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"QUANTITATIVE ASSESSMENT OF PROTEIN AND FIBER ENHANCEMENT IN PASTA THROUGH BREWERS SPENT GRAIN FORTIFICATION"

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ABSTRACT

This study looked into the use of spent grain flour in pasta development which are leftover grain from distilleries for its fibre and protein content. Using a D-optimal approach, the study sought to maximise the impact of spent grain input on pasta's qualitative metrics. The wasted grain percentage was changed (25%, 30%, 35%, and 40%) to optimise the pasta matrix, with an emphasis on cohesiveness, fracturability, protein, total dietary fibre, total plate count, cooking loss, in-range firmness, and colour paste. The results showed that the best proportion of spent grain in the pasta recipe was 25%.

This discovery highlights the potential of using leftover grain in pasta manufacturing, providing a sustainable alternative for improving nutritional properties while keeping desirable texture and sensory features. Overall, this study provides useful insights into the development of functional pasta products, which fit with the growing desire for sustainable and nutritious food options.

Key words : spent grain; pasta; brewery; energy; barley

INTRODUCTION

Pasta is an extruded food manufactured from a variety of grains, including wheat, oats, barley, corn, and sorghum. Italian-born pasta provides a variety of micronutrients, including macronutrients. It mostly has greater protein, carbs, and low fat. Pasta varieties are evolving today, and it is significant to scholars as well. Fortifying food can help those who lack certain nutrients. The two types of extruders used to make pasta are single screw and twin screw. The nutritional value, thermal stability, color, and microstructure of pasta can all be significantly impacted by the fortification of wheat with other grains or plant and animal sources. Pasta that has been heated at a high temperature may lose cooking time. Pasta is a high-energy food that contains many carbohydrates, moderate protein and some fat.

Beer ranks as the fifth most consumed beverage globally, following tea, soda, milk, and coffee, with an estimated annual worldwide production surpassing 1.34 billion hectares in 2002 (Fillaudeau et al., 2006). During beer production, various residues and by-products are generated, with spent grains, spent hops, and surplus yeast being the most common ones. These by-products stem from the primary raw materials used in the brewing process (Mussatto, 2009). Spent grains, for instance, are the result of the mashing process, an initial operation in breweries aimed at solubilizing malt and cereal grains to extract the wort, which is essentially water with extracted matter (Fillaudeau et al., 2006).

Statistics indicate that approximately 3.4 million tons of brewers' spent grain (BSG) are produced annually in the EU, with the UK contributing over 0.5 million tons alone (Stojceska et al., 2008). On the other hand, Brazil, ranking as the world's fourth-largest beer producer in 2002 with an output of 8.5 billion liters per year, generates about 1.7 million tons of BSG (Mussatto et al., 2006).

Regarding the generation of brewers' spent grain, barley stands as the world's fourth most significant cereal after wheat, maize, and rice, primarily utilized as animal feed or as a raw material for beer production (Kishore, N., et al., 2016). Barley grains are notably rich in starch and proteins, consisting of three main components: the germ (embryo), the endosperm (comprising the aleurone and starchy endosperm), and the grain coverings. Barley seeds are comprised of several integral parts, including the innermost layer surrounding the aleurone, the pericarp layers above it, and the protective husk. The pericarp serves as a semi-permeable barrier, defining the seed's exterior and interior. This husk, primarily composed of lignocellulose cell walls with traces of proteins, resins, and tannins, shields the grain from external influences.

Upon harvest, barley undergoes cleaning and sorting based on size for beer production. Plump and medium-quality grains are individually malted after a dormancy period of four to six weeks. The malting process involves three stages: maceration, germination, and drying.

During maceration, barley grains are soaked in water at controlled temperatures for about two days, facilitating hydration and stimulating germination. The germination phase, lasting around 6 or 7 days, promotes the synthesis and activation of enzymes crucial for starch endosperm transformation.

Subsequently, the malt is dried at specific temperatures to a moisture content of 4 to 5% to prevent microbial contamination and enhance aromatic components.

After drying, the malt undergoes a storage period to achieve homogeneity and balance. In the brewery, the malt is ground and mixed with water, gradually increasing the temperature to promote the hydrolysis of starch and other components. This process facilitates the solubilization of degradation products, ensuring the production of high-quality beer.

FORMULATION OF SAMPLES

In this phase samples were formulated in three different concentrations.In first treatment 65g of refined flour is used along with the 25g of brewers spent grain flour and 5g of corn flour and 5g of spices. In second treatment 60g of refined flour is used along with the 30g of brewers spent grain flour and 5g of corn flour and 5g of spices. At last 55g of refined flour is used along with the 35g of brewers spent grain flour and 5g of corn flour and 5g of spices.

METHODOLOGY

The Procedure Description

- **Mixing**

In this phase, all the ingredients—bsg flour,refinrd wheat flour.corn flour,spices and water—are combined. Mixing creates dough, which provides the structure of the gluten network.

Kneading

The goal of the kneading procedure is to stretch and warm the gluten strands, finally producing elastic and bouncy dough. It fortifies the dough, making it able to contain the little carbon dioxide pockets created during the fermentation process.

- **Dividing and Shaping**

After having soft and elastic dough, it can be divided into small dough and shaped with same appearance.

- **Drying**

To get rid of the moisture, use a hot air oven to dry the pasta.For 1:30 hours, the temperature will be 85 degrees Celsius.

- **Packaging**

Packaging must be done in a sterile area to prevent dangerous microorganisms breeding in the pasta.

Sensory profile of Brewers Spent Grain Pasta

The Brewers Spent Grain Pasta samples recorded significant improvement in sensory scores compared to control pasta sample. The sample S2 (65g Refined Wheat Flour + 25g Brewers Spent Grain Flour +5g Corn Flour +5g Spices per 100g) was found to have the highest significant difference ($p<0.05$) scores for color (7.9), taste (7.9), flavor (8.1),texture (8.0), mouth feel (7.4) and overall acceptability (7.9) .

Statistical analysis

In the statistical analysis, critical difference (CD) and standard error (SE) were calculated using Excel. The critical difference indicates the minimum difference required between two values to be considered statistically significant. This helps identify meaningful variations between samples. On the other hand, standard error measures the precision of sample estimates, providing a range within which the true value is likely to lie. These analyses enable robust interpretation of the data, highlighting significant differences and ensuring the reliability of the findings.

Proximate Analysis of formulated samples

Table:1

Sr. No.	rameters	ntrol	al 1	al 2	al 3
	tein (%)	20±0.26	34±0.15	08±0.16	82±0.10
	isture (%)	2±0.08	7±0.13	9±0.10	2±0.11
	ide Fiber (%)	0±0.07	5±0.10	3±0.10	0±0.08
	Ash content (%)	9±0.01	5±0.01	4±0.01	4±0.01
	Fat (%)	8±0.02	±0.02	±0.05	±0.05
	Carbohydrates (%)	01±0.54	19±0.19	36±0.51	82±0.66

Moisture content

Moisture content influences product shelf life it increases susceptibility to microbial growth. Product quality such as texture, taste, and appearance depends on the moisture content of the product. The dried BSG composition varied quite widely, containing approximately 5–8% moisture content.(Balogun et al., 2017).The moisture content of formulated extruded snack food products are 9.12±0.08, 8.87±0.13, 8.49±0.10 and 8.32±0.11%.

Protein content

Each protein molecule is made up of amino acids, which are distinguished by the presence of nitrogen and, in certain cases, sulfur. A gram of protein provides 4Kcal/g. was observed that protein content in brewers spent grain flour is 14.5–30% protein.(Coelho et al., 2014).The protein content of formulated snack food products are 10.20±0.26, 13.34±0.15, 14.08±0.16 and 14.82±0.10 %.

Fat content

A dietary fat molecule is made up of multiple fatty acids (long chains of carbon and hydrogen atoms) bound to a glycerol. The developed extruded snack food product was low in fat content. It was observed that 8–

34.82% extracted fat present in brewers spent grain flour. (Niemi et al., 2013).It was observed that the fat content of formulated products are 1.08±0.02, 3.4±0.02, 4.3±0.05 and 5.7±0.05 %.

Fiber content

Dietary fiber, also known as roughage, is the percentage of plant-based foods that human digestive enzymes cannot completely break down. It is made up of two primary parts. Soluble fiber is easily fermented in the colon into gases and physiologically active by-products, such as short-chain fatty acids generated in the colon by gut bacteria; it is vicious, can be called prebiotic fiber, and delays stomach emptying, resulting in a delayed feeling of fullness in humans. . Pasta labeled high in fiber had lower CL values (3.47 ± 0.86%).(Sahin et.al.,2021).

The fiber content of formulated snack food products is 2.70±0.07, 5.35±0.10, 5.93±0.10 and 6.50±0.08 % respectively.

Carbohydrate content

Depending on how many monomer (sugar) units they contain, carbohydrates are classed as monosaccharides, disaccharides, or polysaccharides. Rice, noodles, bread, and other grain-based goods, as well as potatoes, yams, beans, fruits, fruit juices, and vegetables, contain them in considerable amounts. Monosaccharides, disaccharides, and polysaccharides are sugar molecules with one, two, or three sugar units. Because polysaccharides are often lengthy, many branching chains of sugar units, they are often referred to as complicated carbohydrates..(Jenkins D, et al., 1986). The Carbohydrate content of snack food products was 76.01±0.54,68.19± 0.19%,66.36±0.51,63.82±0.66.

Ash content

It is the inorganic material remains after moisture and organic substances have been eliminated from food sample with eating in presence of oxidizing agents, and it is used to calculate the total amount of minerals present. The ash content of brewers' spent grain (BSG) is ranging from 1-1.5%.(*Santos et.al,2003*)

Extruded snack food products had an ash content of 0.89±0.01, 0.85±0.01, 0.84±0.01 and 0.84±0.01 %.

Functional properties of formulated snack food product

Samples	**Water Holding Capacity (g/g)**	**Water Solubility Index (%)**	**Oil Holding capacity (g/g)**
Control	1.45±0.11	2.05±0.07	1.09±0.20
S1	3.7±0.164	3.12±0.03	1.9±0.021
S2	3.0±0.38	4.09±0.08	2.0±0.023
S3	3.9±0.080	6.17±0.01	2.12±0.028

Table:2

Water holding capacity

Water absorption capacity varies from product to product. The water absorption capacity depends on the amount of starch and protein present in the sample (Sumnu and Sahin 2008). The WHC level varied from 3.055 to 4.346 g/g. (Ktenioudaki et al., 2013b).

Some factors influence the water absorption capacity It was evaluated that the water absorption capacity (WAC) of 1.45±0.11, 3.7±0.164, 3.0±0.38 and 3.9±0.080 %.

Oil holding capacity (OAC)

Oil absorption capacity is the amount of oil absorbed by the product or material. the OHC ranged from 1.916 to 2.219 g/g. (Ktenioudaki et al., 2013b).The oil absorption capacity (OAC) 1.09±0.20, 1.9±0.021, 2.0±0.023 and 2.12±0.028 %. OAC of extruded snack food products was low as compared to the WAC.

Shelf life assessment of extruded product

Total Plate Count (TPC) is a method of estimating the total number of microorganisms (mold, yeast, bacteria) in brewers spent grain pasta. The TPC values of the formulated pasta samples during the storage period were showed in the Table. According to the results showed in the Table. It is revealed that, the total plate count of the pasta samples increased somewhat during the storage period of three months. During the evaluation of storage stability of the pasta, the total plate count increased from 3.47 to 4.03 on the last day of storage period accordingly. Similarly, the other samples TPC also increased with the storage time. As shown in the table no 3, the recorded TPC of the sample at the initial day were 3.47 respectively, which were then increased till last day (60th) of the storage period as showed the results as 4.03 respectively.

Table:3

TPC	0 day	15 day	30 day	45 day	60 day
	$3.47 X 10^3$	$3.65 X 10^3$	$3.88 X 10^3$	$4.20 X 10^3$	$4.32 X 10^3$

Yeast and mold count

The microbial quality of the formulated pasta treatments were analyzed in terms of TPC and yeast mold count during storage at ambient conditions. The influence of storage condition of the yeast and mold count is showed in Table. The yeast and mold count at the first day of storage period for the control sample was 3.36 respectively. It was shown that as the storage period passes, the yeast and mold count of all the pastas increased. It happened due to the increased condition of moisture content of the pasta. The moisture content increased during the storage period which facilitates the growth of the microorganisms, therefore due to this, the yeast and mold count increased significantly. According to the value given in the Table no 4, 4.8, on the 120th day, the YMC values for the treatment 3.97 respectively.

Table:4

Yeast and Mold Count	0 day	15 day	30 day	45 day	60 day
	$3.36 X 10^3$	$3.47 X 10^3$	$3.65 X 10^3$	$3.83 X 10^3$	$3.97 X 10^3$

CONCLUSION

The goal was to attempt and substitute the refined flour used in snack goods with something that would increase the amount of fiber they contain. Since brewer's spent grain is available in significant quantities and would otherwise go to waste, it was determined to be a good substitute. Finding out about the cognizance/awareness and acceptability of snack foods manufactured from brewer's spent grain was the main goal of the study. A pasta considered. Next, in order to achieve one of our goals, we added brewer's spent grain to the finished formulation in place of some of the refined flour. After the recipe was created and followed the established guidelines and standards. The product was created in the end. After that, we stored to check its shelf life. spent grain is naturally dry, enriching ingredients must be added slightly more to the product than to one that solely comprises refined flour in order to maintain the food's moisture and freshness. Grain flour that has been spent should be kept dry to prevent spoiling. Spent grain should either be air dried and stored in a dry place, or it should be dried in an oven. Grain that has been thoroughly wet should be utilized within two days and kept in the refrigerator. There should be a 40/45 % to 55/60 % ratio between wasted grain flour and all-purpose flour (also known as refined flour). Since adding more than 50% BSG flour causes the final product to become overly fibrous and dry. In conclusion, there is a good chance that these items will find a market if specific safety measures and methods are taken. Because of the BSG products' sustainable nature and high nutritional content..

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