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Development and analysis of nutritional rich traditional snack product from foxtail and finger millet by using whey protein concentrates (WPC)

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Abstract
Cereals and millets form the basic diet for millions of people throughout the world and Whey Proteins Concentrate (WPC) is an excellent source of dietary nitrogen and branched chain amino acids. Whey Protein Concentrate (WPC) at different levels of substitution i.e. control (T_0), 2.5 parts (T_1), 5 parts (T_2), 7.5 parts (T_3) and 10 parts (T_4), to assess physicochemical and sensorial attributes. In related to the physical properties of raw foxtail and finger millet *papad* prepared from treatments T_0 to T_4 content were 19.25 to 21.25 total number, 0.74 to 0.66 mm thickness, 6.10 to 6.35 gm weight, 11.22 to 11.06 cm diameter. Chemical analysis revealed that 10 parts of WPC supplemented *papads* showed maximum moisture content (5.15), fat content (2.27), protein content (15.79) and ash content (3.75) per cent also minimum carbohydrate content (73.04) per cent as compared to control. Physical properties of fried foxtail and finger millet *papad* were 7.06 to 7.62 gram weight, 15.73 to 20.00 per cent oil absorption, 13.98 to14.24 cm diameter and Expansion ratio 24.59 to 28.75 per cent. Foxtail and finger millet *papad* supplemented with 10 parts of WPC showed maximum overall acceptability (8.03) in fried *papad*. In the color attributes L* value of *papad* was decreased from (T_0) 63.99 to (T_4) 48.97, a* and b* values were increased from 7.26 to 11.95 and 23.61 to 28.04 respectively.

Keywords: WPC, foxtail and finger millet *Papad*, Physico-chemical and sensory properties.

Introduction
In recent years great need is felt revive our traditional food sector mainly to provide impetus and value addition for sustainable development of it's largely cottage, tiny and rural sector. Snack foods have long been a part of diets both in developing and developed countries (Garg and Dahiya, 2003) [6].

Papad is a popular and tasty food item in the Indian diet in many centuries, which is regularly consumed as a meal, accompaniment, after roasting or frying or as adjunct along with vegetable soups and curries (Chowdhury *et al.* 2009) [5]. It is also known as *Appalam* and essentially a thin wafer like product, circular in shape, rolled and nutritious as well.

Millets are important crops of Asia and Africa (especially in India and Nigeria), with 97 percent of millet production in developing countries. Various traditional foods and beverages such as *roti*, bread (fermented or unfermented), porridge, snacks and fast foods, baby foods, millet wine, millet nutrition powder etc are made up of millets (Chandrasekara and Shahidi, 2012) [3] and it contains 60-70 per cent carbohydrates, 7-11 per cent proteins, 1.5-5 per cent fat, and 2-7 per cent crude fibre and are also rich in vitamins and minerals. They are excellent source of vitamin B, magnesium, and antioxidants (Singh, K. P *et al.* 2012) [14]. Millets are also rich sources of micronutrients and phytochemicals (Liu, R.H. 2007) [9]. It is an alkaline forming food, alkaline based diet is often recommended to achieve optimal health, meaning when it combines with digestive enzymes. The soothing alkaline nature of millet helps to maintain a healthy pH balance in the body, crucial to prevent illnesses.

Foxtail millet *(Setaria italica)*, a member of the family *Poaceae*, is one of the oldest cereal crops. Foxtail millet grain is rich in protein (12.3%) and iron (2.8mg/100g) as compared to rice (6.8% protein and 1.8mg iron/100g grain) and rich in fat 4.3 per cent which is superior to rice and wheat. The grain is good source of beta - carotene, which is the precursor of Vitamin A (Murugan and Nirmalakumari 2006) [10]. Foxtail millet is mixed with legumes to make porridge and also mixed with soybean to make mixed flour. Foxtail millet has low glycemic index (GI), used for preparation of low GI biscuits and *burfi*, a sweet product and it is an ideal for people suffering from diabetes (Anju and Sarita, 2010) [1] and also fermented to make vinegar, yellow wine, maltose, beer and other related products.

Whey proteins are an excellent source of dietary nitrogen and branched chain amino acids which are used to fuel working muscles and stimulate protein synthesis. Whey protein has

antimicrobial, antiviral and antioxidant properties, and they also act as techno-functional ingredients in many formulated food systems due to their good solubility, surface activity and gelling properties. In addition, whey proteins and their associated peptides display significant functional food ingredient potential (Chatterjee and Kanawjia, 2010) [4].

Protein malnutrition is a serious problem for people whose diets mainly consist of cereal or starch foods (Haupt *et al*. 1997) [7]. Whey Protein Concentrate (WPC) has a protein content of 25-89 per cent according to standards. Whey protein greatly enhances the nutritional value of cereal based products. An incomplete essential amino acid profile in cereal based protein can cause serious malnutrition problems for vegetarians and people in developing countries who lack high quality protein. Whey proteins are complement with cereal protein, producing food with the optimum balance of essential amino acid and improve nutritional quality.

Use of Whey Protein Concentrate in preparation of cereal based traditional products was not only improving the product quality but also provide essential nutrients mostly proteins. Considering the importance of cereal based traditional products and nutritive profile of Whey Protein Concentrate it is studied on "Protein Enrichment of Minor Millet *Papad* by Using Whey Protein Concentrate."

Materials

Millet grains

Minor millets such as foxtail millet (DHF-1) and finger millet (CO-9) are procured from the Indian Institute of Millet Research (IIMR), Rajendranagar, Hyderabad.

Whey Protein Concentrate (WPC)

Whey Protein Concentrate (WPC-70) required for study was purchased from Modern dairy limited, Karnal.

Ingredients

Salt, alkaline salt (*papad*khar), red chilly powder, cumin, sesamum, asafoetida and fortune soybean oil was procured from the local market of Parbhani.

Chemicals and Glassware's

Chemicals (Analytical grade) were procured from standard firms and glassware's required for conducting chemicals analysis and preparation of product utilized from laboratory of department of AHDS, VNMKV, Parbhani.

Treatment Details

During this *papad* preparation two minor millets viz. Foxtail millet (DHF-1) and Finger millet (CO-9) were utilized with WPC.

T_0 – 70 parts Foxtail millets + 30 parts finger millet

T_1 – 67.5 parts of Foxtail millets + 30 parts finger millet + 2.5 parts of WPC

T_2 – 65.0 parts of Foxtail millets + 30 parts finger millet + 5.0 parts of WPC

T_3 – 62.5 parts of Foxtail millets + 30 parts finger millet +7.5 parts of WPC

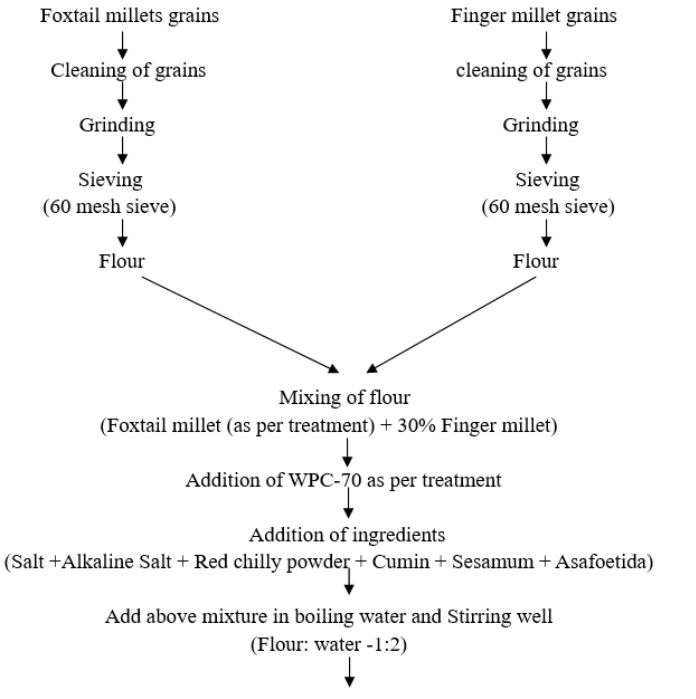
T_4 – 60.0 parts of Foxtail millets + 30 parts finger millet +10.0 parts of WPC

Methodology

Table 1: Recipe for Preparation of Protein Enriched Minor Millet *Papad*

Sr. No	Ingredients	Quantity for 100 gm
1	Salt	2 gm
2	Alkaline Salt (*Papad*khar)	3 gm
3	Red chilly powder	1 gm
4	Cumin	1.5 gm
5	Sesamum	2 gm
6	Asafoetida	0.5 gm
7	Water	200 - 220 ml
8	WPC- 70	As per treatment combinations

Flow diagram for preparation of protein enriched foxtail and finger millet *Papad*



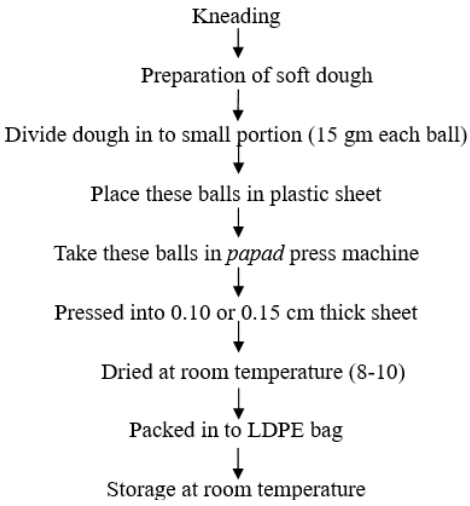


Fig 1: Preparation of protein enriched foxtail millet and finger millet *papad*

Dehulled foxtail millet and finger millet grains were cleaned and ground in grinder followed by sieving in 60 mesh sieve to make flour. WPC as per the treatment combinations and calculated amount of ingredients (Salt +Alkaline Salt + Red chilly powder + Cumin + Sesamum + Asafoetida) were added. This mixture was boiledin water with 1: 2 ratios with constant stirring to make smooth dough. Allow to dough to stand undisturb for 30 minutes. Prepare small balls weighing approximately 15 gm weight by rolling on palm. Press these balls in *papad* press machine by applying slight weight by hands, so that the thickness of *papad* should remain constant approximately 0.60 to 0.80 mm. spread the prepared *papads* on food grade plastic sheet for drying at room temperature for 8-10hours followed by storage in low density polythine bags at room temperature in dry place.

Product Evaluations

Physico-Chemical Properties

Total Number of *Papad*

The total number of various millet *papad* obtained from 100 g of foxtail + finger millet and WPC were prepared and recorded.

Unit Weight of Raw and Fried *Papad*

The unit weight of raw and fried foxtail + finger millet *papads* were recorded by taking the weight of 10 *papads*.

Diameter of Raw and Fried *Papad*

The diameter of raw and fried foxtail + finger millet *papads* were measured on opposite ends with the help of thread and recorded.

Determination Colour of fried *papad*

Colour was measured in terms of L*, a* and b* values. L* is known as lightness and extends from 0 (black) to 100 (white). The other two co-ordinates a* and b* represent redness (+60) to greenness (- 60) and yellowness (+60) to blueness (-60) respectively were recorded.

Chemical Characteristics of *papad*

Chemical parameters like moisture, fat, protein, ash, carbohydrate, content, were determined by (AOAC, 1990) [2].

Organoleptic characteristics of fried *papad*

The fried Protein Enriched fried *Papad* was subjected to organoleptic characteristics like colour and appearance, body and texture (mouth feel), flavour and overall acceptability by scoring method using 9 point Hedonic scale.

Oil absorption

Papad from each selection were weighed before and after deep frying (180 ± 5^0c) in an electronic balance. Before measuring the weight after frying, the *papad* were wiped with tissue paper to remove the adhering surface oil. The difference in weight was worked out and expressed as oil uptake in percentage (Vedprakash and Madhavareddy, 2018) [15].

Expansion Ratio

The expansion ratio of fried protein enriched *papad* was calculated according to the procedure given below,

$$\text{Expansion ratio} = \frac{DF - DR}{DR.} \times 100$$

Where,

DF= Diameter of fried protein enriched minor millet *papad*

DR= Diameter of raw protein enriched minor millet *papad*

Statistical Analysis

The data obtained was analysed using Completely Randomize Design.

Results and Discussion

Table 1: Chemical composition of WPC, foxtail and finger millet grains

Sr. no	Composition	WPC Powder	Foxtail millet Grains	Finger millet Grains
1	Total Solid (%)	96.96	91.95	90.10
2	Ash (%)	6.20	1.09	2.40
3	Moisture (%)	3.04	9.42	9.50
4	Protein (%)	70.85	13.0	8.80
5	Fat (%)	6.50	3.67	3.90
6	Carbohydrate (%)	-	74.19	75.00
7	NPN (%)	0.18	-	-
8	Calcium (%)	1.70	-	-
9	Chloride (%)	1.57	-	-
10	Acidity (%)	1.62	-	-

(Rathour *et al.*, 2016; Nazni and Bhuvaneshwari, 2015; Kamtkar *et al*., 2015) [13, 11, 8]

Table 2: Effect of WPC on Physical Properties of Raw Foxtail and Finger Millet Raw *Papad*

Treatments	Total Number	Thickness (mm)	Weight (gm)	Diameter (cm)
T_0	19.25^{a}	0.74^{a}	6.10^{a}	11.22^{a}
T_1	19.50^{ab}	0.72^{ab}	6.16^{b}	11.19^{ab}
T_2	20.25^{bc}	0.70^{b}	6.25^{c}	11.14^{b}
T_3	20.75^{cd}	0.68^{bc}	6.29^{d}	11.10^{bc}
T_4	21.25^{d}	0.66^{c}	6.35^{e}	11.06^{c}
SE	0.32	0.01	0.01	0.02
CD at 5%	0.96	0.03	0.03	0.06

From the table 2 it was observed that total number of foxtail and finger millet raw *papad* increased from 19.25 to 21.25 in T_0 to T_4. This might be due to increased weight of dough by moisture through addition of WPC powder. The average thickness (mm) of control foxtail and finger millet raw *papad* sample i.e. T_0 was 0.74 mm which was higher than all experimental samples and the weight of foxtail and finger millet raw *papad* increased significantly from 6.10 to 6.35 gram, this may be due to the increased moisture percentage. The T_4 treatment was lower diameter of raw *papad* i.e. 11.06 cm than other, whereas highest diameter was recorded for treatment T_0 i.e. 11.22 cm. there was decrease in diameter of raw *papad*, there was the shrinkage of *papad* with increasing the level of WPC.

Table 3: Effect of WPC on Chemical Properties of Raw Foxtail and Finger Millet raw *Papad*

Treatments	Moisture (%)	Fat (%)	Protein (%)	Ash (%)	Carbohydrates (%)
T_0	3.34^{a}	1.24^{a}	8.14^{a}	2.85^{a}	84.43^{a}
T_1	3.80^{b}	1.56^{b}	10.27^{b}	3.18^{b}	81.19^{b}
T_2	4.20^{c}	1.84^{c}	12.26^{c}	3.45^{c}	78.25^{c}
T_3	4.87^{d}	2.08^{d}	14.18^{d}	3.62^{d}	75.25^{d}
T_4	5.15^{e}	2.27^{e}	15.79^{e}	3.75^{e}	73.04^{e}
SE	0.04	0.02	0.07	0.04	0.01
CD at 5%	0.11	0.06	0.22	0.12	0.04

There was significant (P<0.05) increased in moisture content of experimental foxtail and finger millet raw *papad* i.e 3.34 to 5.15 per cent as the levels of WPC powder increased. This happened might be due the hydrophobic effect of whey proteins which binds the water molecules and increased the moisture content. The T_4 treatment was significantly higher content (2.27%) fat, whereas lowest fat content (1.24%) was recorded for treatment T_0. The increasing trend for protein was observed in successive treatment. The treatment T_4 had significantly higher protein content (15.79%) as compared to the rest of the treatments. The WPC powder are strongly affected on the protein content of developed product this is due to the higher amount of protein percent in whey protein concentrate powder. The highest value of ash (3.75%) was observed in T_4 (10 parts WPC supplemented finger millet *papad*) while lowest value (2.85%) was observed in T_0 (control sample). Result revealed that the ash content in all samples differed significantly. This might be due to high minerals in WPC powder, foxtail millet and in finger millet grains and significant (P<0.05) decrease in carbohydrate content of experimental raw finger millet *papad* as the level of WPC increased. This might be low carbohydrate content in WPC.

Table 5: Effect of WPC on Physical Properties of Finger and Foxtail Millet Fried *Papad*

Treatments	Weight (gm)	Oil absorption (%)	Diameter (cm)	Expansion ratio
T_0	7.06^{a}	15.73^{a}	13.98^{a}	24.59^{a}
T_1	7.20^{b}	16.88^{ab}	14.08^{b}	25.82^{b}
T_2	7.37^{c}	17.92^{b}	14.14^{c}	26.92^{c}
T_3	7.49^{d}	19.02^{bc}	14.19^{d}	27.83^{d}
T_4	7.62^{e}	20.00^{c}	14.24^{e}	28.75^{e}
SE	0.02	0.37	0.01	0.01
CD at 5%	0.06	1.10	0.04	0.03

The T_4 treatment was significantly higher weight i.e. 7.62 gram than other, whereas lowest weight (7.06 gm) was recorded for treatment T_0. This happened is may be due to the replacement of moisture by oil at the time of frying. The maximum oil absorption was observed for fried sample of T_4 (20%) prepared from 10 parts of WPC supplemented sample and minimum for control foxtail and finger millet fried *papad* T_0 (15.73%). The oil absorption of fried finger *papad* during frying is increased it might be due the replacing moisture content by the oil. There was significant (P<0.05) increase in diameter of experimental foxtail and finger millet *papad* as the level of WPC powder increased and the average expansion ratio of control fried finger millet *papad* sample i.e. T_0 was 28.75 per cent which was lower than all experimental fried finger millet *papad*. This is might be due to the decrease in the thickness, added alkaline salt *(papadkhar)* and replacement of moisture by oil in the developed product.

Table 6: Effect of WPC on Colour (L*, a* and b* values) of Finger Millet and Foxtail Millet Fried *Papad*

Treatments	(L*) Lightness	(a*) Redness	(b*) Yellowness
T_0	63.99^{a}	7.26^{a}	23.61^{a}
T_1	54.50^{b}	8.12^{b}	25.40^{b}
T_2	52.77^{c}	9.81^{c}	26.14^{c}
T_3	50.62^{d}	10.71^{d}	27.08^{d}
T_4	48.97^{e}	11.95^{e}	28.04^{e}
SE	0.01	0.01	0.01
CD at 5%	0.03	0.04	0.03

The lightness (L*) value of foxtail and finger millet fried *papad* decreased from 63.99 to 48.97, which is due to the development of browning or colored compounds through the maillard reaction between the WPC lactose and the free amino groups from the lysine incorporated with the protein ingredients. Redness/greenness of foxtail and finger millet fried *papad* showed an increasing trend from lowest value (7.26) was observed in control foxtail and finger millet fried *papad* (T_0) to highest value (11.95) was found in 10 parts of WPC supplemented foxtail and finger millet fried *papad* (T_4). The increase in redness of foxtail and finger millet fried *papad* could be attributed to darkening of WPC and caramalization during frying at high temperature. Yellowness (b*) of foxtail and finger millet fried *papad* increases with an increase the WPC level. The b* value of the samples ranged from 23.61 to 28.04. It was observed that the yellowness of foxtail and finger millet fried *papad* increases from control sample (T_0) to 10 parts of WPC supplemented sample (T_4) which may be attributed to degradation of compounds during frying.

Table 7: Effect of WPC on Organoleptic Properties of Foxtail and Finger Millet Fried *Papad*

Treatments	Flavour	Colour and appearance	Body and Texture	Overall acceptability
T_0	6.30^a	7.00^a	7.10^a	6.80^a
T_1	6.70^b	7.42^b	7.25^b	7.12^b
T_2	6.92^c	8.20^c	7.60^c	7.57^c
T_3	7.32^d	8.52^d	7.84^d	7.89^d
T_4	7.58^e	8.33^e	8.30^e	8.07^e
SE	0.02	0.06	0.02	0.02
CD at 5%	0.07	0.18	0.06	0.07

Table no 7 revealed that the addition of different rate of WPC in foxtail and finger millet had significant ($P<0.05$) improving effect on flavour score of experimental samples up to 10 parts (T_4) i.e. 7.58. The score for colour and appearance increased up to the treatment T_2 where was 7.5 parts of WPC powder added after that in treatment T_4 there was decreased the score for colour and appearance. It may due to the increased darker colour of product by maillard browning, physical quality attributes like frying parameters, cooking behavior. The maximum score (8.30) was received to foxtail and finger millet fried *papad* prepared with 10 parts of WPC and minimum score (7.10) to the control sample which is prepared without parts of WPC. There was significantly increased the score of body and texture of product it may due to the increased crunchiness of product. The overall acceptability score for the fried foxtail + finger millet *papad* with 10 parts WPC (T_4) was significantly ($P<0.05$) superior over all treatments.

Conclusion

In view of experimental results obtained during the present investigation, it may be concluded that the foxtail and finger millet fried *papad* prepared with 10 parts of WPC received highest score for flavor, body and texture, colour and appearance & overall acceptability was liked very much by the judges in the organoleptic evaluation. In Physical properties of raw *papad* total number slightly increases as the WPC supplementation level increase. WPC also affected on physical properties of fried *papad*. In colour characteristics, Lightness value of foxtail and finger millet fried *Papad* decreased as the WPC level increased which is due to the development of colored compounds through the maillard reaction. Redness as well as yellowness of fried *papad* increases with an increase in the WPC level which may be attributed to darkening of WPC and degradation of compounds during frying at high temperature. Oil absorption and Expansion ratio increased as the WPC level increased, variation might be due to varied moisture content in dried *papad* samples. Results also showed that with an increase in the WPC supplementation level, in millet *papad*, samples there was increase in moisture, protein, ash and fat content and total carbohydrate decreases. From the present study, it can be concluded that the 10 parts WPC supplemented *papad* samples were nutritionally rich.

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