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Anumolu Teja Venkata Sai
School of Agriculture, Lovely Faculty of Technology and Science, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Anumolu Teja Venkata Sai
School of Agriculture, Lovely Faculty of Technology and Science, Lovely Professional University, Phagwara, Punjab, India

Effect of protein concentrate on nutritional and physicochemical properties of cookies and biscuits

Anumolu Teja Venkata Sai

Abstract
Protein enhancement of cookies and biscuits seeks to address target groups with higher demands for this nutrient, as well as customers who want goods that deliver more than basic nutrition, through a generally acknowledged product. Several protein sources have been investigated for this purpose, and while flours are the most popular, and protein concentrates may be viable alternative. Although this reformulation appears easy, it is well recognized that little changes in the formulations can have a significant impact on the rheology of dough as well as on the physicochemical, nutritional and sensory properties of the final product.

Keywords: Whey protein concentrate (WPC), Fish protein concentrate (FPC), Rice bran protein concentrate (RBPC), protein enrichment

Introduction
A lot of effort has gone into developing food products that can help people health. While overweight/obesity is on the rise in all age groups in developing countries, under nutrition continues and concurs with weight gain and burden of diet-related illness. In addition, recent outbreaks of infectious diseases such as malaria, Ebola virus disease, the HIV pandemic, and the covid-19 crisis highlight the need of eating a balanced diet (Galanakis, 2020) [1]. As a result, several health organizations have been encouraged to make and consume better food, such as food that has been supplemented with functional elements. Several popular or traditional foods have been employed as vehicles in fortification schemes for this aim. Popular foods are good carriers for nutrient assimilation and a rising and increasingly demanding market for the therapy of health issues is focusing on them (Granato D. B., 2010) [2]. Biscuits for example have the potential to be a better meal (Nogueira, 2018) [3] to achieve dietary requirements or to avoid nutritional disorders. Biscuits provide a number of options for treating human nutrition-related diseases. They are commonly eaten as snacks or as a side dish with other foods. They come in variety of shapes and tastes with longer shelf life and are convenient to use (Agama-Acevedo, 2012) [4] & (Manley, 2011) [5]. As an outcome, biscuit production and consumption have risen dramatically over the world (Canalis, 2017) [6]. Protein calorie malnutrition is a prevalent and significant problem in developing nations like India. Biscuits and cookies are almost interchangeable terms in India for commercially manufactured items made with refined flour, hydrogenated fats, and sugars as well as emulsifiers and other chemicals. To boost the nutritional content of cookies several countries use fortified or composite flours (Baljeet, 2010) [7]. Cookies are a type of food that is quite popular in practically in every consumer daily diet (Nassar, 2008) [8]. Other ingredients such as raisins, oats, chocolate chips, or nuts may be included in cookies. Crisp cookies are known as biscuits in most English-speaking regions, with the exception of the United States and Canada (Abayomi, 2013) [9] & (Adeyeye, 2015) [10]. Commercial biscuits have a low protein content of roughly 7 to 10% (Indrani, 2007) & (Gani, 2015) [12], which is considered low. Protein enrichment of biscuits and other cereal items is appealing because of their low protein content, since it improves nutritional characteristics and increases protein consumption. Biscuits are eaten as a snack or as a supplement to other foods because of their unusual texture, scent and flavor, as well as the pleasure they provide. They are usually thought of as a decent source of energy rather than a vital nutrient. Their high sugar and fat content has been a source of public health concern, since they are frequently connected to the development of ailments such as cardiovascular disease, diabetes, and obesity. As a result, biscuits with health claims gotten greater attention on the market, indicating a potential for increased manufacturing.

Cookies and biscuits with fewer calories and claims like "no fat", "reduced fat", "no added sugar", and "enhanced with many nutrients and/or functional elements including proteins, vitamins and minerals, and fibers" are becoming increasingly popular on the market.

To increase the protein level of biscuits, a variety of additives and raw materials were employed because legumes such as soybeans, peas, chickpeas, and beans, are high in carbohydrate, protein, and fiber, and contain enough levels of vitamins and minerals, they have been utilized as protein sources to fortify biscuits, helping to meet the health-related expectations of aware consumers. Furthermore, cereal and legume proteins are nutritionally complimentary in terms of lysine and sulphur amino acids. Due to their nutritional and functional properties, milk and whey proteins have been employed in protein enrichment and fortification of most bakery products (Gani, 2015) [12] & (Tang, 2017) [13] & (Guimarães, 2011) [14] & (Ammar, 2011) [15] & (de Almeida Marques, 2016) [16]. Some fish species or byproducts, as well as other raw materials including macambira (de Farias, 2011) [17], spirulina platensis, brown flax seeds (de Moura, 2014), bee pollen (Krystyjan, 2015) [19], sunflower seeds, pumpkin seeds, safflower, and cashew kernel have been incorporated as protein source of cookies and biscuits. In general there are more investigations on protein fortification using composite flours. Protein concentrates and protein isolates, on the other hand, have been incorporated as alternative protein enrichment sources since they have a high protein content are easily digestible by humans, and some are comparable to the nutritional quality of milk, meats and eggs. Many protein concentrates are utilized in cookies and biscuits to increase their physicochemical and nutritional qualities. Protein concentrations such as whey, rice bran, fish, and fish fillet protein concentrates are often applied.

Whey protein concentrates (WPCs) are a kind of whey protein that is used in a variety of foods. Confectionery, cereals, and nutrition bars, processed cheeses, baked foods, sports drinks, and muscle growth formulas all include them. Ultrafiltration (UF) eliminates lactose, minerals, and Non protein nitrogen (NPN), leaving the whey proteins to be spray-dried, resulting in WPCs powders with protein levels of up to 90% may be manufactured via diafiltration, which involves diluting whey protein retentate after UF processing with water to remove practically all of the lactose and minerals (Early, 2012) [20]. Whey protein concentrates (WPCs) have been used to improve the texture, flavor, and appearance of biscuits, cookies, cakes, sponges, and glazes. Whey proteins included into baked goods have distinct functional qualities. Solubility, water binding/absorption, viscosity, gelation, cohesion, adhesion elasticity, emulsification, and foaming are some of the factors to consider. The majority of these properties are crucial in the baking process (Wani, 2015) [21]. Fish protein concentrate (FPC) is a flour created from fish flesh that has a higher concentration of high-quality protein (between 75 to 95%) than the original material intended for human consumption, and is made by removing the majority of the fat and water. It can be used as wheat flour substitute in bakery items to boost the nutritional value of the finished product (Dewita, 2015) [22] & (Chattopadhyaya, 2004) & (Murueta, 2007). Fish protein concentrate may be maintained at ambient temperature for long period of time without suffering significant changes, in addition to having a high protein content (Dewita, 2015) [22]. In recent years fish protein concentrates has been used in a variety of baked food products (such as biscuits, cakes, and breads) with the goal of enhancing protein content and improving nutritional value by raising the concentration of key amino acids (Mohamed, 2014) [25] & (Ibrahim, 2009) [26] & (Abou-Zaid, 2014) [27] & (Bristone, 2017) [28].

Rice bran is a nutritionally valuable byproduct of rough rice milling, with a protein content of 12-15%, higher than any other part of the rice kernel (Yadav, 2011) [29]. Although the protein content of milled rice flour and normal rice flour is quite low, rice protein are known to be very nutritious, hypoallergenic, and beneficial to human health.

As a result of this, protein concentrates have been used as one of the protein enrichment substitute in production of several bakery products in recent years.

In light of foregoing, we have decided to investigate these three protein concentrates (rice bran protein concentrates, whey protein concentrates, fish protein concentrates) in greater depth, exposing a literature review focusing on the effects of these protein concentrates in the enhancement of cookies and biscuits in many aspects, including dough rheology, physicochemical, sensory, nutritional properties, and end product shelf life.

Effect of protein concentrates
On the dough rheology

Soft flours are used to make cookies and biscuits. Wheat efficiency for biscuit manufacturing is defined by its low protein content (8 to 10% in the grain), low water absorption, and poor deformation resistance (Pedersen, 2004). Various protein sources are utilized to boost the protein content and nutritional value of cookies. The rheological properties of dough are affected by the addition of protein sources. The findings of research that looked at the effects of varying protein concentrations in wheat flour revealed a wide range of outcomes on dough rheological properties. The addition of up to 0.3 percent fish protein concentrate to flour increased water absorption capacity, dough stability, dough development time and weakening time of dough (Mohamed, 2014) [25]. The addition of 0.7% whey protein concentration resulted in an increase in WA and a decrease in DS and DDT (de Farias, 2011) [17]. Whereas, (Gani, 2015) [12] & (Sudha, 2011) [31] found that adding WPC up to 15% reduced WA, DS, and raised DDT.

Table 1: Effect of whey and fish protein concentrates on dough rheology

Analysis	Protein concentrate (%)	Result	Reference
Farinograph	FPC (0.3%)	Increased WA, DS, DDT	(Mohamed, 2014) [25]
	WPC (0-7%)	Increased WA Decreased DS, DDT	(Ammar, 2011) [15]
	WPC (0-15%)	Decreased WA, DS	(Gani, 2015) [12]
	WPC (0-15%)	Decreased WA, Increased DDT	(Sudha, 2011) [31]
Alveograph	WPC (0-15%)	Reduced P and L	(Sudha, 2011) [31]
Pasting properties	WPC (0-15%)	Maximum, hold, and ultimate viscosities, as well as breakdown and	(Gani, 2015) [12]

		setback, were all reduced	
	WPC (0-15%)	Increased PT lower maximum, hold, and ultimate viscosities, as well as breakdown and setback.	(Sudha, 2011) [31]

WPC: whey protein concentrates, FPC: fish protein concentrates, WA: water absorption capacity, DS: dough stability, DDT: dough development time, P: maximum pressure, L: extensibility, PT: pasting temperature.

The overview of the results that obtained through these protein concentrates can be observed in Table 1. It is clear that addition of protein concentrates has a significant impact on the dough's rheological behavior, since there is virtually a change (either improvement or reduction) as a result of the addition of the various protein sources. The inclusion of flours appears to aid in the increase of WA, maybe because of the other component (fibers, for instance) present. Whey product (concentrate) on the other hand tend to lower this parameter, owing to a decreased water holding capacity or a physical obstacle to wheat flour hydration.

On the physicochemical properties of cookies and biscuits

Table 2: Studies on the effect of different protein concentrates on physical properties of cookies and biscuits

Analysis	Protein concentrate%	Results	Reference
Diameter	WPC 20 to 40%	Reduced	
	WPC 2 to 6%	Decreased	
	FPC 5 to 10%	Increased slightly	
	RBPC 5 to 15%	Slightly decreased	
Thickness	WPC 20 to 40%	Showed greater increase	(Parate, 2011) [32]
	WPC 2 to 6%	Decreased	
	FPC 5 to 10%	A little decrease	
	RBPC 5 to 15%	Lightly increased	
Spread ratio	WPC 20 to 40%	Decreased	(Abraha, 2018) [33]
	WPC 2 to 6%	Raised	
	FPC 5 to 10%	Increased	
	RBPC 5 to 15%	Decreased	
Spread factor	WPC 20 to 40%	Decreased	(Parate, 2011) [32]
	WPC 2 to 6%	Increased	
Weight	WPC 20 to 40%	Reduced	
	WPC 2 to 6%	Decreased	
	RBPC 5 to 15%	Increased	
Fracture ability	FPC 5 to 10%	Decreased at higher composition	
	RBPC 5 to 15%	Increased	
Hardness	FPC 5 to 10%	Decreased	(Abraha, 2018) [33]

WPC: whey protein concentrate, RBPC: rice bran protein concentrate, FPC: fish protein concentrate.

Table 2 depicts the changes in physical qualities of cookies and biscuits caused by the addition of various protein concentrations. (Parate, 2011) [32] found that adding 20 to 40% WPC to cookies resulted in a decrease in diameter, spread ratio, spread factor, weight, and an increase in thickness, whereas (Wani, 2015) [21] did find that incorporating 2 to 6% WPC to cookies resulted in a decrease in thickness, diameter, weight, and an increase in spread ratio and spread factor. (Gallagher, 2005) [34] Discovered a reduction in thickness in WPC supplemented cookies. (Yadav, 2011) [29] Stated that when the amount of RBPC increases the diameter and spread ratio drop and there is a little rise in thickness, as well as a progressive increase in weight and fracture strength. The study that investigated the inclusion of FPC in biscuits (Abraha, 2018) [33] discovered a bigger loss in biscuit hardness and fracture ability at increasing levels of composition, but very low change in diameter, thickness, and spread ratio. The physical characteristics of cookies and biscuits plays an important impact in customer acceptance. We can see from the table above that the weight of RBFC fortified biscuits is higher due to RBPC propensity to absorb water. The increased thickness of WPC-included cookies might be attributed to a drop in diameter and an increase in thickness, which resulted in a decrease in spread ratio. The biscuits spread ratio is a diameter-to-thickness ratio. Cookies with a high spread ratio are regarded as having the most desirable quality feature (Chauhan, 2016) [35]& (MAreTI, 2010). Increased protein content in biscuits can make them harder (Gani, 2015) [12] & (Bristone, 2017) [28] The texture qualities of hardness and fracture ability in biscuits are particularly essential and desirable quality features for baked items. Because of its direct link with human impression of freshness. Hardness is the textual trait that receives greater attention in the evaluation of quality distinctive baked goods (MAreTI, 2010).

Table 3: Effect of protein concentrates on chemical properties of cookies and biscuits

Analysis	Protein concentrate%	Result	Reference
Moisture	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 10%	Increased in all protein concentrate fortified biscuits	(Youssef, 2012) [37]

Fat	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 15%	Fat content increased in WPC fortified cookies and also increased with very little change in RBPC, FPC added biscuits.	(Abraha, 2018) [33]
Protein	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 10%	Showed greater increase in all types of biscuits.	(Munaza, 2012) [42]
Fiber	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 10%	Decreased in all types of biscuits except RBPC fortified biscuits Fiber content increased in RBPC biscuits.	(Abraha, 2018) [33]
Carbohydrates	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 10%	Decreased in all type of biscuits.	(Parate, 2011) [32]
Ash	WPC 20 to 40% WPC 2 to 6% RBPC 5 to 15% FPC 1 to 3% FPC 5 to 10%	Very little increase in all types of fortified biscuits	(Mohamed, 2014) [25]

The chemical properties of different protein concentrate added biscuits and cookies are summarized in Table 4. The moisture content of all of the above mentioned enriched biscuits steadily rose as the composition level increased. The higher the WPC supplement amount, the higher the moisture content (O'Brien, 2003) [38]. This might be due to more bound water in the system. According to the (Eneche, 1999) [39], biscuits with a moisture level of 5.0 to 6.0 percent will have a longer shelf life. (Mustafa, 1986) Discovered a correlation between increased protein content and increased moisture content of bakery goods. Because there is more fat percent in whey protein concentrate than wheat flour, fat content of WPC added biscuits is higher, while fat percent of other biscuits is lower. Increasing the all protein concentrate mixed biscuits and cookies had a higher percentage of protein content. Protein content is high in RBPC, FPC, and WPC. Rice bran is a strong source of fiber, as well as a significant quantity of protein in rice bran protein concentrate (Abdul-Hamid, 2000) [41] as well as RBPC mixed biscuits have high fiber content when compared to WPC and FPC. It was found that increase in moisture, protein, fat, fiber and ash content leads to reduction of carbohydrates in all protein concentrates fortified biscuits and cookies. There was a very low change in ash content of all fortified biscuits.

On the nutritional properties of biscuits and cookies

As predicted, adding protein sources to the biscuits resulted in a significant boost in this nutrient (Table 4). Protein quality, on the other hand, is determined by the amount of essential amino acids in the proteins, which should be higher than the FAO/WHO/UNO standard values as well as protein digestibility. In this respect, the nutritional quality of a protein deficient in an important amino acid can be increased by combining with another protein that is high in that specific amino acid. However, excessive ingestion of any amino acid can cause "amino acid antagonism" or toxicity, resulting in a higher requirement for other necessary acids, as well as probable growth inhibition and pathological diseases. Allergic responses in children and adult can be triggered by allergens found in various protein source materials (Damodaran, 2007) [43]. The most prevalent allergy for newborn is cow's milk, with lactalbumin being the major allergen (Taylor, 1987). During processing protein go through a number of chemical modifications (Damodaran, 2007) [43]. Protein interaction with polysaccharides and fibers can slow or stop protein breakdown (Villemejane, 2016). For example, lysine, which is currently scarce in grain proteins, might become much scarcer. The millard reaction causes a substantial reduction of lysine availability due to the condensation interaction between reducing sugars and the amino side-chain of lysine (Pérez, 2013) [46]. The loss of lysine availability rose linearly with the addition of WPC and reduced with the addition of water in the formulation (Pérez, 2013) [46]. The positive link between lysine availability loss and WPC was predicted, according to these same investigators, because the whey protein concentrate utilized had a high lactose content. The protein-phenolic interaction is another interaction that effects protein structure and can reduce protein bioavailability (Ozdal, 2013) [47] & (Świeca, 2014) [48]. Phenolic chemicals can bind to proteins, which can limit their bioavailability (Świeca M. G.-D., 2013) [49]. The protein digestibility of biscuits will be determined by the protein content of the sources utilized, the other components used in product formulation, and the processing to which the goods will be subjected, based on the foregoing considerations. Furthermore, when these proteins are kept, they may experience certain changes, necessitating further research into the components discussed earlier. As a result, research into the nutritional properties of protein enriched biscuits is critical and should not be overlooked, as it guarantees that the primary goal is met: biscuit with increased protein content and superior quality that provides customers with the advantage of this nutrient.

On the sensory characteristics of cookies and biscuits

Table 3: overview of sensory acceptance of cookies and biscuits

Sensory properties of RBPC fortified biscuits	Result	Reference
	Decrease in scores of color, appearance, flavor, texture, and taste. Acceptability - moderately acceptable 10% of mixture	(Yadav, 2011) [29]
WPC fortified biscuits 2 to 6 percent	Decrease in scores of color, flavor, texture, and taste at higher composition Acceptability – acceptable at 4% composition	(Wani, 2015) [21]
WPC fortified biscuits 20 to 40%	Greater decrease in scores of color, appearance, flavor and taste. Acceptability – acceptable at 25% level of composition	(Parate, 2011) [32]
FPC fortified biscuits 1 to 3%	Didn't caused any significant effect on sensory properties of cookies.	(Mohamed, 2014) [25]

The sensory characteristics of cookies and biscuits reduced significantly when RBPC and WPC were used in varied formulations. Cookies made with a greater composition of WPC and RBPC have a darker color and harder texture, resulting in a bitter taste. While the addition of FPC- fortified cookies had no discernible impact, there was a little reduction in all sensory qualities. At lower protein compositions, the general acceptability of cookies and biscuits fortified with RBPC, WPC and FPC is higher.

Conclusion

Protein enrichment in cookies and biscuits, whether in the form of composite flour (the most frequent) or protein concentrates has a significant impact on dough behavior and technical properties. Because the gluten proteins and starch are diluted, the dough becomes weaker and its viscosity (pasting qualities) changes. In terms technological characteristics protein enhancement produces variations in biscuit size, color, and texture as well as a bitter taste. The problem of creating biscuits with a greater protein content and quality that also allow this nutrition to be available to the human body was picked as one of the nutritional solutions. In the literature, there were studies that employed Whey protein concentrate, Rice bran protein concentrate, Fish protein concentrate. Even with the data from research that utilized these protein sources, their impact on biscuit manufacturing processes are still unknown. Few studies have looked at these impact or compared the various options, procedures, particularly when it comes to molding phases Furthermore, research is required. Which examines the technical impacts as well as the protein content of the final product

Reference

1. Galanakis CM. The food systems in the era of the coronavirus (COVID-19) pandemic crisis. Foods. 2020;9(4):523.
2. Granato D, Branco GF, Nazzaro F, Cruz AG, Faria JA. Functional foods and nondairy probiotic food development: trends, concepts, and products. Comprehensive reviews in food science and food safety. 2010;9(3):292-302.
3. Nogueira ADC, Steel CJ. Protein enrichment of biscuits: A review. Food Reviews International. 2018;34(8):796-809.
4. Agama-Acevedo E, Islas-Hernández JJ, Pacheco-Vargas G, Osorio-Díaz P, Bello-Pérez LA. Starch digestibility and glycemic index of cookies partially substituted with unripe banana flour. LWT-Food Science and Technology. 2012;46(1):177-182.
5. Manley D. (Ed.). Manley's technology of biscuits, crackers and cookies. Elsevier. 2011.
6. Canalis MSB, León AE, Ribotta PD. Effect of inulin on dough and biscuit quality produced from different flours. International Journal of Food Studies, 2017, 6(1).
7. Baljeet SY, Ritika BY, Roshan LY. Studies on functional properties and incorporation of buckwheat flour for biscuit making. International Food Research Journal, 2010, 17(4).
8. Nassar AG, AbdEl-Hamied AA, El-Naggar EA. Effect of citrus by-products flour incorporation on chemical, rheological and organolepic characteristics of biscuits. World Journal of Agricultural Sciences. 2008;4(5):612-616.
9. Abayomi HT, Oresanya TO, Opeifa AO, Rasheed TR. Quality evaluation of cookies produced from blends of sweet potato and fermented soybean flour. International Journal of Biological, Food, Veterinary and Agricultural Engineering. 2013;7:350-355.
10. Adeyeye SA, Akingbala JO. Physico-chemical and functional properties of cookies produced from sweet potato-maize flour blends. Food Science and Quality Management. 2015;43:48-57.
11. Indrani D, Prabhasankar P, Rajiv J, Rao GV. Influence of whey protein concentrate on the rheological characteristics of dough, microstructure and quality of unleavened flat bread (parotta). Food Research International. 2007;40(10):1254-1260.
12. Gani A, Broadway AA, Ahmad M, Ashwar BA, Wani AA, Wani SM. Effect of whey and casein protein hydrolysates on rheological, textural and sensory properties of cookies. Journal of Food Science and Technology. 2015;52(9):5718-5726.
13. Tang X, Liu J. A comparative study of partial replacement of wheat flour with whey and soy protein on rheological properties of dough and cookie quality. Journal of Food Quality, 2017.
14. Guimarães DH. Utilização de soro de queijo na elaboração de biscoitos doces. RECEN-Revista Ciências Exatas e Naturais. 2011;13(2);271-285.
15. Ammar AS, Salem SA, Badr FH. Rheological properties of wheat flour dough as affected by addition of whey and soy proteins. Pakistan Journal of Nutrition. 2011;10(4):302-306.
16. de Almeida Marques G, de São José JFB, Silva DA, da Silva EMM. Whey protein as a substitute for wheat in the development of no added sugar cookies. LWT-Food Science and Technology. 2016;67:118-126.
17. de Farias NS, Cavalcanti MT, de Souza Eller SCW, Feitosa VA, Florentino ER. Elaboração de biscoitos tipo cookie enriquecido com macambira, Bromélia

laciniosa. Revista Verde de Agroecologia e Desenvolvimento Sustentável, 2011;6(4):10.
18. de Moura CC, Peter N, de Oliveira Schumacker B, Borges LR, Helbig E. Biscuits enriched with brown flaxseed (Linum usitatissiumun L.): nutritional value and acceptability. Demetra: Food, Nutrition & Health. 2014;9(1):71-82.
19. Krystyjan M, Gumul D, Ziobro R, Korus A. The fortification of biscuits with bee pollen and its effect on physicochemical and antioxidant properties in biscuits. LWT-Food Science and Technology. 2015;63(1):640-646.
20. Early R. Dairy products and milk-based food ingredients. In Natural food additives, ingredients and Flavourings. Woodhead Publishing. 2012, 417-445.
21. Wani SH, Gull A, Allaie F, Safapuri TA. Effects of incorporation of whey protein concentrate on physicochemical, texture, and microbial evaluation of developed cookies. Cogent Food & Agriculture. 2015;1(1):1092406.
22. Dewita S. Quality assessment of fish protein concentrate from catfish (*Pangasius hypopthalmus*) during storage at room temperature. IOSR Journal of Environmental Science, Toxicology and Food Technology. 2015;9:20-23.
23. Chattopadhyaya AK, Rao BM, Gupta S. A simple process for the uttilization of small bony fish as edible fish powder. 2004.
24. Murueta JHC, Carreño FG. Concentrates of fish protein from bycatch species produced by various drying processes. Food Chemistry. 2007;100(2):705-711.
25. Mohamed GF, Sulieman AM, Soliman NG, Bassiuny SS. Fortification of biscuits with fish protein concentrate. World J Dairy Food Sci. 2014;9(2):242-249.
26. Ibrahim SM. Evaluation of production and quality of salt-biscuits supplemented with fish protein concentrate. World Journal of Dairy and Food Sciences. 2009;4(1):28-31.
27. Abou-Zaid A, Mohamed AS. Production and Quality Evaluation of Nutritious High Quality Biscuits and Potato Puree Tablets Supplemented with Crayfish Procombarus Clarkia Protein Products. Journal of Applied Sciences Research. 2014;10(7):43-53.
28. Bristone C, Charles A, Idakwo P. Development of Nigerian based food like biscuit (Guliguli) from mixtures of sorghum, maize, soyanen, mmoringa leave and crayfish. International Journal of Current Research. 2017;9(10):59664-59671.
29. Yadav RB, Yadav BS, Chaudhary D. Extraction, characterization and utilization of rice bran protein concentrate for biscuit making. British Food Journal. 2011.
30. Pedersen L, Kaack K, Bergsøe MN, Adler-Nissen J. Rheological properties of biscuit dough from different cultivars, and relationship to baking characteristics. Journal of Cereal Science. 2004;39(1):37-46.
31. Sudha ML, Rajeswari G, Rao GV. Influence of defatted soy flour and whey protein concentrate on dough rheological characteristics and quality of instant vermicelli. Journal of texture studies. 2011;42(1):72-80.
32. Parate VR, Kawadkar DK, Sonawane SS. Study of whey protein concentrate fortification in cookies variety biscuits. International journal of food engineering, 2011, 7(2).
33. Abraha B, Mahmud A, Admassu H, Yang F, Tsighe N, Girmatsion M. Production and quality evaluation of biscuit incorporated with fish fillet protein concentrate. J Nutr. 2018;8(6):1000744.
34. Gallagher E, Kenny S, Arendt EK. Impact of dairy protein powders on biscuit quality. European Food Research and Technology. 2005;221(3):237-243.
35. Chauhan A, Saxena DC, Singh S, Yildiz F. Physical, Textural, and Sensory Characteristics of Wheat and Amaranth Flour Blend Cookies. Cogent Food & Agriculture, 2016, 1–8.
36. Mare TI MC, Grossmann MVE, Benassi MDT. Características físicas e sensoriais de biscoitos com farinha de soja e farelo de aveia. Food Science and Technology. 2010;30:878-883.
37. Youssef HMKE, Mousa RM. Nutritional assessment of wheat biscuits and fortified wheat biscuits with citrus peels powders. Food and Public health. 2012;2(1):55-60.
38. O'Brien CM, Chapman D, Neville DP, Keogh MK, Arendt EK. Effect of varying the microencapsulation process on the functionality of hydrogenated vegetable fat in shortdough biscuits. Food research international. 2003;36(3):215-221.
39. Eneche EH. Biscuit-making potential of millet/pigeon pea flour blends. Plant foods for human nutrition. 1999;54(1):21-27.
40. Mustafa AI, Al-Wessali MS, Al-Basha OM, Al-Amir RH. Utilization of cowpea flour and protein isolate in bakery products. Cereal foods world (USA). 1986.
41. Abdul-Hamid A, Luan YS. Functional properties of dietary fibre prepared from defatted rice bran. Food chemistry. 2000;68(1):15-19.
42. Munaza B, Prasad SGM, Gayas B. Whey protein concentrate enriched cookies. International Journal of Scientific and Research Publications. 2012;2:165-173.
43. Damodaran S, Parkin KL, Fennema OR. (Eds.). *Fennema's food chemistry*. CRC press. 2007.
44. Taylor SL, Lemanske Jr, RF, Bush RK, Busse WW. Food allergens: structure and immunologic properties. Annals of allergy. 1987;59(5 Pt 2):93-99.
45. Villemejane C, Denis S, Marsset-Baglieri A, Alric M, Aymard P, Michon C. In vitro digestion of short-dough biscuits enriched in proteins and/or fibres using a multi-compartmental and dynamic system (2): Protein and starch hydrolyses. Food chemistry. 2016;190:164-172.
46. Pérez S, Matta E, Osella C, de la Torre M, Sánchez HD. Effect of soy flour and whey protein concentrate on cookie color. LWT-Food Science and Technology. 2013;50(1):120-125.
47. Ozdal T, Capanoglu E, Altay F. A review on protein–phenolic interactions and associated changes. Food Research International. 2013;51(2):954-970.
48. Świeca M, Sęczyk Ł, Gawlik-Dziki U, Dziki D. Bread enriched with quinoa leaves–The influence of protein–phenolics interactions on the nutritional and antioxidant quality. Food chemistry. 2014;162:54-62.
49. Świeca M, Gawlik-Dziki U, Dziki D, Baraniak B, Czyż J. The influence of protein–flavonoid interactions on protein digestibility in vitro and the antioxidant quality of breads enriched with onion skin. Food Chemistry. 2013;141(1):451-458..