IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

INFLUENCE OF WHEY PROTEIN CONCENTRATE (WPC) - A FUNCTIONAL INGREDIENT ON RHEOLOGICAL ATTRIBUTES OF FOXTAIL MILLET BASED RTE FOOD

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Abstract:

Whey, a protein complex derived from milk, is being touted as a functional food with a number of health benefits compared to other constituents. The terminology WPC is being used for the dried whey having more than 25 per cent protein and as such there is a wide variation in composition of resultant WPC, ranging from 25 to 90 per cent protein. The special nutritional significance of millets and WPC, their beneficial effects have made the present research to develop value-added millet-based food products with improved functional & Rheological attributes. The corn-wheat was replaced with foxtail millet at various proportions of 25, 50, 75 and 100 per cent levels and subjected to extrusion process followed by oil frying. From the various physico-chemical, functional, rheology tests and sensory perceptions, it was found that replacement of 50 per cent foxtail millet was best suited for formulating foxtail millet based RTE food. Further RTE food was enriched with WPC at 4, 6, 8 and 100 per cent levels among various levels of addition of 6 per cent WPC was found to be acceptable.

Key Words: Minor millet**,** Foxtail millet, WPC, Rheological property, RTE food

Introduction:

The present awareness about nutrition and health care has focused research to identify newer sources of nutritional materials with the desirable functional characteristics. In this regard use of underutilized millets such as foxtail millet and WPC a major dairy by-product in development of extruded snacks in the form of RTE food is clearly a consequence of the recent trend to satiate the growing needs of modern consumer.

Foxtail millet (*Setaria italica*) is also known as Italian, Hungarian, German and Siberian millet. Though China is the leading producer of foxtail millet, it is also grown widely in India and is the most important millet in Japan. It is one of the world's oldest cultivated crops. Foxtail millet ranks second in the total world production of millets and it continues to have an important place in the field of agriculture all over the world providing approximately six million tons of food to millions of people, mainly on poor or marginal soils in the Southern Europe and in the temperate subtropical and tropical Asia (ICAR, Indian farming, 2016).

Foxtail millet has nutrient profile of carbohydrate (60.00 %), protein (12.30 %), fat (4.3 %), crude fiber (8.0 %), minerals (3.3 %) with 331 k cal of energy. Foxtail millet comprises of lysine 140 mg/ g of N, tryptophan 60mg/ g of N, phenyl alanine 420 mg/ g of N, methionine 180 mg/ g of N, cystine 100 mg/ g of N,threonine 190 mg/ g of N, leusine 1040mg/ g of N, isoleusine 480mg/ g of N, valine 430mg/ g of N (IIMR, 2016).

Whey is the largest by-product of the Dairy industry. It is obtained during the manufacture of cheese, casein, paneer, chhana and shrikand which are very popular and have great market demands especially for cheese as its consumption is steadily increasing due to changing food habits. Normal bovine milk contains about 3.5 per cent of protein of which casein constitutes 80 per cent and whey proteins 20 per cent (Marshal, 2004). Whey proteins comprised of 61.4 per cent β-lactoglobulin, 20.5 per cent α- lactalbumin, 6.0 per cent serum albumin and 12.2 per cent immunoglobulin. WPC with its high protein quality score and high percentage of BCAAs (branched chain amino acids), has long been popular as a muscle-building supplement. However, research suggests it may have far wider applications as a functional food .They possess proportionately more sulphur containing amino acids (cysteine and methionine) than caseins, which contribute to the higher PER of whey proteins (3.2) than casein (2.6). Any protein with a PER of 2.5 or more is considered as good quality proteins They also have higher nutritional value because of relatively high proportion of branched chain and essential amino acids. The Biological Value (BV), Net Protein Utilization (NPU), Protein Efficiency Ratio (PER) and Protein Digestibility are higher (104, 92, 3.6, 1.6) as compared to casein (77, 76, 2.9, 1.0), whole egg (100, 94, 3.8, 1.0), respectively (Jayaprakasha and Brueckener, 2005; Tsutsumi and Tsutsumi, 2014).

Whey proteins provide good functional and nutritional properties for formulation novel products which have potential to improve the quality of food products. The texture of the extrudate is a very essential for evaluation of physical property for ready to eat snack. It largely depends on the composition and nature of the raw material of the mix used for extrusion. The ingredient composition and moisture content of the mix are the main factors that affect the texture of the final extrudate (Rohini and Bansal, 2013). Texture Profile analysis of extruded snacks is especially required for snack foods, where crunchiness is a desirable attribute. A complete texture evaluation includes springiness, gumminess, Fractuability, cohesiveness, hardness, chewiness and mechanical properties of foods. Hardness is defined as the force required to compress a substance between the molar teeth (in the case of solids) or between the tongue and palate in the case of semisolids. The substance is compressed to a given deformation or penetration, which is designated as soft, firm or hard. The hardness (HD) and crispness (CR) is associated with the expansion and cell structure of the extruded product.

Materials and methods:

Preparation of foxtail millet flour

The foxtail millet grains were cleaned and soaked in potable water for 24 h with a grain to water ratio of 1:3. The soaked grains was spread on a muslin cloth and allowed for germination at a temperature of 37 °C for 24 h. The sprouted grains were dried at 37 °C. The dried grains were then subjected to roasting followed by milling of the foxtail millet grains in a domestic flour mill to get the malted foxtail millet flour.

Enrichment of WPC to foxtail millet based RTE food

The standardized blend of foxtail millet and Corn-wheat (50:50) was further enriched with WPC at the rate of 4, 6, 8 and 10 per cent levels. The enriched flour was preconditioned to prepare dough as per standard moisture per cent and temperature. The dough was extruded in a single screw extruder followed by frying at standard temperature (110^{o}C). The developed product was subjected to Rheological to adjudge the right proportion of WPC.

Analytical techniques used for analyzing RTE food

The moisture,fat,Ash content of all the ingredients and samples was estimated as per IS: SP 18 (Part XI), 1981.The total protein content of the dried samples of ingredients as well as final RTE food was computed by estimating total nitrogen by the Micro kjeldahl method as per procedure given in IS: SP 18 (Part XI), 1981.Crude fiber of the sample was estimated by using moisture and fat-free samples and expressed as g/ 100g or per cent of the samples used as per AOAC (1984).

Rheometer

Anton-paar oscillatory Rheometer available at NDRI, Bengaluru was used to analyze rheological properties of RTE food**.** The textural properties of extrudates were measured using Texture Analyzer (Stable Microsystems, Surrey, UK) fitted with 49 N load cell and 36 mm diameter cylinder probe with pre and post-test speed of 1mm/s and 10 mm/s respectively. The calculations were done by 'Texture Expert' software attached to the texture analyzer.

Hardness (HD) is the maximum force required for a probe to penetrate the extrudate and is expressed as N (Newton force). Crispiness (CR) denotes jaggedness of the representing fragility of snack foods. The CR was estimated by the number of peaks of the compressive curve for extrudate. Gumminess was calculated as multiple of hardness and cohesiveness; Chewiness was calculated as multiple of hardness, cohesiveness and springiness.

Result & Discussion:

Effect of enrichment with WPC on chemical composition of foxtail millet based RTE food

The formulated product with 50 per cent foxtail millet, 50 per cent corn: wheat, 20 per cent horse gram, 20 per cent sugar was further enriched with different levels of WPC. The various levels of WPC used in formulating foxtail millet RTE food is given in Table 1. The results interpreted clearly indicate that WPC at different level of incorporation had non-significant effect on moisture, fat and mineral content. However, the protein, crude fibre and carbohydrate had significant effect on RTE food.

As depicted in result the moisture content of control sample was 3.58 per cent and the WPC enriched product possessed moisture per cent ranged between 3.51 to 3.35 per cent. Similarly, fat per cent ranged between 4.65 to 4.45 per cent for 4 to 10 per cent incorporation of WPC. The mineral content for control was 2.72 when compared to WPC added product at 4 to 10 per cent level. The mineral content varied from 2.74 to 2.77, respectively. On contrast, the values pertaining to protein content significantly increased with increase in WPC levels. The protein content for control was 14.10 per cent. The formulated product had increased protein level and it was observed to be 16.65, 17.85, 19.01, and 20.12 for 4, 6, 8 and 10 per cent WPC level, respectively. The highest protein content was 20.12 for 10 per cent enrichment with WPC.

The crude fibre content decreased with increase in addition of WPC level. The control had the fibre content of 5.22 per cent and developed product resulted in 5.01, 4.92, 4.83 and 4.74 per cent crude fibre for 4, 6, 8 and 10 per cent WPC level.

The carbohydrate content of RTE food had decreased values when compared to control. The carbohydrate content of foxtail millet based RTE food was 67.46, 66.42, 65.42 and 65.36 for 4, 6, 8 and 10 per cent WPC level indicating that increased WPC levels decreased carbohydrate level in the formulated product.

The chemical composition pertaining to the foxtail millet RTE food is depicted (Table 1) and the discussion regarding the combination is given here under. As per the observation made by the result it can be clearly seen that the moisture, fat and mineral content had a non-significant effect upon addition of WPC at different levels. However, protein, crude fiber and carbohydrate had a significant effect which is highly desirable and most expected.

The shoot up in the protein content was observed and it varied between 14.10 for control and 16.65, 17.85, 19.01 and 20.12 for 4, 6, 8 and 10 per cent of WPC enrichment to foxtail millet based for protein content increase in the RTE food. This can be attributed to the fact that WPC being rich source of protein (80.40) contributes to the desirable increase in protein content. However, decline in the crude fibre and carbohydrate was observed as WPC lacks crude fibre and contains less carbohydrate (7.70) content. Similar result was observed with several researcher and the results are in accordance with the result of a previous finding as well (Thejeswini and Rao, 2014; Swapnil *et al.,* 2015).

Table 1: Effect of enrichment with WPC on chemical composition of foxtail millet Based RTE food

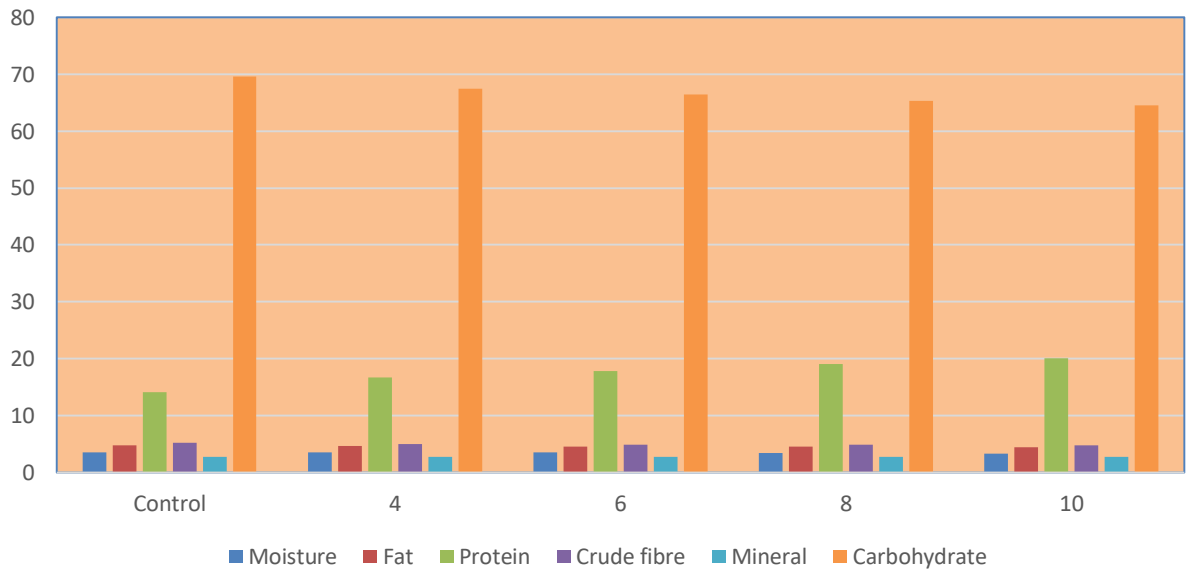
Levels of WPC	Moisture	Fat	Protein	Crude fibre	Mineral	Carbohydrate
			Per cent			
Control	3.58[a]	4.80[a]	14.10[a]	5.22[a]	2.72[a]	69.58[a]
4	3.51[a]	4.65[a]	16.65[b]	5.01[a]	2.74[a]	67.46[b]
6	3.48[a]	4.58[a]	17.85[c]	4.92[b]	2.75[a]	66.42[c]
8	3.46[a]	4.57[a]	19.01[d]	4.83[b]	2.77[a]	65.36[d]
10	3.35[a]	4.45[a]	20.12[e]	4.74[c]	2.77[a]	64.57[e]
CD (*P* = .05)	0.28	0.39	1.03	0.06	0.11	0.72

Note:

* All values are average of three trails

Similar super scripts indicate non-significance at the corresponding critical difference (CD)

Fig 1: Effect of enrichment with WPC on chemical composition of foxtail millet based RTE food



Effect of enrichment with WPC on rheological properties of foxtail millet based

RTE food

The effect of enrichment with WPC on rheological properties of foxtail millet based RTE food is represented in Table 2 and Fig 2.

The hardness of extended RTE food had a significant influence as the level of WPC increased. The hardness decreased to 485.00N for 10 per cent WPC from 543.21N for 4 per cent incorporation level of WPC.

The crispiness increased up to 6 per cent WPC level though received non-significant. After that crispiness decreased to 30 and 28 for 8 and 10 per cent level of WPC. The gumminess decreased with increase in WPC levels. The gumminess for control has 108.00 whereas for 4, 6, 8 and 10 per cent WPC the gumminess noticed was 105.00, 104.00, 102.00 and 101.00, respectively. The chewiness of RTE food received non-significant up to the level of 6 per cent after that changed significantly as WPC level increased to 8 and 10 per cent. The chewiness was 16.72 for control when compared to 16.01, 15.95, 15.70 and 15.25 for 4, 6, 8 and 10 per cent WPC level. Thus, the result with hold the fact that WPC greatly contributes to the textural attributes of foxtail millet based RTE food

The main criteria for optimization of rheological parameters of RTE food are to have desirable property which could result in high acceptance of the product.

The hardness of the product decreased simultaneously upon addition of WPC, again proving the functionality of WPC in the incorporated foxtail millet based RTE product. A drastic decrease in hardness can be noted in the result as WPC is increased. The hardness varied from 560.30 to 485.00 for 0 to 10 per cent WPC addition. Similar trend was also observed for gumminess and chewiness of the product where it decreased with increase in WPC. However, the most desirable characteristics of RTE food, the crispiness increased with increase in WPC which could be attributed that it is mainly due to functionally of WPC and starch dextrinization which leads to more expanded product with less hardness and more crispiness in ready to eat product. On the basis of the results achieved in this investigation, it can be revealed that the textural properties of expanded extrudates are significantly influenced by interactions of corn and WPC. It is known that the micro structure of expanded products such as bubble size, distribution of bubbles and bubble cell wall affects the hardness of extrudates.WPC being a superior functional ingredient has high impact in reducing hardness. The result obtained is comparable with the result of Harini *et al*. (2019) Patil *et al*. (2017) and Yu *et al*. (2017).

Table 2: Effect of enrichment with WPC on rheological properties of foxtail millet based RTE food

Levels of WPC (%)	Hardness	Crispiness	Gumminess	Chewiness
Control	560.30^{a}	35^{a}	108.00^{a}	16.32^{a}
4	543.21^{b}	36^{a}	105.00^{b}	16.01^{a}
6	531.00^{c}	37^{a}	104.00^{c}	15.95^{a}
8	510.00^{d}	30^{b}	102.00^{d}	15.30^{b}
10	485.00^{e}	28^{b}	101.00^{e}	15.25^{b}
CD (*P* = .05)	10.33	3.03	0.81	0.52

Note:

* All values are average of three trails

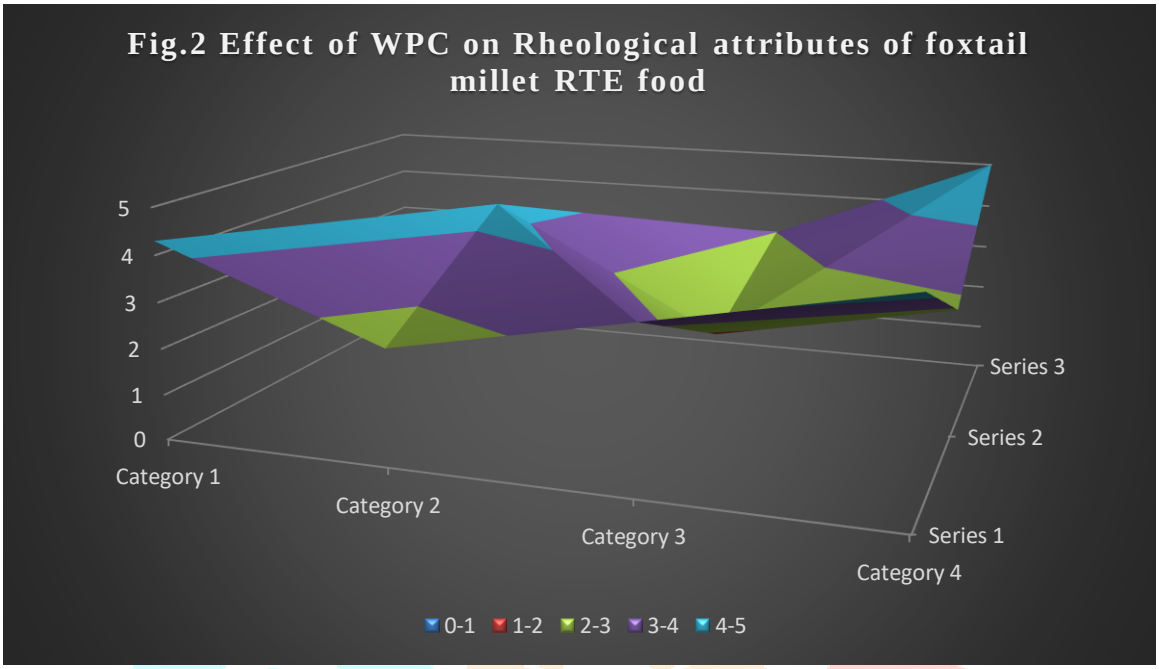
Similar super scripts indicate non-significance at the corresponding critical difference (CD)

Hardness = Maximum force required for a probe to penetrate the extrudate (N)

Crispiness = Number of peaks

Gumminess = Hardness x cohesiveness

Chewiness = Hardness x cohesiveness x springiness



Conclusion:

Whey proteins are one of the highest quality natural proteins available with excellent nutritional and functional properties and has been widely utilized in variety of foods when compared to the various sources of other proteins such as soya, beef, egg, casein due to their multi-dimensional functionality. Whey proteins are one of the highest quality natural proteins available. The biological components of whey, including lactoferrin, betalactoglobulin, alpha-lactalbumin, glycomacropeptide, and immunoglobulins, demonstrate a range of immune-enhancing properties, besides this foxtail millet which are nutritionally rich with cobohydrates, proteins ,fibre and micronutrients when such valuable ingredient incorporated in to the trendy RTE food will certainly increase the value of the product.

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