD value
Moisture (%)	81.3±2.51	88±2.64	5.85
Protein (%)	3.33±0.15	2.7±0.2	0.403
Ash (%)	4.33±0.208	3.7±0.28	0.592
Fat (%)	1.53±0.15	1.33±0.15	0.346
Carbohydrate (%)	3.5±0.1	3.1±0.1	0.22
Calcium (mg/100g)	256±38.1	150±131	77.55
Iron (mg/100g)	74±7.2	68±6.5	15.7

- RSP-Raw spinach paste, BSP –Blanched spinach paste
- Values are expressed as mean ± standard deviation of three determinations.
- Mean values with similar superscripts within a row do not differ significantly (P<0.05).

Mean sensory score for texture of instant noodles decreased from 7.57 to 6.31 with increasing level of substitution of raw spinach paste and blanched spinach paste. Mean sensory score for texture showed in Table 4.5. Results revealed that the control had highest mean sensory score for texture (7.57) followed by T1 (7.28), T4 (7.28), T6 (6.92) andT2 (6.78) while T5 (6.61) and T3 (6.71) had least sensory score for texture.

Mean sensory score for taste decreased from 7.5 to 6.28 with increasing level of substitution of raw spinach paste and Blanched spinach paste in instant noodles. Mean sensory score for taste shown in Table 4.2 revealed that the control had highest mean sensory score for taste (7.5) followed by T1 (7.35), T4 (7.07), T6 (6.78), & T2 (6.64) while T3 (6.28) andT5 (6.57) had least score for taste.

Mean sensory score for flavor of instant noodles decreased from 7.42 to 6.28 with increasing level of substitution of spinach paste as showed in the Table 4.2 Mean sensory score for flavor showed in Table 4.2 revealed that the mean sensory score for flavor in control (7.42) at top position followed by T4 (7.07), T1 (6.92), T6 (6.85) and T5 (6.64), T3 (6.35) andT2 (6.28.) had least score for flavor.

Overall acceptability was determined on the basis of sensory quality scores obtained by the evaluation of color, flavor, taste and texture of the instant noodles

The mean sensory score regarding overall acceptability of instant noodles are showed in Table 4.2 revealed that the mean sensory score for overall acceptability in control was maximum while 30% of RSP and 30%BSP incorporated instant noodles had lowest acceptability. The decrease in overall acceptability was due to decrease in sensory quality characteristics such as color, flavor, taste and texture scores of instant noodles. Statistically significant difference (P>0.05) was observed in mean color, texture, taste, flavor and overall acceptability scores of instant noodles prepared from Raw spinach paste and Blanched spinach paste T1 and T4 had maximum mean sensory scores for all the sensory attributes compare to other variations studied. These values are similar to the value reported by khan *et al.,* (2015) studying which it was reported that the 10% of spinach powder has the maximum sensory scores in chapaties compare to other treatments.

Table 2: Mean sensory scores of instant noodles prepared by spinach paste

Treatments	Color	Texture	Taste	Flavor	Overall acceptability
C	8.35±0.744	7.57±0.85	7.5±0.65	7.42±0.64	7.71±0.72
T1	7.64±0.744	7.28±0.61	7.35±0.841	6.92±0.91	7.57±0.64
T2	7.0±0.87	6.78±0.80	6.64±0.841	6.28±0.91	7.07±0.73
T3	7.35±0.84	6.71±0.82	6.28±0.825	6.35±0.92	7.21±0.89
T4	7.78±0.89	7.07±0.61	7.14±0.949	7.07±0.828	7.92±0.82
T5	6.5±0.85	6.61±0.61	6.57±0.513	6.64±0.63	7.01±0.73
T6	7.14±0.86	6.92±0.61	6.78±0.801	6.85±1.09	7.21±0.89
CD value	0.625	0.546	0.590	0.650	0.587

Table 3: Colour values of spinach paste fortified instant noodles

Samples	Color values		
	L*	a*	b*
Control sample	82.45±0.35	0.73±0.15	13.37±0.22
T1	44.35±0.40	25.68±0.25	61.48±0.4
T2	55.45±0.88	17.41±0.28	40.73±0.21
CD	0.517	0.691	0.465

- C- Control sample.
- T1- Instant noodles prepared by incorporated 25% of raw spinach paste
- T2- Instant noodles prepared by incorporated 15% of blanched spinach paste
- T3 - Instant noodles prepared by incorporated 25% of Raw spinach paste
- T4- Instant noodles prepared by incorporated 20% of blanched spinach paste.
- T5- Instant noodles prepared by incorporated 30% of Raw spinach paste
- T6- instant noodles prepared by incorporated 30% of blanched spinach paste.
- Values are expressed as mean ± standard deviation of three determinations.
- Mean values with similar superscripts within a row do not differ significantly (P<0.05).

Physical characteristics of instant noodles

Colour analysis of instant noodles: Color scores of the Instant noodles were presented as L*, a* and b* values in the Table 3. Generally the L* value ranges from 0 to 100 indicating luminance or lightness component along with two chromatic components, a* component from green to red and the b* component from blue to yellow. The L*a*b* units are often used in food research studies to determine the uniform distribution of colors as L*a*b* units are very close to human perception of colour. The colour of food ingredients is important as it has a bearing on the visual appeal of the product to which they are added (Sahin *et al.*, 2011). The color of the spinach paste added to instant noodles was analyzed using Munsell colour charts. Noodles prepared with treatment T2 was light in colour than the T1 noodles because of Spinach content which contain chlorophylls and other colored components. The colour values ΔL, Δa and Δb ranged from 82.45 to 44.35; 25.68 to 0.73and 61.48 to 13.37 respectively as shown in Table 4.3. The maximum ΔL value was observed in control sample and least was for T1 sample and the maximum Δa was observed in T1 and least was for control sample. The maximum ΔB value was observed in T1 and least in was for control sample.

Measurement of optimum cooking time: The cooking time for noodles differs to each other due to variation in their ingredient composition and the values noted were 7.5, 6.25, and 5.5 minutes for the control sample, and treatments T1, T2 respectively and are represented in Table no 4. The cooking time for control sample was significantly higher (P<0.05) in all samples compared to treatments T1 and T2. The cooking time for treatment T1 was significantly higher (P<0.05) compared to treatment T2.

Measurement of cooking loss: The cooking loss was 1.12±0.62, 1.75±0.95, and 1.35±0.75 minutes for the control sample, and treatments T1, T2 respectively and are represented in Table no 4.4. The cooking loss for treatment T1 was significantly higher (P<0.05) in all samples compared to treatment T2 and control sample.

Table 4: Cooking time and cooking loss of spinach paste fortified instant noodles

S. No	Sample	Cooking Time (Min)	Cooking loss (Min)
1.	C	7.5 ± 0.57	1.12 ± 0.62
2.	T1	6.25 ± 0.5	1.75 ± 0.95
3.	T2	5.5 ± 0.57	1.35 ± 0.75
	CD	0.869	1.207

Whereas, C- Control sample.

- T1- Instant noodles prepared by incorporated15% of raw spinach paste
- T2- Instant noodles prepared by incorporated 20% of blanched spinach paste
- CD- Critical difference.
- Values are expressed as mean ± standard deviation of three determinations.
- Mean values with similar superscripts within a row do not differ significantly (P<0.05).

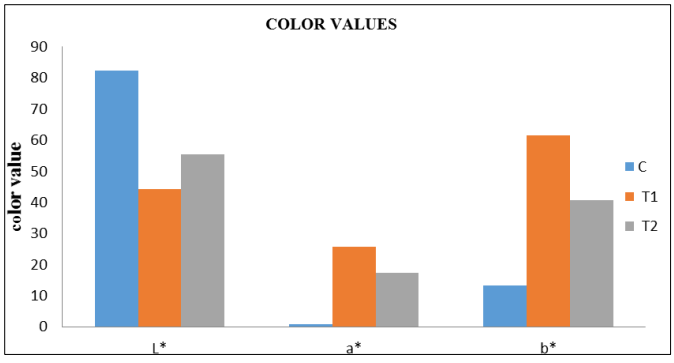

Fig 1: Color values of instant noodles

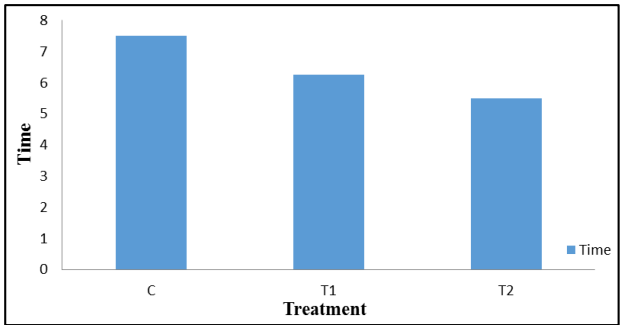

Fig 2: Cooking time of instant noodles

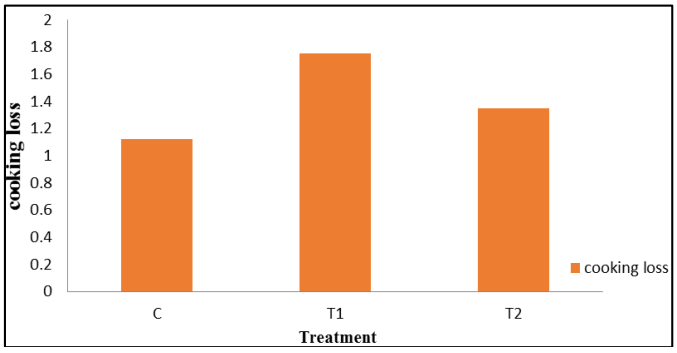

Fig 3: Cooking loss of instant noodles

Chemical and nutritional quality characteristics of instant noodles: Results of chemical and nutritional quality characteristics of instant noodles prepared with wheat flour in combination of blanched spinach paste and Raw spinach paste were presented in Table No 5.

Moisture %

The Moisture content observed was 4.3±0.15%, 5.6±0.1% and 6.6±0.2% for the control, and treatments T1 and T2 respectively. The moisture content of treatment T2 was significantly higher (P<0.05) in all sample compared to treatment T1 and control sample. However, statistically significant difference was observed between the control and both the experimental samples (T1 and T2).

Protein %

The protein content observed was 11.56±0.30%, 12.73±0.10 % and 12.53±0.40% for the control, and treatments T1 and T2 respectively. The protein content of treatment T1 was significantly higher (P<0.05) in all sample compared to T2 and control. The protein content of T1 was significantly higher (P<0.05) compared to control.

However, statistically significant difference was observed between the control and both the experimental samples (T1 and T2). Statistically significant difference was not observed between the treatments T1 and T2.

Ash %

The ash content observed was1.46±0.15%, 2.33±0.25% and 2.53± 0.15% for the control, and treatments T1 and T2 respectively. The ash content of noodles increased from 1.46% to 2.53% with increase in the level of incorporation of RSP and BSP. The results showed that T3 had the maximum ash content (2.53%), followed by T1(2.33%) while minimum ash content was observed in control sample *i.e.* C (1.46%).

Statistically significant difference was observed in ash content between the control and both the experimental samples (T1 and T2) but there is no significant difference in ash content between the T1 and T2.

Fat %

The fat content observed was 4.53±0.15%, 8.59±0.26, 11.59±0.34 for the control, and treatments T1 and T2 respectively. Statistically significant difference was observed in the fat content of control and both the experimental samples (T1 and T2). The Fat content of T2 was significantly higher (P<0.05) in all samples compared to treatment T1 and control. The fat content of T1 was significantly higher (P<0.05) compared to control.

Carbohydrate %

The carbohydrate content observed was 74.16±0.04%, 70.39±0.08% and 65.33±0.48% for the control, and treatments T1 and T2 respectively. The carbohydrate content of instant noodles decreased from 74.16% to 65.33% with increase in the level of substitution RSP and BSP. The results showed that the control had the maximum carbohydrate content (74.16%) and treatment T2 had the lowest carbohydrate content (65.33%) among all the samples.

Statistically significant difference was not observed in the carbohydrate content of control and both the experimental samples (T1 and T2) and also between the treatments of T1 and T2.

Mineral content in instant noodles: The incorporation of spinach paste increased the mineral content in the products in comparison with control as shown in Table 6.

The calcium, iron, content in spinach showed significant difference (p<0.05) between control and other sample. The values for calcium ranged from 35.4mgto 75.9mg, iron 2.7to 4.80mg per100gms content.

Table 5: Chemical and nutritional quality characteristics of instant noodles

Nutrients	C	T1	T2	CD value
Moisture (%)	4.3±0.15	5.6±0.1	6.6±0.2	0.346
Protein (%)	11.56±0.30	12.73±0.10	12.53±0.40	0.639
Ash (%)	1.46±0.15	2.33±0.25	2.53± 0.15	0.382
Fat (%)	4.53±0.15	8.59±0.26	11.59±0.34	0.532
Carbohydrate (%)	74.16±2.95	70.39 ±0.64	65.33 ±1.32	3.811

Table 6: Mineral value of spinach paste fortified instant noodles

Nutrients	C	T1	T2	CD value
Calcium	35.46±0.50	68.95±0.93	75.96±0.95	1.640
Iron	2.76±0.15	3.76±0.16	4.80±0.16	0.274

Whereas C- Control sample.

- T1- Instant noodles prepared by incorporated15% of raw spinach paste
- T2- Instant noodles prepared by incorporated 25% of blanched spinach paste
- CD- Critical difference.
- Values are expressed as mean ± standard deviation of three determinations.
- Mean values with similar superscripts within a row do not differ significantly (P<0.05).

Shelf life studies of instant noodles: Instant noodles (Control, TreatmentT1 and T2) were kept for storage study. The samples were observed daily for visual difference and were subjected to sensory evaluation on 0, 15th and 30th day. The results of the mean sensory evaluation of noodles from initial day to end of storage period are presented in the Table 7.The changes in mean sensory scores of noodles decreased from initial to 30th day of storage period in both control and spinach paste fortified instant noodles. The sensory parameters in control sample were decreased from initial to 30th day for color (8.35 to 6.92), texture (7.57 to 6.42), taste (7.25 to 6.14), flavor (7.50 to 6.23) and overall acceptability (7.93 to 6.69) respectively. In the same way the mean sensory scores decreased significantly from initial to 30th day in raw spinach paste and blanched spinach paste incorporated instant noodles.In15% Raw spinach paste incorporated instant noodles the sensory score decreased from 7.64 to 6.71 for color, 7.28 to 6.14 for texture, 7.35 to 6.21for taste, 6.92 to 5.65 for flavor and 7.57 to 5.50 for overall acceptability. In 20% blanched spinach paste incorporated instant noodles the sensory score decreased from 7.78 to 6.78 for color, 7.07 to 6.07 for texture, 7.14 to 6.42 for taste, 7.21 to 6.20 for flavor and 7.92to 6.15 for overall acceptability.

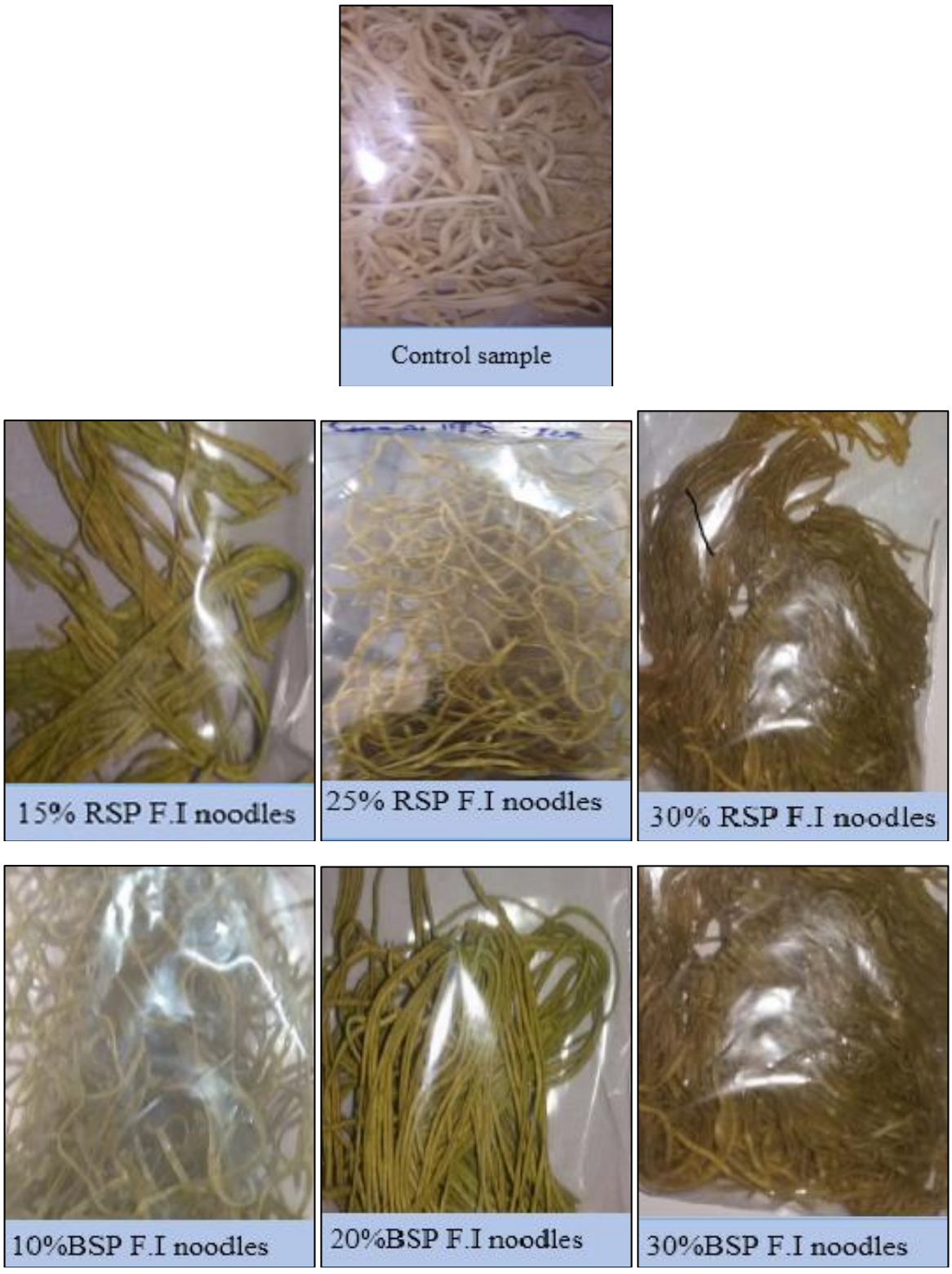

Fig 4: Schematic view of Fortified Instant Noodles

Statistical analysis revealed a significant difference for all the sensory characteristics of instant noodles between the treatments and both before and after storage period of 0^{th}, 15^{th} and 30^{th} day. Shelf life is a major consideration in developing, producing and marketing of food product, it refers to the time during which a product remains 'acceptable' to a consumer in terms of sensory characters. Many factors influence the shelf life of the product like, moisture loss, spoilage due to microorganisms, enzymatic changes and oxidation reported by Adegoke *et al*. (1998).

Nutritional characteristics of instant noodles during storage: The results of analysis of chemical and nutritional quality characteristics of instant noodles during storage are showed in Table 8. The moisture content of instant noodles before storage was 4.3%, 5.6%and 6.6% for the control, T1 and T2 respectively. The moisture content of instant noodles after storage was 5.2%, 6.3% and 7.3% for the control, T1 and T2 respectively. The results revealed that there statistically significant increase in the mean moisture content of instant noodles was observed from 0^{th} day to 30^{th} day of storage period. The protein content of instant noodles before storage was 11.56%, 12.73% and 12.53% for the control, T1 and T2

respectively. The protein content of instant noodles after storage was 11.34%, 12.3% and 12.28% for the control, T1 and T2 respectively.

The results revealed that there was a significant decrease in mean protein content of instant noodles from 0th day to 30th day of storage period as shown in the Table 4.4. 2The decrease in protein content during storage might be due to hydrolysis of peptide bonds by the help of protease enzyme that cause splitting of protein molecules during storage. Similar decrease of protein content with storage period in single cell protein biscuits was reported by Kanchana *et al.*, (2008). The ash content of instant noodles before storage was 1.46%, 2.33% and 2.53%for the control, T1 and T2respectively. The ash content of instant noodles after storage was 1.13%, 1.91% and 2.3% for the control, T1 and T2respectively. The results revealed that there was a significant decrease in the mean ash content of instant noodles from 0th day to 30th days of storage period as showed in the Table 8.

The fat content of instant noodles before storage was 4.53%, 8.59% and 11.59% for the control, T1 and T2 respectively. The fat content of instant noodles after storage was 3.63%, 7.69% and 10.66% for the control, T1 and T2 respectively. The results revealed that there was a significant decrease in mean fat content of instant noodles from 0th day to 30th day of storage period as showed in the Table 4.14.This decrease in fat content during storage was due to the incorporation of moisture in noodles from the atmosphere and due to oxidation of fatty acids resulting in free fatty acid formation.

The carbohydrate content of instant noodles before storage was 74.16%, 70.36% and 65.33% for the control, T1 and T2 respectively. The carbohydrate content of instant noodles after storage was 75.53%, 68.66% and 64.18% for the control, T1 and T2 respectively. The results revealed that there was a significant decrease in mean carbohydrate content of instant noodles from 0th day to 30th day of storage period as showed in the Table No. 8.

Table 7: Sensory value of instant noodles during storage

Treatments	Duration (Days)	Sensory attributes				
		Color	Texture	Taste	Flavor	Overall acceptability
C	0th day	8.35±0.74	7.57±0.85	7.25±0.65	7.42±0.64	7.71±0.72
	15th day	7.07±0.73	7.35±1.00	6.25±0.66	6.22±0.16	5.98±0.76
	30th day	6.92±0.73	6.42±0.75	6.14±0.66	6.19±0.10	5.65±0.77
T1	0th day	7.64±0.747	7.28±0.61	7.35±0.84	6.92±0.91	7.57±0.64
	15th day	6.85±0.66	7.5±0.858	6.07±0.07	6.17±0.28	6.21±0.63
	30th day	6.71±0.72	6.14±0.77	6.21±0.80	5.68±0.505	5.50±0.59
T2	0th day	7.78±0.89	7.07±0.61	7.14±0.94	7.0±0.828	7.92±0.82
	15th day	6.92±0.61	6.7±0.82	6.25±0.80	6.78±0.09	5.9±0.86
	30th day	6.78±0.82	6.07±0.73	6.42±0.93	6.20±0.507	6.15±0.49
CD Value	0th day	0.625	0.546	0.590	0.650	0.577
	15th day	0.513	0.687	0.625	0.163	0.633
	30th day	0.576	0.575	0.618	0.417	0.526

Table 8: Nutritional characteristics of instant noodles during storage

Nutrients	Duration	C	T1	T2	CD value
Moisture (%)	Before	4.3±0.15	5.6±0.1	6.6±0.2	0.346
	After	5.2±0.1	6.3±0.28	7.3±0.2	0.352
Protein (%)	Before	11.56a±0.30	12.73±0.10	12.53±0.40	0.639
	After	11.34±0.14	12.3±0.2	12.28±0.07	0.295
Ash (%)	Before	1.46±0.15	2.33±0.25	2.53± 0.15	0.382
	After	1.13±0.15	1.91±0.07	2.3±0.1	0.352
Fat (%)	Before	4.53±0.15	8.59±0.26	11.59±0.34	0.532
	After	3.63±0.15	7.91±023	10.11±0.55	0.564
Carbohydrate (%)	Before	74.16±2.95	70.39±0.64	65.33±1.32	3.811
	After	73.53±0.35	68.66±0.73	64.18±0.16	0.950

Whereas**,** C- Control sample.

- T1- Instant noodles prepared by incorporated15% of raw spinach paste
- T2- Instant noodles prepared by incorporated 20% of blanched spinach paste
- CD- Critical difference
- Values are expressed as mean ± standard deviation of three determinations.
- Mean values with similar superscripts within a row do not differ significantly ($P<0.05$).

Conclusion

Spinach fortification at 10%, 20%, 30% in wheat flour noodles were studied. The moisture content, Protein, fat and ash contents were increased compared to control and spinach fortification at 20% is highly acceptable in terms of sensory analysis and found stable in storage. Cooking time and cooking losses were reduced with the level of spinach incorporation.

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