Substituting Butter with Pumpkin Puree in Muffin Formulation: A Low-Fat Alternative for Improved Nutritional Profile

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ABSTRACT

People who consume high-fat foods have more chance of cardiovascular disease. Muffins, widely consumed baked foods, are geared towards gelatinous sensory experience with high-fat and cholesterol content from excessive butter. This study aims to create a low-fat muffin formula based on replacing butter with pumpkin puree that can be much more suitable for fat-cutting. This study aimed to make low-calorie muffins by using pumpkin puree as a substitute for butter, the percentage of which varied from 25% to 100%, to determine the applicability and acceptability of the method in muffin baking. The formulation was prepared using pumpkin puree instead of butter in 25%, 50%, 75% and 100% concentrations, plus a control formulation with butter alone. The sensory attributes, including colour, smell, texture, taste, and overall likeability, were evaluated in each formulation to find out the best one. Formulation C with 75% pumpkin puree (alternative to butter) was demonstrated to be the best-liked sensory product that duplicated the attributes of the control cupcakes, indicating its viability as a muffin butter substitute. The study concludes that pumpkin puree could be a better choice to substitute butter when producing muffins, as it is a healthier option with fewer calories and fats in comparison, but without compromising on sensory quality. A formulation with 75.7% puree displayed encouraging sensory profiles.

Keywords: high-fat diets, muffins, butter, pumpkin puree, low-fat

INTRODUCTION

Incorporating fats and oils into the food system is critical because they act as sources of dietary essentials and influence various foods' texture, flavour, and palatability. Also known as glycerol esters and fatty acid molecules, fats and oils carry fat-soluble Vitamins and essential nutrients for the body's overall functioning (1). These lipid compounds, too, have their share in the physical and mouth-feel properties and food taste; thus, consumer approval and palatability are also associated with it. Additionally, fats and oils are major building blocks that provide the verve and essence of emulsions, thus contributing to the quality and texture of myriad culinary concoctions, including salad dressings, sauces and others (2).

On the other hand, the inappropriate use of traditional fat sources creates serious health issues, and the creation of fat substitutes comes on the scene as a necessary and credible alternative. Fat replacers act like fat substances by reducing calories (3). They may be subdivided into fat replacers and fat mimics, respectively, where both play a role in food items' sensory and nutritional value. Among them, there is also a category of fat replacers, which are made from different substances (carbohydrates, proteins, and modified fats), and each of them provides specific functionalities and application possibilities in creating food products (4).

The substitute of normal fat carriers in bakery products for substituting muffins with pumpkin mash is a new perspective in the development of low-fat products. This study evaluates the possible implications and feasibility of replacing butter with pumpkin puree while holding constant misc formulation variables to enhance muffins' nutritional profile (5).

This study aims to produce low-fat muffins by selecting alternative fat sources or fat substitute fillers to replace butter, reducing calorie content per gram but maintaining desired texture and flavour richness. It shows butter's role in a butter muffin recipe (and) how it might affect calorie density and the motive behind the choice of a low-fat person's diet. The current study gives a valuable practical guide on fat reduction in baked products manufacturing, and it also recommends disputing the chicken and egg

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ISSN Online 3049-7647 © 2024 Elysian Sciences Publishing House

case by eliminating or significantly reducing the total amount of fat in the muffin recipe so that the muffin would be, at the same time, nutritious and enjoyable. Thus, creating healthier options in the baked goods market would result.

LITERATURE REVIEW

Physicochemical Properties of Fats and Oils

The physicochemical properties of fats and oils are crucial for their functionality, and this behaviour depends on the type of system in which they will be applied. The fatty acid makeup is critical here because of the amount of the melting point, the stability against oxidation, and dietary value (6). Saturated fatty acids, whose carbon atoms are bonded with single bonds and devoid of double bonds, are normally more meltingly and more stable in their reaction with oxygen than unsaturated fatty acids. On the other hand, the saturated type of fatty acids have just one or several double bonds; hence, the melting points are lower, and they are more susceptible to oxidation than saturated fats (7).

For example, the number of unsaturated bonds statued by the iodine value determines whether double bonds exist on the fatty acid chain. The iodine value attribute of oils becomes apparent with the preference for oxidation and, as a result, has a shorter shelf life, and the colour and taste deteriorate (8). The type of profile of fatty acids is one of the reasons why it is essential for the welfare of fatty acids. It is related to fatty acid types such as omega-3 and omega-6, which are necessary for cardiovascular health and other physiological functions (9).

On the other hand, the oils consist of additional features such as viscosity, refractive index, and density that alter the dessert processing and formulation. Viscosity, controlled by temperature and shear rate, determines whether or not a building of food product will go easily or with difficulty (10). These magnitudes can be used to detect the degradation in product purity or for quality control of the compositions while manufacturing. The physicochemical properties of fats and oils are key in applying food formulations to ensure the right taste and smell, nutrition levels of foods, and shelf life (11).

Role of Fat Replacers in Food Systems

Fat replacers in the food industry are no longer a fresh concept, and consumers are increasingly concerned about healthy food without sacrificing their favourite tastes and textures (12). Fat replacers represent substances designed to mimic fat functionality involved in food texture and stability while at the same time being either low in calories or having improved nutritional profiles. These substitutes are formulated to perform diverse functions such as texture modification, flavour enhancement, and moisture retention, creating a mouthfeel comparable to the original high-fat or moderately-fat food products (13).

Another category, hydrocolloids, includes gums, pectins, and cellulose derivatives capable of changing the food system's rheology. This component can do what fats do, resembling mouthfeel and textural sensation (14). They mimic the fullness of fats even though they have zero calories. Emulsifiers, the other group of fat substitutes, worked by dispersing the fat into a water-rich composition, thereby attaining increased stability and texture over the usage of conventional fat (15).

Protein-based fat replacers derived from sources like whey, soy, or eggs are fat replacements with properties similar to fats, such as emulsification, foam stabilisation, and moisture retention (16). These proteins can then be grouped into varied protein networks that support the required textural quality and, at the same time, decrease fat contribution. Along with this, integral starch-based fat alternatives developed from modified starches or maltodextrins influence and give the products viscosity and mouth-raveling sensations in low-fat products (17).

Nutritional Benefits of Pumpkin Puree

One cannot deny that pumpkin puree is a reliable, nutritious food because it has distinct nutrients that mostly subside hunger. To put it another way, it has multifarious relevances in various foodstuffs. The pumpkin puree, abundant in various vitamins, minerals, and antioxidants, is the healthiest substance that can be added to highly nutritious meals as it turns them into healthier ones (10). Carrot puree is hardly a surprise as beta-carotene is a compound of the pumpkin, and its grand health benefits include enhancement of sight, immunity, workouts, and skin. The colour of a pumpkin puree is deep orange; the only interpretation is that pumpkins have beta-carotene levels. Slimming down on the savings, Hokkaido and Kabocha pumpkins get the highest amount (18).

The fibres in pumpkin puree are either soluble or insoluble when the diet is considered. These two types of fibre are

responsible for the proper digestion process, and you will be helped with the sensation of feeling full (19). The soluble fibre in pumpkin puree controls blood sugar and cholesterol levels, thus making it an excellent source for promoting cardiac health and regulating metabolism. On the other hand, fibre that cannot dissolve ionises the stool and makes it move in a normal pattern, preventing constipation and encouraging gut motility (20).

In addition to adding micronutrients to the diet, pumpkin puree contains diverse beneficial phytochemicals such as flavonoids, carotenoids, and phenolic compounds associated with antioxidant and anti-inflammatory properties (20). The bioactive compounds in foods are potent with antioxidant properties; hence, they effectively manage the signs of oxidative stress and inflammation and generally regulate the risks of developing cardiovascular diseases, cancer, and neurological disorders (21).

Challenges and Opportunities in Substituting Butter with Pumpkin Puree in Muffin Formulation

Replacing butter with pumpkin puree for muffin formulation could be challenging, but it can also give space for innovation in food production. In addition, lipid changes occur that include density, composition, and texture, affecting taste, texture, and feel in general (22). With the rich flavour of traditional muffins, the butter acts as the muffins' moistness contributor and crumbles down; it may result in a drier and less tender product with the pumpkin puree's lower fat content and water activity (20).

In addition, fresh pumpkin accompanies loose moisture and water-soluble parts in the muffin dough so that it may influence the viscosity, rheology, and baking of the final product. The excessive water content of pumpkin puree might cause unpleasant structural alterations, which could be especially unsatisfactory in the case of bread made with it if no compromising ingredients or thickeners are used to avoid it (23). Besides, the flavour of pumpkin puree also might cause the need for muffin recipe modification, meaning a reduction of added sugar amount or even the exclusion of additional flavour additives to ensure a desirable taste and sweetness level (23).

Despite the challenges, unleashing pumpkin puree's potential in muffin formulation further opens up various possibilities for product innovation and uniqueness. Pumpkin puree is an excellent brain food and, thus, makes muffins more nutritious by providing vitamins, minerals, fibre and antioxidants required for good health (24). This ensures that health-conscious consumers can enjoy delicious and healthy bakery items. Not only that, but the hue from the pumpkin puree with individual flavours can make muffins visually attractive with a special twist of the season or niche products on the market (25).

METHODOLOGY

Raw Materials

This study makes use of different raw ingredients such as King Arthur unrefined all-purpose flour, pumpkin material from the Imtiaz deposit market, granulated sugar from a local company, table salt from retailing shop, nurpur unsalted vegetable oil, Rossmoor baking powder, eggs from a local market and vanilla essence from another local market to produce different muffin samples. File wrappers were made of paper, and many ingredients were used, including pumpkin puree, sugar, salt, fat, baking powder, eggs, and vanilla essence.

Formulation of Pumpkin Puree

Pumpkin puree has gained popularity among muffin bakers as an ingredient due to its versatility. It is prepared by boiling a variety of sugar pie pumpkins, butternuts, or buttercups, then cutting them into cubes and steaming them until soft. The softened pumpkin chunks are ground into a smooth puree using a grinder, a fat replacer in the muffins.

Formulation of Muffins

Muffins were prepared at different concentrations of pumpkin puree, using all-purpose flour, sugar, eggs, salt, baking powder, milk (control), vanilla extract, butter, and pumpkin puree in standardised quantities.

Preparation of Muffins

The muffin recipe involves mixing pumpkin puree, sugar, flour, and baking powder in a bowl. Butter is added to the mixture, followed by dry ingredients like flour, baking powder, and salt. The batter is then scooped into greased or lined muffin pans, filling each cup with about 1/4 cup. Turbinado or crystal sugar is sprinkled on top. The muffins are baked at 350 degrees Fahrenheit for 25 minutes or until done, with halfway rotation. After baking, they are allowed to cool to 35 degrees Celsius.

Determination of Moisture Content

The moisture content of muffin samples was determined using a protocol. Petri plates were weighed and labelled, and small samples (3 grams) were placed in petri dishes. The samples were heated at 130 degrees Celsius for 2 hours, cooled in a desiccator and heated again for 30 minutes. The residue was weighed, and moisture content was calculated using the formula %M = ((Ww-Wd)/Ww) x 100, where %M represents moisture content, and Ww represents the sample's weight after drying.

Determination of Ash Content

The ash content of muffin samples was determined by charring a weighed sample on a hot plate, incineration in a furnace at 550 ± 10°C for 3 hours, cooling and weighing the sample, and then expressing it as a percentage.

Extraction of Fat by Soxhlet Method

The Soxhlet method was used to extract the fat content from muffin samples. Glass apparatus was rinsed with petroleum ether and dried in an oven. Samples were weighed, placed in thimbles, and heated on a heating mantle. The extraction lasted for around 6 hours, after which the solvent was collected, the sample dried, and weighed.

Qualitative Test of Protein

The protein content of muffin samples was qualitatively tested using the ninhydrin method. A 20% ninhydrin solution was prepared by dissolving 0.2g of Ninhydrin in acetone or ethanol. Test solutions were prepared by mixing 1 ml of the sample with 1 ml of distilled water in dry test tubes. A few drops of 2% ninhydrin solution were added to each tube.

Determination of Protein Content by Kjeldahl Method

The Kjeldahl method was used to quantitatively determine the protein content of the muffin samples, following the following protocol:

Digestion

The sample was weighed, placed in a digestion flask, and mixed with Missouri catalyst tablets and sulfuric acid. The mixture was heated until white fumes were observed, and the digestion process continued for 180 minutes. The sample was then cooled, diluted, and transferred to a distillation unit.

Distillation

The sample was distilled using a sodium hydroxide solution to neutralise pH and convert NH4+ into NH3, which was then captured in a boric acid solution with Tashiro's indicator and titrated with HCl solution.

Texture Profile Analysis

The texture profile of muffin samples was analysed using a texture analyser, following a protocol of a double compression test with a spherical probe, initial compression height set at 50%, speed of 1 mm/s, and 5 seconds waiting time. The analysis included hardness, springiness, cohesiveness, and chewiness.

Determination of Density

The density of the muffin samples was weighed using a 100 mL measuring cylinder to determine the mass of the sample and then divided by the volume to calculate their density. The process comprised a clean 100 mL cylinder and water to fill the position up to 50 mL.

Determination of Nitrogen-Free Extract (NFE)

The muffin samples' nitrogen-free extract content was calculated using the formula % NFE = 100 - (% moisture + % CF + % CP + % EE + % Ash).

Determination of Crude Fiber

The acid-base digestion method was employed for fibre estimation. Muffin samples were treated with acidic and basic solutions, filtered, dried, and weighted to obtain crude fibre content.

Muffin Height and Volume

Height and volume were measured using an electronic calliper and the rapeseed displacement method, respectively, for raspberry mini-muffins.

Determination of Muffin Color by Colorimeter

The colour of the muffin samples was determined by using a colourimeter that operates with the Lab colour scale system.

Springiness, Cohesiveness, and Hardness of Muffins

The main texture properties of muffin samples were assessed by determining their resilience, adhesiveness, and hardness.

RESULTS

Table 1 represents muffin samples' fat content analysis results to highlight the fat content differences in different

formulations. The study assayed fat content using pumpkin puree as an alternative fat source for muffin samples. The control group had 1% fat as a component of their diet. However, as pound cake was added, the fat level was increased. Even though pumpkin puree was added, the fat level was eventually reduced. Our comparative analysis identified the difference in muffins with 25% pumpkin puree from others as 1. -13.0% and -4.3%, respectively. 5% and 1. The other % in the bread group contains 50% and 75% pureed pumpkin. The greatest decrease in fat percentage was observed in buns with 100% pumpkin puree content as the lowest value. 2% fat content. The outcomes indicate that pumpkin puree could be an available fat-replacing agent in pastry goods, leading to healthier alternatives with less fat content.

Table 1: Fat Content of Muffin Samples

SAMPLE	FAT CONTENT
Control (butter)	1.9%
25%	1.7%
50%	1.5%
75%	1.4%
Control (pumpkin puree)	1.2%

Table 2 presents the moisture content analysis outcomes for individual sample muffins to highlight the relative differences in their formulations. The humidity percentage was 3 for the control group. During this process, general bread with 2% and 25% of pumpkin puree had slightly lower values of 3, whereas 75% of pumpkin puree muffins had even lower values. 1% and 3. 3%, respectively. On the other hand, baked muffins with pumpkin puree, which had a 50% share of the total mass, had a very slightly elevated moisture content of 3%. 4%. The control muffins with 100% puree from pumpkin were awed with moisture 3. The emulsifying characteristics are strong, with a moisture content retention of 34%. This may be why pumpkin puree has a reputation for moisture retention and may complement bakery products, enhancing their texture and shelf life.

Table 2: Moisture Content of Muffin Samples

SAMPLE	MOISTURE CONTENT
Control (butter)	3.2%
25%	3.1%
50%	3.4%
75%	3.3%
Control (pumpkin puree)	3.34%

Table 3 depicts the ash content analysis of muffin samples with different formulations, revealing the variability. A group was fed butter as the fat source with 4% ash. 6. But in sample number 25, complete with 25% pumpkin puree, ash content significantly increased to 6%. 2%, meaning that carbon-rich asteroids might add a new link to the chain of ongoing meteoritic genealogy. 50% pumpkin puree-loaded muffins showed a mean calorie content rise of 17. Minerals make up 2% of the digitally measured economy, as a substantial contribution shows. Despite that, the 75% pumpkin puree muffins had the values that also led to the reduction to 10. 0.4% of memory was saturated, i.e. a saturation effect was observed. The blend of muffins without sugar substitutes demonstrated an ash content of 9/100%. Therefore, 6% indicate that pumpkin purée mineral content substantially impacts the diet.

Table 3: Ash Content of Muffin Samples

SAMPLE	ASH CONTENT
Control (butter)	4.6%
25%	6.2%
50%	17.2%
75%	10.4%
Control (pumpkin puree)	9.6%

Table 4 shows the protein levels found using the Kjeldahl method across different muffin formulations, which varied slightly. The control group used butter in the fat and had a protein content of 6. On the other hand, muffins with ground pumpkin purree displayed a steady upsurge of protein, such that they had a much higher content of 52% protein. The protein quantity for a cake with 25% pumpkin puree was 6%. 93%. The more significant increase in this brand of muffin was captured mostly in the 50% and 75% pumpkin puree muffins, which showed 7. 50% and 8. 01% respectively. The highest protein content was found in control muffins with 100% pumpkin puree, followed by 100% mixed puree at 8. 90%. This disadvantage highlights the nutritional importance of pumpkin puree as a multifunctional additive in baked goods.

Table 4: Protein Content by Kjeldahl Method of Muffin Samples

SAMPLE	PROTEIN CONTENT
Control (butter)	6.52%
25%	6.93%
50%	7.50%
75%	8.01%
Control (pumpkin puree)	8.90%

Table 5 shows the variations in the volume of rapid seed replacement method muffin samples, shown in different formulations. For the butter muffins of the control group (a group in which fat is obtained only from butter), the volume was 1459 g. 55 cm^3. On the other hand, UV-B irradiation led to a different response in muffins made from diverse levels of pumpkin puree. The muffins going down to 25% pumpkin puree were found to have a lower volume of 122ml. A reduction of 17 volumes to 41 cm^3 but slightly increased volumes for those with 50% and 75% pumpkin puree. We made some muffins with 100% pumpkin purée and found that their volume was more stable around 1431. 66 cm^3. Hence, the trials illustrated that muffin formulations might be affected due to differences in the material's consistency, texture and integrity.

Table 5: Volume by Rapseed Method of Muffin Samples

SAMPLE	VOLUME (cm3)
Control (butter)	1459.55 cm3
25%	122.44 cm3
50%	1414.7 cm3
75%	1412.77 cm3
Control (pumpkin puree)	1431.66 cm3

Table 6 shows the muffin sample analysis and the differences in the total carbohydrate levels among different formulations, indicating crude fibre content. For the control group, which used butter instead of sugar, these muffins had 54 total carbohydrate counts. 88g. Although muffins baked with varying pumpkin puree-loaded contents resulted in negligible deviation of total carbohydrate, the difference is detectable. The 25%, 50%, and 75% of the pumpkin puree muffins also showed slight differences from the other group. However, the control muffin had the highest differentiation. A rather small difference in size was found in mummies, too, containing pure pumpkin. These results show that adding pumpkin puree to vegetable protein bars reduces total carbohydrate content, which is probably affected by different bar formulations and ingredient composition.

Table 6: Crude Fiver of Muffin Samples

SAMPLE	TOTAL CARBOHYDRATE (g)
Control (butter)	54.88g
25%	54.72g
50%	54.66g
75%	54.18g
Control (pumpkin puree)	54.11g

Table 7 shows the physical properties and texture profiles of muffins made with various pumpkin puree concentrations. The muffins were tested using height measurement, hardness scale (firmness) lookup, springiness scale, chewiness, stickiness and cohesiveness index. The control muffins with un-leavened batter were reduced in height to 4 cm. Coming to the bake experiments, the height of cookies containing 100% pumpkin puree was 60 cm, compared to those containing 25%, 50%, 75%, and control pumpkin puree that was 3,5,6, and 7 cm high. 13 cm, 5. 00 cm, 5. 11 cm, and 5. 07 cm, respectively. Muffin was the hardest, with the puree 25% as a result, and the figure was 352. 30% of the mix. It also indicated that the pumpkin puree addition made 31% of the crumbly texture smoother. Up till 47 mJ was the lowest and 62 mJ the highest energy. 83 MJ. The results shed light on the best approaches to muffin formulations to develop the product's most desirable sensory features and consumer appeal.

Table 8 shows the colour analysis of muffin samples. A colourimeter reveals slight variations in L*, a*, and b* values among the different formulations. The half-baked control (butter) muffins were scored at L* value 59. 97, compared with 60, L* values of 25%, 50%, 75% and control standing for pumpkin puree (PP) muffins, respectively. 43, II. 77, II. 37, and II. 25, respectively. The* value changes (with a little difference in all formulations) while representing the degree of redness/greenness. The b*, indicating yellowish/blueness, fluctuates slightly among the blends. Pumpkin puree influenced the stability of colour attributes. However, the observed changes were small in lightness, redness and yellowness units. Thus, the results will contribute to the visual characteristics of the muffins formulated with pumpkin puree and, therefore, the optimisation of formulations to achieve the specified colour profiles and consumers' attraction.

Table 7: Physical Properties of Muffins Height and Texture Profile

FORMULATION	CONTROL (butter)	25%	50%	75%	CONTROL (pp)
Height (g)	4.90	5.13	5.00	5.11	5.07
Hardness (mm)	164.98	352.30	325.72	276.61	265.51
Springness (mm)	0.91	0.97	0.97	0.97	0.97
Chewiness (mJ)	31.47	97.04	85.86	62.83	51.67
Cohesiveness	0.24	0.24	0.24	0.24	0.24

Table 8: Colour Analysis of Muffins by Colorimeter

FORMULATION	CONTROL (butter)	25%	50%	75%	CONTROL (PP)
L*	59.97	60.43	59.77	59.37	60.25
a*	-2.01	-1.74	-2.05	-2.36	-2.15
b*	-1.03	-0.36	-1.25	-1.77	-1.66

DISCUSSION

In this study, we analysed carotenoid content in different species and varieties of pumpkins. We explored how processing and storage methods such as pre-processing, preparation, and storage might affect them. Pumpkins, belonging to the family of vegetables' genus Curcurbita, are famous for their large amount of carotenoids, especially β-carotene, forming the majority of total carotenoids of pumpkins. We observe consistent results with previous studies that revealed β-carotene to be the dominant carotene in pumpkins and its concentration being more than 70 µg/g (26). Nevertheless, similarities and differences in the carotenoid content of different species and varieties and within the same species and variety cannot be ignored. This carotenoid variation could be affected by factors such as growing conditions and harvest stage (27).

The method of preparation and processing were the major points in my research work on pumpkins such that carotenoid content changed. We found that carotenoids are oxidised and isomerised during the preparation and processing of food. Ultimately, aroma and colouring loss may lead to decreased biological activity. Exposure to these reactions by temperature, oxygen, and light may cause some modifications (26). Our data support the findings of previous studies, the main idea of which is that carotenoids are the most damageable compounds of all (28).

Moreover, our research concentrated on whether there was a change in pumpkins' carotenoid composition during the storage process. It appeared that pumpkins picked mature and dried in ideal temp and conditions showed better resistance to carotenoid loss. Particularly, we reported that pumpkins are stored for about 2 months post-anthesis or two weeks after harvesting when exposed to a cool environment, visibly improving flavour and making them appealing to consumers since sugars are formed from starch. These results matched previous research, showing that correct storage conditions may aid in keeping the nutritional attributes of the pumpkins (29).

Examining pumpkin carotenoids and their potential applications led to evaluating different methods for preparing pumpkin puree, an ingredient widely used in such cooking applications. Both steaming and steaming were suitable for cooking with the pumpkins, yielding the same results; the steaming method, however, had the clear advantage of being much easier to make as it was done faster, especially in the case of large batches of puree. Our findings are congruent with the recommendations of experienced chefs and the previous literature on how steaming and roasting are the proper methods for pumpkins (30).

Besides, the study we participated in specifically examined muffin batter physicochemical properties, considering density, pH, viscosity, and line spread capability. We noted that batter viscosity, influenced mainly by flour ingredients and water amount, was a vital factor in deciding the overall outcome of the muffins. More batter viscosity proved beneficial because it would affect the quantity and quality of air incorporated into the product and its organoleptic characteristics. This study affirmed the need for a particular consistency of the batter for the output to be high quality, as demonstrated earlier (31).

In addition, we analysed the technical values of the muffins made using different formulations, which also considered pumpkin puree a fat substitute. The study showed that pumpkin puree muffins had a lower fat content and a higher moisture content than the control muffins. This finding is supported by the benefits of using pieces of pumpkin as a fat equivalent that provides lower calories and more moisture content in baked products (32).

Furthermore, we carried out sensory testing to estimate consumers' obtuseness with the texture of muffins. We have found that pumpkin puree as a fat alternative worked very well for the muffin recipe, especially for people who are health conscious, students, and those suffering from chronic diseases or diabetes. Such findings also agree with increasing public preference for healthier bakeries' stuff. Pumpkin puree is a good example of a functional ingredient which can improve the quality of baked products (5).

In the first place, therefore, the results from the study metaphorically point out the variety in carotenoid content in pumpkins observed among various species and strains. Our research confirms previous reports of experimental studies demonstrating that factors such as growing conditions, maturation stage, or post-harvest handling are responsible for fluctuations in the carotenoid content of

pumpkins (33). This brings forth a need to study the biochemistry of flow balance and is a piece of advice to fill up the nutritional value and appealing taste of the pumpkins since this information is essential. Furthermore, our study shows differences between how carotenoids are prevented from being destroyed and better absorbed from various pumpkin products. These lessons put together part of a more in-depth picture of the factors influencing the quality of pumpkins and their derivatives for nutrition.

As a part of our detailed exploration of the applications of pumpkins for producing ingredients, which is an active component of our research, we considered the functional attributes of protein and its role in the development of fat-reduction strategies for muffin-making. Such an outcome has shown support for the reports that protein-based fat replacers just as well perform the functions of fat, fattiness and texture features in baked foods (34). Accordingly, it gave food manufacturers the vital support to enrich their bakery items such as low-fat cakes and cookies. Furthermore, the findings indicate that cooks must pay close attention to the dough to know its rheological characteristics, which would be the secret of their strength and sensory qualities (35).

Hence, sensory analysis plays a role in traffic lights' establishing the quality and general acceptance of the product. The muffins were made with protein-based fat replacers mixed with pumpkin ingredients, and sensory evaluation methods were used. We analyse the sensory attributes, aroma, and texture characteristics. The research points to sensory analysis in the development of products, which is previously proven in the current literature that has emphasised the account of sensory analysis in the formulation of products, refinement of formulae and the optimisation of sensory attributes by consumer preference (36). This highlights the role of sensory analysis as a tool that promotes the sensory appeal of bakery items and consumer acceptance, thereby increasing their popularity in the market and the satisfaction of consumers with such products.

CONCLUSION

In conclusion, the study showed that replacing butter with pumpkin puree in muffins improves the nutritional score and consumer acceptance. Pumpkin muffins, a vitamin and mineral source, do more than that since they help to regularise the heartbeat and blood pressure. Nevertheless, higher pumpkin concentration will likely lead to harder and chewier muffins while changing the products' colour, redness, hue, and yellowness. However, this is separate from the muffins being largely liked by the consumers, with 75% favouring pumpkin puree and 25% preferring pumpkin filling as the most wanted. Such love is derived from the overall eye-catching colour and the rich quality of the pumpkin taste. The study concludes that making muffins with 75% pumpkin puree instead of normal butter as a primary fat source can be a good option for increasing the nutritional quality and the consumers' liking of these cakes.

Acknowledgements

The author(s) thanks the staff of Jinnah university for Women for their support in this study,

Funding

None.

Conflict of Interest

The author(s) declares no conflict of interest.

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Received on:1May 2024 Accepted on15 May 2024 Published on 23 May 2024

DOI:

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