



# Utilization of Fish Powder in Ready-to-Eat Extruded Snacks

Aparna Kuna\*, N. Lakshmi Devi and K. Kalpana

Post Graduate and Research Centre, Acharya N.G. Ranga Agricultural University,  
Rajendranagar, Hyderabad - 500 030, India

## Abstract

Ready-to-Eat (RTE) snacks were developed using corn (*Zea mays*), rice (*Oryza sativa*), roasted Bengal gram dal (*Cicer arietinum*), green gram (*Pharsalus aureus* Roxb), black gram (*Phaseolus mungo* Roxb) and fish (*Catla catla*) powder with a lab scale twin screw extruder. The extrudates were subjected to acceptability studies initially and at the end of the storage period viz., two months at laboratory level by panel of judges using a 5-point hedonic scale. Physico-chemical characteristics like bulk density, piece density and expansion ratio were measured and proximate composition, minerals and omega-3 fatty acids were assessed. Among the different blends studied, the most acceptable were T9 (corn + rice + black gram dal + fish powder in the ratio of 40:40:10:10) and T10 (corn + rice + roasted bengal gram dal + fish powder in the ratio of 40:40:10:10). Acceptable RTE snacks of good quality can be developed by extrusion cooking, utilizing cereals, pulses and fish powder.

**Keywords:** Ready-to-eat snacks, extrusion, fish powder, acceptability, nutrient composition

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\* E-mail: aparnakuna@gmail.com

## Introduction

Most snack foods being cereal based are either poor sources of protein or contain proteins of poor nutritional quality (Iqbal et al., 2006). Incorporation of protein rich food into cereal based snacks by using extrusion cooking would not only rectify its nutritional inadequacies, but also provides a variety

of food and food products. Many attempts have been made by food scientists to improve protein quality of RTE snacks with incorporation of legumes, isolated proteins or defatted soy flour, meat and cheese analogues (Sumathi et al., 2007; Veronica et al., 2006; Park et al., 1993; Lakshmidhevi et al., 2005; Onwulata et al., 1998).

Currently, there is an ever increasing awareness about health foods and fish is gaining more acceptance because of its special nutritional and functional properties. Fish is not only an excellent source of high nutritional value protein but also of lipids that contains omega-3 fatty acids, especially, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Kris-Etherton et al., 2000; 2002). Omega-3 fatty acids are essential for normal growth and development and may prevent or moderate coronary artery disease, hypertension, diabetes, arthritis, other inflammatory and auto-immune disorders as well as cancer (Simopoulos, 2000). Interestingly, fish is also a good source of various vitamins (A, D, B<sub>6</sub>, B<sub>12</sub>) and minerals (iron, zinc, iodine, selenium, potassium, sodium etc).

Using fish as raw material, many varieties of highly acceptable ready-to-serve products like frozen surimi, frozen mince block, extruded products and imitated products can be made. A few studies have reported successful incorporation of fish flesh or fish powder into starch-based materials by extrusion processes to produce nutritious extruded products that were acceptable by consumers (Gogoi et al., 1996; Suknark et al., 2001; Shaviklo et al., 2011). Data available on RTE snacks with incorporation of fish mince is limited. Hence, the present study was proposed to incorporate fish mince to develop acceptable products manufactured by extrusion cooking, utilizing fish, and to determine the retention of nutrients and omega-3 fatty acid content of the products.

## Materials and Methods

The raw materials like corn grits, rice grits, black gram dal, roasted Bengal gram dal, green gram dal and fish were procured from local markets. Corn grits, rice grits, black gram dal, roasted Bengal gram dal and green gram dal were dried at 55°C for 2 h and were subsequently ground in a hammer mill into flour and sifted through 300- $\mu$ m sieve. The individual flours were then stored in glass containers under dry conditions at room temperature until used for further applications.

Fresh quality *Catla catla* was procured from local market and meat was removed by manual filleting. It was thoroughly washed with freshwater and simmered at low flame, mince was separated and dried in a cabinet drier at 60°C for 24 h and ground in a domestic grinder. The fish powder was sieved, passing through 44 mm mesh sieve, packed in plastic container and stored in refrigerator until further use.

The flour formulations were conditioned to a moisture level of 17% considering its initial moisture level and extruded in a laboratory model co-rotating twin screw extruder (Sciencetech Engineers, Kolkata, India) for development of the extrudates. The barrel diameter and L/D ratio were 37 mm and 27:1, respectively with screw configuration standardized for processing flour-based products. A volumetric feeder was used for feeding the dry mixture to the extruder.

To optimize the process variables of extrusion cooking, the blended samples were mixed thoroughly to get a homogenous mixture and

tempered by adding a predetermined amount of water, by spraying and mixing in a laboratory model blender thoroughly to adjust the feed moisture content to 17-20%. The preconditioned samples were packed in a polythene bag, kept for two h in a refrigerator at 4°C for moisture equilibrium and then fed into the extruder hopper. Different formulations (Table 1) were extruded at temperatures of 80 $\pm$ 5°C (heater I) and 95-105°C (heater II), 300-350 r m<sup>-1</sup> screw speed, 100 $\pm$ 10°C die temperature and 15 $\pm$ 2 kg h<sup>-1</sup> feed rate.

Expansion ratio was determined by taking the diameter of 10 extrudates using a Vernier calipers and dividing by the diameter of the die used (Singh et al., 2000). Piece density was determined by taking the weight and volume of 10 extrudates from each formulation. To arrive at an estimate of volume, the length as well as diameter of 10 pieces of the product was measured. The volume was calculated from the expression  $\Pi r^2 h$  where,  $\Pi = 3.14$ ;  $r$  = radius of the product and  $h$  = the length of the product. The weight of the pieces was divided by the volume to obtain density and expressed as g cm<sup>-3</sup> (Singh et al., 2000). Bulk density was determined by filling a one litre measuring cylinder with the extrudates slightly above the litre mark. The cylinder was tapped 10 times till the products measured up to the litre mark. The weight of the extrudates was taken and the bulk density was calculated.

The moisture content of the samples was determined by following the method of AOAC (1990). Carbohydrate content was estimated by the difference. The energy values of the extrudates were determined by

Table 1. Formulations used for product development

| Extrudates      | Raw material                                                                  | Rate of formulations for 100 g product |
|-----------------|-------------------------------------------------------------------------------|----------------------------------------|
| T <sub>1</sub>  | Corn + rice (C+R)                                                             | 50:50                                  |
| T <sub>2</sub>  | Corn + rice + green gram dal (C+R+ Gg)                                        | 40:40:20                               |
| T <sub>3</sub>  | Corn + rice + black gram dal (C+R+ Bl)                                        | 40:40:20                               |
| T <sub>4</sub>  | Corn + rice + roasted Bengal gram dal (C+R+RBn)                               | 40:40:20                               |
| T <sub>5</sub>  | Corn + rice + fish powder (C+R+ F <sub>1</sub> )                              | 40:40:20                               |
| T <sub>6</sub>  | Corn + rice + fish powder (C+R+ F <sub>2</sub> )                              | 42.5:42.5:15                           |
| T <sub>7</sub>  | Corn + rice + fish powder (C+R+ F <sub>3</sub> )                              | 45:45:10                               |
| T <sub>8</sub>  | Corn + rice + green gram dal + fish powder (C+R+ Gg+F <sub>1</sub> )          | 40:40:10:10                            |
| T <sub>9</sub>  | Corn + rice + black gram dal + fish Powder (C+R+ Bl +F <sub>1</sub> )         | 40:40:10:10                            |
| T <sub>10</sub> | Corn + rice + roasted Bengal gram dal + fish Powder (C+R+RBn+F <sub>1</sub> ) | 40:40:10:10                            |

computation and expressed in kilo calories. The crude protein content of the samples was estimated using Microkjeldal method AOAC (1990) and calculated as the product of percent nitrogen and a multiplication factor. The amount of fat in the food mixes was determined using soxhlet method AOAC (1990). Ash and crude fibre content of the sample was estimated by AOAC (1990) method. Calcium, phosphorus and iron content in the samples were calculated based on the nutritive value of Indian foods (Gopalan et al., 2004). Omega 3 fatty acids were estimated by gas chromatography (Chrisite, 1998).

The extrudates were separately packed in Metalized Polyethylene Terephthalate (MPET) and stored at room temperature for two months. The sensory assessments were conducted in a purpose-built, ten-booth sensory evaluation laboratory by a panel of 30 members. All the ten samples were coded using random three-digit numbers and served with the

order of presentation counter-balanced. They were asked to evaluate the products for acceptability based on its texture, taste, flavour, mouth feel and overall acceptability using five-point hedonic scale (Amerine et al., 1965). Sensory analysis was repeated again after two months (60 days).

Results were subjected to statistical analysis with the window stat programme. Mean and standard deviation for ten replicates were calculated. Completely Randomized Design (CRD) Analysis of variance (ANOVA) was used to know the significant differences for the different treatment combinations and to find the best treatment combination.

## Results and Discussion

Scores for sensory attributes and overall acceptability of extruded snacks before and after two months storage period are presented in Fig.1. Extrudates made from corn, rice, and green gram dal, black gram dal and roasted Bengal gram dal alone were

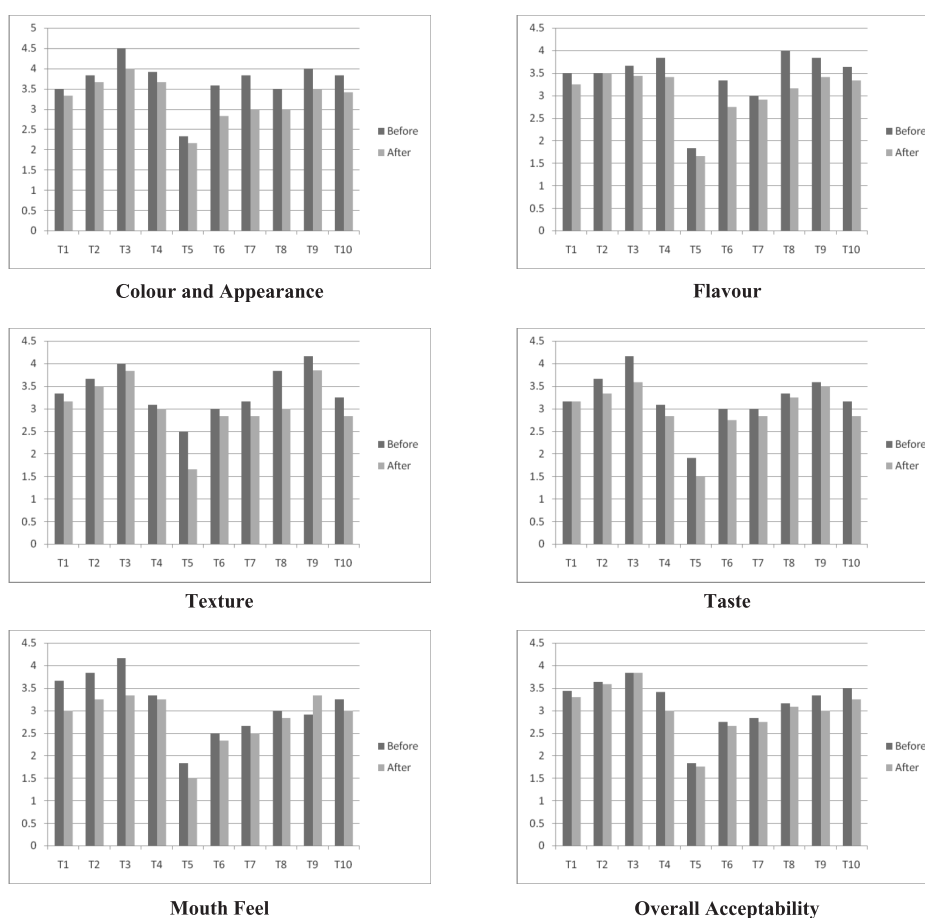


Fig. 1. Sensory evaluation of RTE snacks before and after two months storage period

served as control. All the control extrudates scored well for colour and appearance. The T<sub>3</sub> (C+ R+Bl) and T<sub>9</sub> (C+ R+ Bl+F<sub>1</sub>) samples scored higher than the other samples. This could be due to better porosity in T<sub>3</sub> and T<sub>9</sub> samples. After two months storage, a similar trend was observed for colour and appearance.

The extrudates made from T<sub>5</sub>, T<sub>6</sub> and T<sub>7</sub> scored least compared to T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> and T<sub>4</sub> and cereal, pulse and fish incorporated extrudates T<sub>8</sub>, T<sub>9</sub> and T<sub>10</sub> due to the mild fish flavour and after taste. The textural properties of all the extrudates were good with the exception of T<sub>5</sub>, which was made by incorporating fish powder (20%) with significantly ( $p<0.05$ ) higher hardness. However, no significant difference was found for texture after two months of storage.

The taste of all the extrudates was found to be good with the exception of T<sub>5</sub> sample. Among experimental extrudates, the highest score (3.58) was given for T<sub>9</sub> and the least score (1.91) for T<sub>5</sub>. After storage also, there was no significant difference between the samples. However, control samples had better taste than the experimental samples. Mouth feel of control extrudates (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> & T<sub>4</sub>) was significantly ( $p<0.05$ ) higher than the experimental extrudates (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub>, T<sub>8</sub>, T<sub>9</sub> and T<sub>10</sub>).

The mean scores for overall acceptability of the extrudates made from control samples was significantly ( $p<0.05$ ) higher (T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub> & T<sub>4</sub>) than experimental samples (T<sub>5</sub>, T<sub>6</sub>, T<sub>7</sub>, T<sub>8</sub>, T<sub>9</sub> & T<sub>10</sub>). Among experimental samples, overall acceptability of T<sub>9</sub> and T<sub>10</sub> was higher than other experimental snacks. After

storage for 60 days also similar trend was observed for overall acceptability. While the nutritional qualities of the products are a key consideration, the RTE extruded snack also needs to be acceptable to its target market (Potter et al., 2012). As Shoar et al. (2010) reported, acceptability depends mainly on the organoleptic properties of the snacks, which are usually measured in terms of texture, taste and appearance. The RTE extrudates made with fish mince powder in the study (T<sub>2</sub>, T<sub>3</sub> and T<sub>9</sub>) were well acceptable in terms of colour, flavor, texture, taste, mouth feel and overall acceptability.

The highest diameter and maximum expansion was observed for control extrudates than fish incorporated extrudates (Table 2). Diameter and expansion ratio decreased with higher amount of fish powder in the formula. However, there was no significant difference between the extrudates for diameter and expansion ratio. The higher the starch content of the extrudates the more the expansion and the more the protein the less is expansion (Adesena et al., 1998). Control snack appeared to be expanded and puffed more than the experimental snacks. The bulk density and tap density was higher for T<sub>5</sub> than the control samples and other experimental samples, but no significant difference was found between the experimental and control snacks. The addition of high level protein reduces expansion ratio and increases bulk density (Martinez–serna & Villota, 1992). This has been ascribed to the protein interactions at higher concentration. The protein fractions reinforce the product cell wall and increase breaking strength

Table 2. Physical characteristics of extruded snacks

| Parameter       | T <sub>1</sub> | T <sub>2</sub> | T <sub>3</sub> | T <sub>4</sub> | T <sub>5</sub> | T <sub>6</sub> | T <sub>7</sub> | T <sub>8</sub> | T <sub>9</sub> | T <sub>10</sub> | 'F' Value          |
|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|--------------------|
| Length (cm)     | 32.5<br>±5.65  | 26.2<br>±3.96  | 39.8<br>±3.63  | 26.1<br>±1.45  | 25.9<br>±3.03  | 24.9<br>±2.05  | 29.9<br>±3.88  | 26.4<br>±3.47  | 26.7<br>±3.51  | 29.3<br>±5.19   | 2.95**             |
| Weight (g)      | 0.4<br>±0.07   | 0.2<br>±0.09   | 0.3<br>±0.07   | 0.3<br>±0.03   | 0.3<br>±0.04   | 0.2<br>±0.03   | 0.3<br>±0.06   | 0.2<br>±0.04   | 0.2<br>±0.04   | 0.3<br>±0.06    | 0.75 <sup>NS</sup> |
| Diameter (mm)   | 12.0<br>±1.22  | 12.0<br>±0.49  | 11.9<br>±0.89  | 12.1<br>±0.64  | 7.4<br>±0.66   | 10.4<br>±0.58  | 11.1<br>±0.68  | 11.6<br>±0.74  | 11.2<br>±0.90  | 10.6<br>±1.00   | 0.29 <sup>NS</sup> |
| Tap Density     | 1.1<br>±0.01   | 1.1<br>±0.02   | 1.1<br>±0.11   | 1.1<br>±0.16   | 1.3<br>±0.26   | 1.2<br>±0.24   | 1.1<br>±0.01   | 1.1<br>±0.13   | 1.1<br>±0.41   | 1.1<br>±0.19    | 1.02 <sup>NS</sup> |
| Expansion Ratio | 5.9<br>±0.59   | 6.0<br>±0.25   | 5.9<br>±0.44   | 6.0<br>±0.32   | 3.7<br>±0.33   | 5.2<br>±0.29   | 5.5<br>±0.34   | 5.7<br>±0.37   | 5.6<br>±0.45   | 5.3<br>±0.50    | 0.36 <sup>NS</sup> |
| Bulk Density    | 0.4<br>±0.06   | 0.3<br>±0.05   | 0.2<br>±0.04   | 0.3<br>±0.04   | 0.9<br>±0.20   | 0.3<br>±0.04   | 0.3<br>±0.05   | 0.3<br>±0.06   | 0.3<br>±0.06   | 0.4<br>±0.11    | 0.56 <sup>NS</sup> |

Results are mean ± SD of ten samples

(Singh et al., 1991). This may be the cause of higher tap density and bulk density.

The moisture content of the samples ranged from 0.19 to 0.27 g which is desirable for extruded snacks to maintain the crispness (Table 3). The carbohydrate content of fish powder incorporated samples ( $T_5$ ,  $T_6$ ,  $T_7$ ,  $T_8$ ,  $T_9$  and  $T_{10}$ ) was lower and protein and fat content was higher than the control extrudates ( $T_1$ ,  $T_2$ ,  $T_3$  and  $T_4$ ). The energy value of the products ranged from 392 to 437 Kcal.

Similar levels of moisture values upto 0.7 g were reported for RTE extrudates made from sorghum and rice (Lakshmi et al., 2012). Protein content of sorghum and soy (80:20) extrudates was reported to be 16.4 g (Prasad et al., 2007). The highest protein value of 18.2 g was reported in extruded snack from buffalo meat with 60% corn flour (Anand et al., 2005). The extrudates made by incorporating fish

powder was observed to have high ash and crude fibre content. Among fish incorporated samples, omega -3 fatty acid content was higher in  $T_5$  sample than other samples (Table 3). The fatty acids present in the fish could have attributed for higher omega 3 fatty acid content in the samples. The eicosapentaenoic acid (EPA) content of fish mince was 2.4% and docosahexaenoic acid (DHA) content was 6.3% and after extrusion, the EPA content was reduced to 0.1% and DHA was reduced to 0.3% (Table 3). It is due to mixing with flours and thereby causing proportional reduction. The calcium content was higher and phosphorus, iron and zinc content were lower in fish powder incorporated extrudates than control samples.

Well accepted ready to eat snacks can be produced with incorporation of fish powder in cereal and pulses using extrusion cooking. Incorporation of fish powder has improved protein, omega fat

Table 3. Nutritive value of extruded snacks (Per 100 g)

| Nutrients        | $T_1$          | $T_2$          | $T_3$          | $T_4$          | $T_5$          | $T_6$          | $T_7$          | $T_8$          | $T_9$          | $T_{10}$       |
|------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Moisture (g)     | 0.19±<br>0.2   | 0.23±<br>0.1   | 0.27±<br>0.1   | 0.22±<br>0.3   | 0.25±<br>0.2   | 0.27±<br>0.1   | 0.21±<br>0.1   | 0.27±<br>0.1   | 0.22±<br>0.1   | 0.2±<br>0.1    |
| Ash (g)          | 2.78±<br>0.09  | 2.65±<br>1.03  | 2.5±<br>0.06   | 2.96±<br>0.05  | 2.75±<br>0.06  | 2.87±<br>0.11  | 2.71±<br>0.15  | 2.78±<br>0.54  | 2.78±<br>0.15  | 2.84±<br>0.18  |
| Fibre (g)        | 0.31±<br>0.21  | 0.30±<br>0.19  | 0.34±<br>0.20  | 0.33±<br>0.12  | 0.39±<br>0.16  | 0.38±<br>0.14  | 0.33±<br>0.12  | 0.36±<br>0.18  | 0.34±<br>0.14  | 0.36±<br>0.20  |
| Energy (k cal)   | 436.5±<br>0.98 | 436.3±<br>0.86 | 437.9±<br>0.59 | 436.7±<br>0.48 | 392.8±<br>0.73 | 406.9±<br>0.91 | 411.5±<br>0.45 | 425.7±<br>0.61 | 432.5±<br>0.73 | 432.2±<br>0.55 |
| Carbohydrate (g) | 72.2±<br>0.32  | 69.1±<br>0.28  | 69.6±<br>0.19  | 69.3±<br>0.13  | 57.9±<br>0.52  | 61.4±<br>0.21  | 65.0±<br>0.42  | 63.8±<br>0.15  | 63.8±<br>0.13  | 63.8±<br>0.25  |
| Protein (g)      | 8.9±<br>0.28   | 11.5±<br>0.19  | 11.9±<br>0.15  | 11.6±<br>0.23  | 12.0±<br>0.24  | 11.5±<br>0.22  | 10.5±<br>0.32  | 11.5±<br>0.28  | 10.9±<br>0.19  | 11.3±<br>0.15  |
| Fat (g)          | 12.4±<br>0.02  | 12.6±<br>0.03  | 12.4±<br>0.01  | 12.5±<br>0.02  | 12.5±<br>0.02  | 12.7±<br>0.03  | 12.1±<br>0.04  | 13.8±<br>0.03  | 14.8±<br>0.01  | 14.6±<br>0.01  |
| Calcium (mg)     | 10.0±<br>0.31  | 23.0±<br>0.20  | 38.8±<br>0.12  | 19.0±<br>0.22  | 114.0±<br>0.04 | 88.0±<br>0.48  | 67.0±<br>0.10  | 69.0±<br>0.18  | 76.4±<br>0.24  | 66.8±<br>0.30  |
| Phosphorus (mg)  | 254.0±<br>0.28 | 263.9±<br>0.31 | 280.2±<br>0.24 | 271.2±<br>0.25 | 250.2±<br>0.19 | 251.1±<br>0.14 | 252.1±<br>0.15 | 267.2±<br>0.24 | 265.2±<br>0.12 | 260.7±<br>0.10 |
| Iron (mg)        | 1.50±<br>0.15  | 2.05±<br>0.31  | 2.68±<br>0.22  | 3.82±<br>0.24  | 2.1±<br>0.17   | 1.45±<br>0.25  | 1.43±<br>0.21  | 2.40±<br>0.20  | 2.39±<br>0.16  | 2.96±<br>0.17  |
| Zinc (mg)        | 2.05±<br>0.18  | 2.2±<br>0.14   | 2.24±<br>0.11  | 1.98±<br>0.14  | 1.64±<br>0.14  | 1.74±<br>0.10  | 1.83±<br>0.14  | 2.02±<br>0.13  | 1.94±<br>0.18  | 2.01±<br>0.10  |
| EPA (%)          | -              | -              | -              | -              | 0.3±<br>0.02   | 0.2±<br>0.01   | 0.1±<br>0.04   | 0.1±<br>0.01   | 0.1±<br>0.01   | 0.1±<br>0.04   |
| DHA (%)          | -              | -              | -              | -              | 1.0±<br>0.04   | 0.9±<br>0.02   | 0.3±<br>0.11   | 0.3±<br>0.02   | 0.3±<br>0.01   | 0.3±<br>0.01   |

Results are mean ± SD of duplicate analysis

content and calcium content in the extruded snack and reduced the carbohydrate and energy content which indicate that the fish mince powder incorporated RTE product is more nutritious than the control product. It would also provide another avenue for fish utilization and increasing fish consumption.

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