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Effect of *Hypericum perforatum* flour addition on quality characteristics and acceptability of potentially stress-relief cakes

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Abstract

The growing demand for nutritious, health-enhancing foods has led to the development of novel functional foods, particularly bakery products, renowned for their sensory appeal and convenience. The effects of *Hypericum perforatum* incorporation on the quality characteristics and acceptance of innovative cakes were investigated, determining the physicochemical, structural, and sensory properties; color measurement was performed using a colorimeter; texture profile analysis was used for textural property measurement; and total phenolics (Folin-Ciocalteau method) and antioxidant activity (DPPH method) were used. Hypericum flour was incorporated at ratios ranging from 0 to 5%. As a result, moisture content and water activity increased, while baking loss decreased, with no significant differences between hypericum cakes. Crumb and crust lightness (L^*) were decreased with hypericum flour addition. Moreover, hardness and chewiness were increased, though cakes at levels of 1 and 3% showed lower hardness than control. Cohesiveness decreased gradually, while only the cakes with 5% hypericum showed lower springiness. Hypericum cakes exhibited increased total phenolics (31.14 –104.35 mg GAE/100 g) and higher antioxidant activity. Descriptive sensory analysis and acceptability showed that taste characteristics such as sweetness and bitterness were the main determinants of cake acceptance, and additions at levels of hypericum up to 3% could be a promising alternative for health-promoting and mood-boosting innovative cakes rich in bioactive compounds.

1. Introduction

In recent years, food consumers have re-evaluated their behavior and preferences, placing emphasis on healthy and mood-boosting foods, i.e., foods that can help improve mental performance, manage stress, and generally optimize brain function. From now and beyond, consumers are seeking such foods and drinks due to their expressed interest in brain health benefits, as has been reported by Mintel (2023). It should be noted that the cake market size has been estimated at $44.61×10^9 in 2021 and is expected to reach $61.27×10^9 by 2030, growing at a compound annual growth rate (CAGR) of 3.59% (Verified Market Research, 2022), while the cake mix market industry was valued at $1.24×10^9 in 2023 and projected to grow to $1.683×10^9 by 2032, exhibiting a CAGR of 3.83% (Guptai, 2023) due mainly to consumers' desire for ready-to-eat foods, both constituting an important international market. Further, it should be noted that the stress relief supplements market has been estimated to be $0.5×10^9 in 2022 and is expected to reach $0.9×10^9 by the end of 2032, showing a CAGR of 6.75%, with the main market drivers being the expanding number of persons with diseases and conditions due to stress and the consumers' knowledge of the advantages of stress management supplements (Singh, 2023b). In addition, the *Hypericum perforatum* extract market has been estimated to reach $542.21×10^6 with a CAGR of 6.78% from 2022 to 2032 (Market Expertz, 2023).

Generally, cakes could be considered sweet, rich-dough baked goods prepared using flour, sugar or sweetener, fat, eggs, milk, baking powder or soda, and some additional ingredients that are added to enhance their value and acceptability. They are widely consumed products around the globe. Innovations in this field regarding recipes (new-novel ingredients) and decorations, as well as consumer demands for on-the-go products, indulgence in cakes for special occasions, the increasing popularity of customizable cakes, and the interest in baked goods that influence cognitive capacity,

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manage stress levels, and optimize brain function, are among the key drivers that might carry forward the growth of the cake market. The latter leads towards the utilization of various plant-based ingredients, especially medicinal plants, among which are mood-boosting botanicals such as St.John's wort (*Hypericum perforatum*).

Hypericum perforatum, commonly called St. John's wort, may exert potent antidepressant effects, and its use is considered an efficacious and safe treatment. Perhaps it is the most extensively investigated medicinal herb. It should be noted that the leaves and flowering tops constitute the parts used for medicinal purposes (Zirak *et al*., 2019; Kapoor *et al*., 2023; Mohagheghzadeh *et al*., 2023; Wu *et al*., 2023). Pharmacological studies showed that the major biological activities documented include antinociceptive and antidepressant-like effects, cytotoxicity against cancer cells, and antimicrobial activity (Mullaicharam and Nirmala, 2018; Xiao *et al*., 2020; Makarova *et al*., 2021; Khatri *et al*., 2023; Kladar *et al*., 2023). The two most well-known and important compounds of *H. perforatum* are hypericin and hyperforin. It has been reported that hyperforin regulates gene expressions related to depressive states, while hypericin reduces stress-induced behaviors and increases the extracellular brain concentrations of glutamate and acetylcholine (Zirak *et al*., 2019; Caldeira *et al*., 2022; Wu *et al*., 2023). Furthermore, hyperforin shows antimicrobial activity against various microorganisms (Xiao *et al.*, 2020; Jakubczyk *et al.*, 2021; Kapoor *et al.*, 2023; Sherif *et al.*, 2023), while both compounds exert anticancer activity by increasing apoptosis and decreasing the cell viability in tumor-cell lines (Imreova *et al.*, 2017; Xiao *et al.*, 2020; Caldeira *et al.*, 2022). Hence, it is a prominent ingredient to be used in innovative food product development and production, with potential stress relief and mood-boosting properties.

The utilization of wild-growing medicinal plants as raw materials provides food products with specific functional properties. In bakery products, the addition of medicinal plants to the formulation showed a positive effect on dough maturation. This was attributed to the high content of mono- and disaccharides, organic acids, and minerals (Volkova *et al.*, 2020). Jakubczyk *et al.* (2021) studied the addition of St. John's wort in cookies, showing that it had no effect on water and oil absorption capacity. Further, the cookies had a higher content of bioactive compounds, higher antioxidant activity, and more potent anti-metabolic syndrome effects. Dombrovskaya *et al.* (2021) developed a method of preventing bakery products from "potato disease" based on a water-honey extract of hypericum herb. Concurrently, there is an improvement in the gas-forming ability and fermentation activity of the dough, leading to finished products with improved organoleptic and physico-chemical parameters and quality. Chinma *et al.* (2015) added a 12% mixture of mashed carrot and pumpkin and powder of pumpkin seeds and St. John's wort, aiming to enrich the dietetic bakery product, tapa-nan, produced using wheat flour. It was found that St. John's wort increased the water absorption capacity of flour, lowered the dilution of dough consistency, and increased its elasticity. Obviously, published research findings on the use of *H. perforatum* in baked products are very limited.

The present investigation was undertaken to study the incorporation of *H. perforatum* flour into cake formulation, aiming to explore the physicochemical properties, structural properties, textural properties, total phenolic content, antioxidant activity, and organoleptic characteristics of a high-added-value and acceptable product. In addition, the macroscopic structure and morphological characteristics of the innovatively enriched cakes were analyzed using image analysis.

2. Materials and methods

2.1 Materials

Marra Bros Mills S.A. (Korinthos, Greece) donated the wheat flour designed for cake making. *Hypericum perforatum* was gathered in the Northern Evros region (Thrace, Greece) in June 2022. After collection, it was traditionally air-dried under ambient conditions under shadow. The dried flowers and leaves of *H. perforatum* were ground using a rotary mill (Brabender OHG Duisburg, Type 880803, Germany). The *H. perforatum* flour was sealed in airtight jars and stored at 4°C until use. Ingredients such as sugar, vanilla, shortening, eggs, baking powder, and milk were purchased by the local market in Athens.

2.2 Cake production procedure

Wheat flour as well as *H. perforatum* flour were weighed, mixed, and sieved. *Hypericum perforatum* flour was added and mixed with wheat flour in order to obtain different *H. perforatum* flour additions, namely 0%, 1%, 3%, and 5%. The production procedure consists of a specific creaming method. Each experimental preparation was conducted in batches and three replicates. More specifically, for each experimental batch, the whole procedure includes: 250 g flour, 200 g sugar, 125 g shortening, 110 g eggs, 125 g milk, 10 g baking powder, and 1.5 g vanilla. First, the shortening was stirred for 1 min in the mixer. Then the sugar was added, and the mixing continued for 19 mins (the creaming step). After this step, the eggs were gradually added. Finally, the mixing speed was reduced, and the

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milk and flour were added alternately. The flour was mixed immediately so that the trapped air would not be removed. The vanillin was added shortly before the end of mixing. The dough was then divided into two equal parts and placed in disposable rectangular aluminum pans (26.3×10.3 cm). The dough was then baked in an oven (LinkRich DH6A-A, LinkRich Enterprise Limited, China) at a temperature of 170°C for 1 hr. After the baking process, the cakes were left to cool for 1 hr at ambient temperature. The products are stored in PP bags for further analysis.

2.3 Quality characteristics determination

2.3.1 Moisture content and water activity

The moisture content of the cakes was measured using the oven method (Lazou *et al*., 2023). All analyses were performed in triplicate. An a_w-meter (Aqua Lab 4TE, Decagon Devices, Inc., USA) was used to measure the water activity (a_w) of the cake crumb. Three different samples were used for each measurement, and the mean values were reported.

2.3.2 Texture profile analysis

A texture analyzer (TA.XT2i; Stable Micro Systems, UK) was used to measure the textural characteristics of the crumb of each cake. A 25-mm cylindrical probe and a 25-kg load cell were used in a two-fold compression test (TPA) to compress five slices from the center of each cake loaf to 50% deformation. The TPA testing conditions include a 3 mm/s pre-test speed, a 1 mm/s test speed, a 1 mm/s post-test speed, and a 50% sample deformation. The force-time curve was recorded during the TPA test. The evaluated parameters were: hardness (maximum height of the first peak), cohesiveness (area ratio during second compression to area during first compression, as a reference to crumb elasticity), springiness (the time between the end of the first compression and the beginning of the second), and chewiness (obtained by multiplying hardness, cohesiveness, and springiness values, which expresses the energy needed to chew samples) (Mustafa *et al.*, 2018; Lazou *et al.*, 2023).

2.3.3 Baking loss

The cake samples were weighed before (dough) and after baking (after cooling) in order to express the percentage baking loss as described by Lazou *et al.* (2023). The results are the average of three replicate measurements.

2.3.4 Color measurement

Using a colorimeter (HunterLab, Miniscan XE Plus, Virginia, USA), which provides the values of the color parameters L^* (lightness), a^* (green-red), and b^* (yellow -blue) in accordance with the CIELAB system (directional annular 45° illumination, D65 daylight mode), the color of the crust and crumb of the cake samples was measured. The following relationship is used to determine the value of the color difference:

$$\Delta E = \sqrt{\left(L^* - L_o^*\right)^2 + \left(a^* - a_o^*\right)^2 + \left(b^* - b_o^*\right)^2} \quad (1)$$

where L_0, a_0, and b_0 represent the sample's values without the addition of hypericum flour (control cake samples). Five measurements of each loaf's color parameters were taken in triplicate.

2.3.5 Geometrical and morphological properties through image analysis

Photos of the cake loaf and slices (8 in total) were taken for the purposes of this analysis. Pictures were captured using a digital camera (Canon EOS 4000D, Tokyo, Japan). A customized lighting plate (Kaiser slimlite plano) and adequate illumination were utilized simultaneously to achieve the goal, which decreased shadows and increased the sharpness of the images. Subsequently, the images were processed using ImagePro-Plus v7.0.1.658 software to determine loaf and pore geometric and morphological properties. All sample measurements were achieved by following the configurable macros of the program. For each cake loaf, the geometrical properties were calculated, including length (mm), width (mm), thickness (mm), and surface area (mm^2). Moreover, the specific volume (SV) of each loaf was estimated from the loaf dimensions. The number of pores or cells per cm^2, porosity (%), single pore area (mm^2), aspect ratio, roundness (a measure of the difference between the pore and the circle), and diameter (mm) were calculated as part of a thorough investigation into the morphological characteristics of the pores (cells). The average of eight separate pictures is used to calculate the geometrical and morphological characteristics.

2.3.6 Total phenolic content and antioxidant activity

The extraction of phenolic compounds was carried out using methanol as a solvent because methanol is widely recognized as the solvent that extracts almost all phenolics. The samples were continuously extracted for 2 hrs at room temperature with n-hexane at a ratio of 1:5, using an orbital shaker (Orbital Shaker SO1, Stuart Scientific, UK), to remove the fat. After that, a 1:5 methanol extraction was performed on the leftover material, which was then put on a vibrating plate at 40°C for 24 hrs. The methanolic extract was then obtained in a 10 mL volumetric flask (Lafka *et al.*, 2007; Bisharat *et al.*, 2015). The measurement of total phenolics was

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performed at 725 nm using the Folin-Ciocalteau reagent by a micro method as previously described by Andreou *et al*. (2018). The method uses 100 µL of the predetermined amounts of standard or diluted sample solution, 2500.0 µL of distilled H_2O, and 200.0 µL of Folin-Ciocalteau reagent. For each sample or standard solution, triplicate measurements were performed. The total phenolics were calculated using a reference standard curve and expressed in Gallic Acid Equivalents (GAE) per g of sample. The antioxidant activity of phenolic extracts was measured using the reagent DPPH (1,1 diphenyl-2-picrylhydrazine) as described by Lafka *et al*. (2011), using 0.2 mL of methanolic extract solution, 3.8 mL of DPPH methanolic solution (0.0025 g/100 mL CH_3OH), and measuring the absorbance at 515 nm until it stabilized. At the same time, methanol was used as a blank to measure the control's absorbance at 515 nm. A single-beam visible-ultraviolet UV-VIS spectrophotometer (UVmini 1240, Shimadzu, Ltd., Hong Kong) was used for the measurements. The antioxidant activity of the samples was reported as % inhibition of DPPH and was computed using the equation proposed by Yen and Duh (1994).

2.3.7 Sensory evaluation

The sensory evaluation was carried out according to Lazou *et al*. (2023). The descriptive study of the cakes was conducted by a ten-member trained panel made up of students and staff (4 males and 6 females) from the Department of Food Science and Technology at the University of West Attica in Athens, Greece, who ranged in age from 22 to 45. In accordance with International Organisation for Standardisation [ISO]13299:2016 (ISO, 2016), they received training in the precise terminology and methods of sensory analysis. The sensory evaluation of cake was carried out in a sensory evaluation facility with distinct partitioned booths in a climate-controlled environment with standard illumination. Slices of the samples measuring 2 cm thick were placed at room temperature in identical white dishes with a three-digit number. The duration of the sessions was 45 minutes, with four samples presented in each session in a way that allowed for three replicates of each sample. The panelists' palates were washed with water in between tests. The six basic categories of descriptive terms were appearance, odor, flavor, taste, and texture. The panelists were asked to rate and grade them on a scale of 1 to 9, with 1 denoting lesser intensity or an unnoticeable trait, 5 denoting a fairly perceptible characteristic, and 9 denoting higher intensity or a very perceptible or very intense characteristic. The sensory qualities, definitions, and anchors employed in this assessment are summarized in Table 1.

Additionally, 50 untrained panelists consisting of 25 men and 25 women, who were graduate students and staff members at the Department of Food Science and Technology of the University of West Attica, Athens, Greece, were gathered to further evaluate the cake samples in triplicate. The assessment was performed in the same laboratory for sensory evaluation, which was air-conditioned and had normal lighting. The samples were displayed on white plates with a three-digit code. Using a nine-point hedonic scale with a range of 1

Table 1. Terms, attributes definitions and anchors used in the descriptive analysis of innovative cakes.

Attribute	Definition	Anchor
Appearance		
Crust darkness	Degree of color darkness in the crust ranging from light brown to dark brown	Light to dark
Crumb color	Color of crumb ranging from white/yellow to brown	Light to dark
Crumb pore number	Crumb cell number per cm^2	Low to high
Homogeneity of crumb pores	Homogeneity of the size of the crumb cells	Low to high
Aroma	Total intensity of the aroma	Low to high
Taste		
Sweet	Fundamental taste sensation of which sucrose is typical	Weak to intense
Mealy	Raw flour	Low to high
Burnt	Burnt sample	Low to high
Bitter (aftertaste)	Residual taste sensation of which caffeine in water is typical	Weak to intense
Texture		
Hardness	Force required to bite through the sample	Low to high
Springiness	Force which the sample returns to its original size and shape after partial com-	Low to high
Chewiness	Number of chews required before swallowing	Low to high
Friability	Capacity of the sample to break into numerous pieces from the beginning of	Low to high
Cohesiveness	The extent to which a material can be deformed before it ruptures	Low to high
Hydration - Melting	Amount of saliva segregated in the oral cavity during sample chewing	Low to high

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(extreme dislike) to 9 (extreme like), the various cake formulations were assessed for overall acceptability (Lazou *et al*., 2023).

2.4 Statistical analysis

The significance of the impact of the hypericum flour addition on the mean values of the quality attributes was evaluated using analysis of variance (ANOVA). Duncan's multiple range test was used for the determination of the changes in the means of the parameters in cases where there were significant effects of the variables, with a significance threshold of $p<0.05$. SPSS software (IBM SPSS Statistics 20.0) was used for all analyses.

3. Results and discussion

The physiochemical properties of the innovative hypericum-based cake are shown in Table 2. Hypericum cake formulations appeared to have significantly increased moisture content. Samples containing 5.0% hypericum flour exhibited the highest moisture content (29.0%) compared with the control (18.39%). This could be attributed to the presence of more hydrophilic chains, due to the increase in fiber content, as well as oligosaccharides, bioflavonoids, and various macro- and microelements, which lead to greater water absorption capacity and finally to a product with relatively increased functional components (Ho *et al.*, 2013; Beisenbayev *et al.*, 2015; Amini Khoozani *et al.*, 2020). It should also be noted that these hydrocolloids might also interact with the biopolymers of the wheat flour, such as starch, proteins, and pentosans, forming networks that can trap some water (Majzoobi *et al*., 2013). Ataei Nukabadi *et al*. (2021) for cakes containing 12.5% nettle and 12.5% milk thistle also attributed the high moisture content to the high water-binding capacity of the leaves' powder added. Similar findings on moisture content increase have been reported by Hathout (2021) for cakes containing various percentages of Samwah herb (*Cleome droserifolia*) and Volkova *et al*. (2020) for bread made with wheat flour and wild herbs, while Song *et al.* (2017) reported no effects on moisture by adding basil (*Ocimum basilicum* L.) seed mucilage as a fat replacer. Further, as can be seen from Table 2, the addition of hypericum affected the water activity, showing values ranging from 0.839 for the control sample to 0.903 for cakes with 5.0% hypericum, following, in general, the moisture content of cakes. Hypericum addition also led to a statistically significant difference in baking loss between control and hypericum-containing formulations (16.52% for control vs. 15.06% for cake with 5.0% hypericum), while no significant differences were observed between hypericum-containing samples. Song *et al*. (2017) reported that the addition of basil seed mucilage significantly increased baking loss. It is derived that moisture content is crucial to the cake-baking process as it affects the physiochemical, rheological, and structural changes occurring during baking such as water evaporation, volume expansion, starch gelatinization, protein denaturation, and fragrance compound production, which determine the overall product quality.

The color parameters of the innovative hypericum cake, for both the crumb and crust, are presented in Table 2. Hypericum addition led to significant decreases in the $L*$ parameter (lightness) in both the crumb and crust, which became darker, while both the $a*$ and $b*$ parameters were increased. The values of the $a*$ parameter (the red component) were positive for all the samples, and that reflects a predominance of red over green. This could be attributed to hypericum flowers, which contain hypericin, an anthraquinone-derived

Table 2. Physiochemical properties of innovative cake with hypericum flour.

Hypericum flour addition (%)	0	1	3	5				
Baking loss (%)	16.52±0.24^{b}	15.08±0.19^{a}	15.06±0.20^{a}	15.18±0.12^{a}				
	Crumb				Crust			
Hypericum flour addition (%)	0	1	3	5	0	1	3	5
X (% w.b.)	18.39±0.28^{a}	28.57±0.36^{b}	28.49±0.26^{b}	29.00±0.42^{c}	-	-	-	-
a_w	0.839±0.004^{a}	0.900±0.003^{bc}	0.898±0.003^{bc}	0.903±0.005^{bc}	-	-	-	-
$L*$	71.64±0.17^{d}	44.58±0.23^{c}	34.18±0.43^{b}	31.84±0.61^{a}	38.54±0.21^{d}	37.12±0.51^{c}	32.62±0.31^{a}	33.12±0.37^{b}
$a*$	6.15±0.18^{a}	6.31±0.28^{a}	10.90±0.30^{c}	10.12±0.55^{b}	16.22±0.73^{d}	15.83±0.45^{c}	12.21±0.41^{b}	10.34±0.33^{a}
$b*$	34.69±0.52^{d}	28.32±0.27^{c}	20.24±0.38^{b}	18.75±0.52^{a}	24.63±0.35^{d}	20.41±0.77^{c}	16.92±0.61^{b}	15.51±0.63^{a}
ΔE	-	27.80±0.23^{a}	40.44±0.46^{b}	43.01±0.61^{c}	-	4.51±0.71^{a}	10.52±0.65^{b}	12.12±0.75^{c}

Values are presented as mean±SD. Values within the same row for crumb and crust separately, are statistically significantly different ($p<0.05$) among samples according to Duncan's mean values comparison test.

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pigment responsible for the red color (Klemow *et al.*, 2011; Alahmad *et al.*, 2022). Furthermore, significantly higher values for the a^* value were observed in the crust due to the reaction between reducing sugars and amino acids and caramelization as a result of the effect of baking time and temperature. Chemical components, such as proteins and sugars, may enhance such reactions. The b^* parameter (yellow component) was also positive for all samples, reflecting a predominance of yellow over blue hues (Majzoobi *et al.*, 2013; Korus *et al.*, 2017). The addition of hypericum decreased the b^* value both in crust and crumb. Generally, the crust became darker, more reddish, and less yellowish. Generally, the darkness or lightness variation in cakes could be represented by ΔE values. Similar results have been reported by Majzoobi *et al*. (2013) in the case of sponge cake with increased bran content, showing thus the effect of the higher fiber presence, as in the case of hypericum flour addition. The lowest value for ΔE was observed in cakes containing 1.0% hypericum flour and the highest in samples containing 5% hypericum. Crust ΔE values were lower than those of crumb, following the same variation pattern (Table 2).

Texture represents a key characteristic of cakes that determines their quality, freshness perception, and consumer acceptance, which is the manifestation of structural, mechanical, and surface properties (Blanchard, 2014; Song *et al.*, 2017; Setyaningsih *et al.*, 2019; Ataei Nukabadi *et al.*, 2021). The textural characteristics of innovative hypericum cakes are shown in Table 3. Further, hypericum flour incorporation significantly affected the cake hardness. The lowest value of 5.028±0.682 N corresponded to the product containing 1% hypericum, and the highest value of 10.090±0.918 N corresponded to that with an addition rate of 5%. It should be noted that the increasing level of hypericum causes an increase in hardness. However, additions at levels of 1 and 3% gave the final products a lower hardness compared to the control, showing that a softer cake with a more aerated crumb structure was obtained, along with a significantly higher moisture content (Table 2). Moreover, hypericum addition increases the fiber content and hence hydrocolloids, which act as thickening, texturizing, stabilizing, and gelling agents (Song *et al.*, 2017). Cohesiveness decreased gradually from 0.583±0.036 for the control sample to 0.481±0.027 for the sample with 5% hypericum. No significant changes were observed for springiness between the control and cake samples containing up to 3% hypericum. Significantly lower values were observed in samples with 5% hypericum. This could be attributed to the increased presence of hypericum in the cake. It should also be emphasized that cohesiveness depends on the internal resistance of the cake structure, and its decrease has been reported, which can be attributed to the weakening of the gluten network as well as the decrease in the amount of starch and the increase in the fiber content (Ataei Nukabadi *et al.*, 2021; Bhat *et al.*, 2022). Generally, chewiness follows the changes in hardness as it is derived by multiplying hardness, cohesiveness, and springiness values. Samples containing 1 and 3% hypericum showed significantly lower values for chewiness than the control sample, as well as formulations containing 5% hypericum. This could also be attributed to gluten weakening due to hypericum's presence. Such an effect has been reported for sponge cake added with turmeric by Seo *et al.* (2010).

Hypericum perforatum is known to have antioxidant properties owing to its high phenolic and flavonoid content. Compounds with reported antioxidant activity from Hypericum species mainly belong within the flavonoid group, such ascariphenones A and 5,7-dihydroxy-2-isobutyl-4H-chromen-4-one (Xiao *et al.*, 2020). Hence, its antioxidant activity could be attributed to flavonoids and phenolic acids. It should be noted that the antioxidant activity of *H. perforatum* extracts is due to the high content of phenolic compounds (Orčić *et al.*, 2011; Sengera *et al.*, 2023). A detailed report on the chemical characterization and antioxidant activity of nine Hypericum species from Greece has recently been reported by Kakouri *et al.* (2023). Phenolic analysis of hypericum and cakes showed that hypericum flour had the highest concentration of total phenolics (259.04 mg GAE/100 g), whereas wheat flour had a lower concentration (5.30 mg GAE/100 g) (Table 4). Due to the high concentration of total phenolic content in hypericum, the increasing addition of hypericum resulted in an increase in the total phenolic content of the cakes (31.14 mg GAE/100 g to 104.35 mg GAE/100 g). A

Table 3. Textural characteristics of innovative cake with hypericum flour.

Hypericum flour addition (%)	Hardness (N)	Cohesiveness	Springiness	Chewiness (N)
0	7.852±0.374^c	0.583±0.036^c	0.883±0.029^b	3.899±0.243^c
1	5.028±0.682^a	0.553±0.027^b	0.899±0.019^b	2.501±0.371^a
3	6.632±0.576^b	0.533±0.043^b	0.877±0.035^b	3.104±0.409^b
5	10.090±0.918^d	0.481±0.027^a	0.831±0.044^a	4.026±0.338^c

Values are presented as mean±SD. Values within the same column are statistically significantly different (p<0.05) among samples according to Duncan's mean values comparison test.

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Table 4. Total phenolic content and antioxidant activity of innovative cake with hypericum flour.

	Raw materials			
	Wheat flour		Hypericum flour	
Total phenolic content (mg GAE/100 g d.b.)	4.28±0.36		259.04±2.8	
Antioxidant activity %	2.77±0.60		86.87±0.17	
	Cake			
Hypericum flour addition (%)	0	1	3	5
Total phenolic content (mg GAE/100 g d.b.)	6.40±0.56[a]	31.14±1.39[b]	67.81±0.86[c]	104.36±1.50[d]
Antioxidant activity %	5.24±0.43[a]	18.89±1.10[b]	46.88±0.73[c]	69.94±0.71[d]

Values are presented as mean±SD. Values within the same row are statistically significantly different (p<0.05) among samples according to Duncan's mean values comparison test.

statistically significant difference has also been observed between the samples in terms of the antioxidant activity, with hypericum addition increasing the antioxidant activity. The hypericum flour has the maximum antioxidant activity (86.87%), while the sample with a 5% addition exhibited the highest among different cake formulations (69.94%). Such results have also been reported by Jakubczyk *et al*. (2021) for hypericum-containing cookies at levels of 0.5 and 1%; a significant difference between control and hypericum cookies was noticed, while there has been no difference among hypericum-containing cookies at both levels. The present results indicate that cakes enriched with hypericum have a higher bioactive compound content and antioxidant effect. Hence, Hypericum perforatum has good potential to be used for the production of innovative functional cakes with anti-depression and anti-stress properties.

Volume is one of the most important cake characteristics, greatly related to the amount of air incorporated in the baked product. However, similar volumes in cakes do not necessarily mean a similar bubble size distribution, which can be quite different (Sozer *et al*., 2011; Yang and Foegeding, 2011). Composition, and more specifically, sugar at high concentrations and egg proteins, which are responsible for foam structure, lead to finer air bubbles and, hence, higher cake height (Sozer *et al*., 2011). The presence of large bubbles in the cake structure is indicative of disproportionation and coalescence, which occur before foam settles to a cellular solid structure during baking (Yang and Foegeding, 2011). Further, it should be noted that textural and organoleptic properties are influenced by the three-dimensional structure of a bakery product. As the composition is an influencing factor, hypericum flour addition is expected to affect the cake's structural properties. Table 5 shows the geometrical and morphological properties of cakes made with hypericum flour as estimated by the ImagePro-Plus program on cake loaves and slices (Figure 1). As can be seen, hypericum addition had no significant effect on specific volume (SV), though some differences in dimensions, surface, and volume were observed, implying differences in pore characteristics and porosity. In terms of pore properties, the incorporation of the hypericum led to an increase in the number of pores per cm^2, while decreasing the single pore area and porosity. The latter is one of the most crucial elements affecting the quality of baked goods, which describes the composition, volume, and degree of digestibility (Petrusha *et al*., 2017). Porosity appeared to

Table 5. Geometrical and morphological properties of cake made with hypericum flour estimated by Image Pro-Plus program.

Hypericum (%)	Loaf geometrical and structural properties				
	Surface area (mm)	Thickness (mm)	Length (mm)	Width (mm)	*SV* (cm^3/g)
0	2182.10±57.69[a]	59.03±5.71[a]	250.01±1.72[ab]	89.08±1.62[a]	4.08±0.67[a]
1	2427.10±45.69[b]	69.23±5.12[b]	249.96±2.27[b]	97.49±1.82[b]	5.03±0.52[a]
3	2466.93±47.10[b]	68.38±4.94[b]	249.41±1.95[b]	98.27±1.12[c]	4.85±0.52[a]
5	2455.75±34.68[b]	69.56±5.46[b]	253.54±2.36[a]	98.45±1.44[c]	4.90±0.68[a]

Hypericum (%)	Pore morphological Characteristics					
	Number of cells/cm^2	Porosity (%)	Single pore area (mm^2)	Aspect ratio	Roundness	Diameter (mm)
0	6.04±0.01[a]	58.5±0.2[a]	9.24±0.12[a]	1.92±0.12[a]	2.82±0.13[a]	1.18±0.01[a]
1	10.53±0.28[b]	39.1±0.1[b]	3.79±0.20[b]	1.99±0.01[b]	3.15±0.02[b]	1.06±0.01[b]
3	13.28±0.11[c]	31.4±0.5[c]	2.30±0.14[c]	1.99±0.01[b]	3.09±0.09[b]	1.04±0.02[b]
5	15.49±0.28[d]	28.5±0.3[d]	1.92±0.12[d]	2.02±0.01[c]	3.09±0.15[b]	1.00±0.01[b]

Values are presented as mean±SD. Values within the same column are statistically significantly different (p<0.05) among samples according to Duncan's mean values comparison test.

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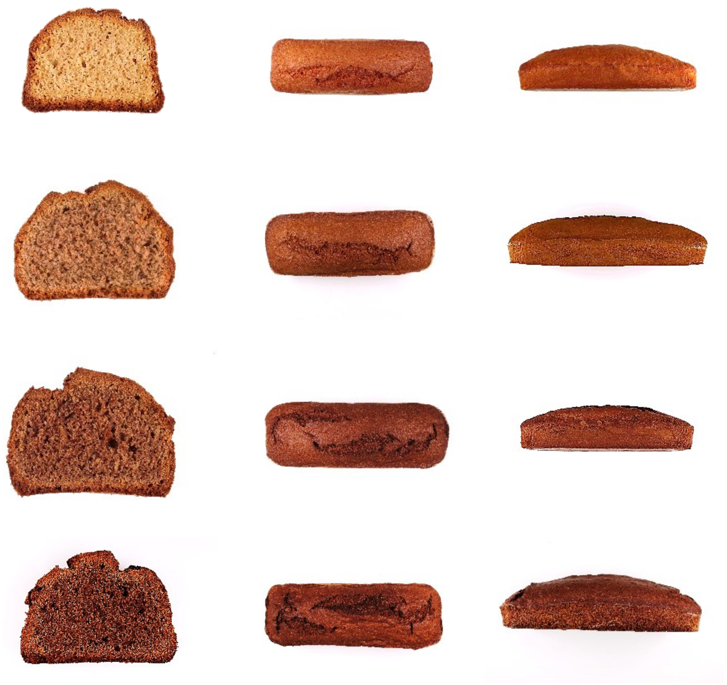
Figure 1. Photographs of innovative cake with hypericum flour.



decrease as the percentage of hypericum increased (58.5% at 0% and 28.5% at 5% addition). Hypericum addition caused a significant decrease in pore diameter compared to the control formulation, without any difference among hypericum-containing formulations. On the contrary, roundness was increased by the addition of hypericum at all levels. Similarly, the aspect ratio appeared to be increased as a result of hypericum addition. It should be noted that pore/cell size is closely correlated to firmness, and in order to obtain a cake with a softer crumb, one option might be to decrease the cell size and the cell wall thickness (Dewaest *et al*., 2018). It seems that hypericum flour addition shows such an effect at levels up to 3%.

The results of the descriptive analysis and acceptability of the innovative hypericum cakes are depicted in Figure 2. The color scores of the crust and crumb are found to be similar to the colorimeter's findings. The incorporation of hypericum flour in cake formulations results in the production of darker products. The number of pores in the crumb that assessed sensorial was unaffected by the addition of hypericum, but the homogeneity of the pores decreased with the hypericum flour addition. The aroma of the innovative cakes had a similar score for all formulations. The taste characteristics that were affected to a high degree were sweetness and bitterness. The sweetness of the cakes dropped significantly at hypericum flour additions higher than 3%. Simultaneously, the bitter taste of the sample increased significantly with the same hypericum additions (≥3%). It has to be noted that the proportion of sugar in the formulations was not changed with the hypericum flour addition. The increase in bitterness may be the result of the increase in bioactive compounds that are present in *Hypericum perforatum*, which was proven from the TPC and antioxidant activity determination. These compounds have been found to activate a distinct human bitter taste receptor (Soares *et al*., 2013). Bitterness could be attributed to polyphenol compounds, which increase with molecular weight glucoside, though controversial results exist where some sensory evaluations perceive smaller polyphenol molecules as bitterer than larger ones. Further, during hyperforin production, bitter acids are produced, which also exhibit a bitter taste (Klingauf *et al*., 2005; Beerhues, 2011; Soares *et al*., 2013). The innovative cakes were found to

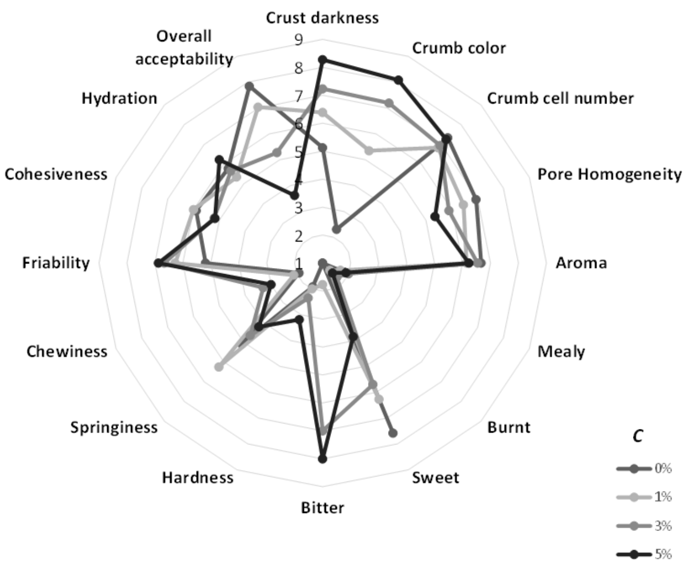


Figure 2. Sensory scores and overall acceptability of innovative cake with hypericum flour.

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be soft (hardness score <5), while the addition of hypericum flour in the formulations increased hardness and chewiness, as similarly found from texture profile analysis. Moreover, the springiness scores were lower for the increased levels of hypericum flour addition. The hydration (melting) of the cakes during the mastication process was found to have the highest value for the 5% hypericum flour addition. This may explain the more intense perception of the bitter taste of these samples. The overall acceptability of the innovative hypericum cakes decreased with the hypericum flour addition. The score was lower than 5 for 5% hypericum flour addition, while it was higher than 6 (acceptable) at 1% addition. These samples had a soft, aerated structure, good elasticity, evenly distributed pores, a strong aroma, and a relatively low bitter taste. However, in the Złotek (2018) study, all the cakes received good scores on the sensory evaluation, suggesting that adding basil did not affect consumer acceptability. In the study by Hafez (2012), the inclusion of marjoram, a plant with antioxidant characteristics, in amounts of 1, 2, and 3% led to variations in the product's color, texture, taste, and aroma, although it was acceptable in amounts of 1 and 2%.

4. Conclusion

The enrichment of cakes with hypericum flour offers an innovative way to enhance the stress-relieving properties and bioactivity of this popular baked good, providing a concurrently medicinal plant-based alternative. Moreover, it offers a way to meet challenges and advancements in formulating and processing in order to face the evolving needs and preferences of consumers. The results of the present work show that the enrichment of cakes with hypericum significantly affects the quality characteristics of these products. The physicochemical properties of the cakes were significantly affected by hypericum. The incorporation of hypericum flour increased the moisture content and water activity and decreased baking loss, with no significant differences between hypericum cakes. Significant decreases in L^* values of crumb and crust were recorded, while positive values for a^* and b^* values were received, showing the effect of the pigments of hypericum flowers. Texture profile analysis parameters were significantly affected by hypericum addition. Image analysis revealed that no significant effect on specific volume was observed, while an increase in pore number, a decrease in single pore area, and porosity occurred. Decreases in porosity and pore diameter were observed, while roundness and aspect ratio were increased. Sensory analysis revealed that sweetness and bitterness were the determinants of hypericum cake acceptance. Finally, it could be concluded that hypericum, at levels of up to 3%, could lead to the production of innovative functional cakes with anti-depression and antioxidant properties.

Conflict of interest

The authors declare no conflict of interest.

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References

Alahmad, A., Alghoraibi, I., Zein, R., Kraft, S., Dräger, G., Walter, J.-G. and Scheper, T. (2022). Identification of Major Constituents of *Hypericum perforatum* L. Extracts in Syria by Development of a Rapid, Simple, and Reproducible HPLC-ESI-Q-TOF MS Analysis and Their Antioxidant Activities. *ACS Omega*, 7(16), 13475-13493. https://doi.org/10.1021/acsomega.1c06335

Amini Khoozani, A., Kebede, B., Birch, J. and Bekhit, A.E.-D.A. (2020). The Effect of Bread Fortification with Whole Green Banana Flour on Its Physicochemical, Nutritional and In Vitro Digestibility. *Foods*, 9(2), 152. https://doi.org/10.3390/foods9020152

Andreou, V., Strati, I.F., Fotakis, C., Liouni, M., Zoumpoulakis, P. and Sinanoglou, V.J. (2018). Herbal distillates: A new era of grape marc distillates with enriched antioxidant profile. *Food Chemistry*, 253, 171-178. https://doi.org/10.1016/j.foodchem.2018.01.162

Ataei Nukabadi, F., Hojjatoleslamy, M. and Abbasi, H. (2021). Optimization of fortified sponge cake by nettle leaves and milk thistle seed powder using mixture design approach. *Food Science and Nutrition*, 9(2), 757-771. https://doi.org/https://doi.org/10.1002/fsn3.2041

Beisenbayev, A.Y., Myrkhalykov, Z.U., Satayev, M.I., Beisenbaeva, Z.A., Dzhandarbekova, D. and Kantureyeva, G.O. (2015). Production of Dietetic Bakery Product - Tapa-Nan with Functional Additives. *Modern Applied Science*, 9(9), 259-266. https://doi.org/10.5539/mas.v9n9p259

Bhat, N.A., Wani, I.A., Hamdani, A.M. and Gani, A. (2022). Development of functional cakes rich in bioactive compounds extracted from saffron and tomatoes. *Journal of Food Science and Technology*, 59(6), 2479-2491. https://doi.org/10.1007/s13197-

021-05267-2

Bisharat, G.I., Lazou, A.E., Panagiotou, N.M., Krokida, M.K. and Maroulis, Z.B. (2015). Antioxidant potential and quality characteristics of vegetable-enriched corn-based extruded snacks. *Journal of Food Science and Technology*, 52(7), 3986-4000. https://doi.org/10.1007/s13197-014-1519-z

Blanchard, C. (2014). On the study of the different factors influencing the structure and the texture of semi-humid baked aerated cereal products: sensory and instrumental dimensions of texture. Dijon, France: Université de Bourgogne, PhD Thesis.

Caldeira, G.I., Gouveia, L.P., Serrano, R. and Silva, O.D. (2022). *Hypericum* Genus as a Natural Source for Biologically Active Compounds. *Plants*, 11(19), 2509. https://doi.org/10.3390/plants11192509

Chinma, C.E., Ilowefah, M., Shammugasamy, B., Mohammed, M. and Muhammad, K. (2015). Effect of addition of protein concentrates from natural and yeast fermented rice bran on the rheological and technological properties of wheat bread. *International Journal of Food Science and Technology*, 50(2), 290-297. https://doi.org/10.1111/ijfs.12619

Dewaest, M., Villemejane, C., Berland, S., Neron, S., Clement, J., Verel, A. and Michon, C. (2018). Effect of crumb cellular structure characterized by image analysis on cake softness. *Journal of Texture Studies*, 49(3), 328-338. https://doi.org/https://doi.org/10.1111/jtxs.12303

Dombrovskaya, Y.P., Derkanosova, A. ., Pushkar, V.V., Manukovskaya, M.V., Klimova, E.A. and Galochkina, N.A. (2021). The use of water-honey extract of hypericum herb to prevent bakery products from “potato disease”. *IOP Conference Series: Earth and Environmental Science*, 640(2), 022044. https://doi.org/10.1088/1755-1315/640/2/022044

Guptai, S. (2023). Global Cake Mix Market Overview. Cake Mix Market Research Report Information By Distribution Channel (Store-Based And Non-Store-Based), By Flavor (Chocolate, Vanilla and Others), By Type (Angel Food Cake, Layer Cake, Flourless or Low-Flour Cake, Chiffon Cake, Cup Cake and Mug Cake), And By Region (North America, Europe, Asia-Pacific, And Rest Of The World) - Market Forecast Till 2032. Retrieved from Market Research Future website: https://www.marketresearchfuture.com/reports/cake-mix-market-2543.

Hafez, A.A. (2012). Physico-Chemical and Sensory Properties of Cakes Supplemented with Different Concentration of Marjoram. *Australian Journal of Basic and Applied Sciences*, 6(13), 463-470, https://doi.org/10.4236/fns.2015.61010.

Hathout, R.A.M. (2021). Chemical, sensory characteristics and texture profile of cupcake enriched with different proportions of Samwah herb (*Cleome droserifolia*). *African Journal of Biological Sciences*, 17(1), 321-332, https://doi.org/10.21608/ajbs.2021.246935.

Ho, L.H., Abdul Aziz, N.A. and Azahari, B. (2013). Physico-chemical characteristics and sensory evaluation of wheat bread partially substituted with banana (*Musa acuminata* × *balbisiana* cv. Awak) pseudo-stem flour. *Food Chemistry*, 139, 532-539. https://doi.org/10.1016/j.foodchem.2013.01.039

Imreova, P., Feruszova, J., Kyzek, S., Bodnarova, K., Zduriencikova, M., Kozics, K., Mucaji, P., Galova, E., Sevcovicova, A., Miadokova, E. and Chalupa, I. (2017). Hyperforin Exhibits Antigenotoxic Activity on Human and Bacterial Cells. *Molecules*, 22(1), 167. https://doi.org/10.3390/molecules22010167

International Organisation for Standardisation [ISO]. (2016). Sensory analysis - Methodology - General guidance for establishing a sensory profile. International Organisation for Standardisation (ISO 13299:2016). Retreived from ISO Website: https://www.iso.org/standard/58042.html.

Jakubczyk, A., Kiersnowska, K., Ömeroğlu, B., Gawlik-Dziki, U., Tutaj, K., Rybczyńska-Tkaczyk, K., Szydłowska-Tutaj, M., Złotek, U. and Baraniak, B. (2021). The Influence of *Hypericum perforatum* L. Addition to Wheat Cookies on Their Antioxidant, Anti-Metabolic Syndrome, and Antimicrobial Properties. *Foods*, 10(6), 1379. https://doi.org/10.3390/foods10061379

Kakouri, E., Trigas, P., Daferera, D., Skotti, E., Tarantilis, P.A. and Kanakis, C. (2023). Chemical Characterization and Antioxidant Activity of Nine *Hypericum* Species from Greece. *Antioxidants*, 12 (4), 899. https://doi.org/10.3390/antiox12040899

Kapoor, S., Chandel, R., Kaur, R., Kumar, S., Kumar, R., Janghu, S., Kaur, A. and Kumar, V. (2023). The flower of *Hypericum perforatum* L.: A traditional source of bioactives for new food and pharmaceutical applications. *Biochemical Systematics and Ecology*, 110, 104702. https://doi.org/https://doi.org/10.1016/j.bse.2023.104702

Khatri, J., Gautam, G., Dhoubhadel, K.M. and Rajbhandari, M. (2023). Phytochemical and Biological Evaluation and Isolation of Quercetin from *Hypericum cordifolium* Flower. *Scientific World*, 16(16), 28-37. https://doi.org/10.3126/sw.v16i16.56765

Kladar, N., Božin, B., Bijelić, K., Bogavac, M., Karaman, M., Srđenović Čonić, B., Rat, M. and

Anačkov, G. (2023). Biological Activity of Genus *Hypericum* Sect. *Hypericum* Species; *H. tetrapterum, H. maculatum* subsp. *immaculatum, H. triquetrifolium*. *Molecules*, 28(17), 6218. https://doi.org/10.3390/molecules28176218

Klemow, K.M., Bartlow, A., Crawford, J., Kocher, N., Shah, J. and Ritsick, M. (2011). Chapter 11 Medical Attributes of St. John's Wort (*Hypericum perforatum*). In Benzie, I.F.F. and Wachtel-Galor, S. (Eds.). Herbal Medicine, Biomolecular and Clinical Aspects. 2nd ed. Boca Raton, USA: CRC Press. https://doi.org/10.1201/b10787

Klingauf, P., Beuerle, T., Mellenthin, A., El-Moghazy, S.A., Boubakir, Z. and Beerhues, L. (2005). Biosynthesis of the hyperforin skeleton in *Hypericum calycinum* cell cultures. *Phytochemistry*, 66(2), 139-145. https://doi.org/10.1016/j.phytochem.2004.11.003

Korus, J., Witczak, M., Ziobro, R. and Juszczak, L. (2017). Hemp (*Cannabis sativa* subsp. *sativa*) flour and protein preparation as natural nutrients and structure forming agents in starch based gluten-free bread. *LWT-Food Science and Technology*, 84, 143-150. https://doi.org/10.1016/j.lwt.2017.05.046

Lafka, T.-I., Lazou, A.E., Sinanoglou, V.J. and Lazos, E.S. (2011). Phenolic and antioxidant potential of olive oil mill wastes. *Food Chemistry*, 125(1), 92-98. https://doi.org/https://doi.org/10.1016/j.foodchem.2010.08.041

Lafka, T.-I., Sinanoglou, V. and Lazos, E.S. (2007). On the extraction and antioxidant activity of phenolic compounds from winery wastes. *Food Chemistry*, 104(3), 1206-1214. https://doi.org/10.1016/j.foodchem.2007.01.068

Lazou, A., Anastasiadis, G., Provata, T., Koliou, Z. and Protonotariou, S. (2023). Utilization of industrial hemp by-product defatted seed flour: effect of its incorporation on the properties and quality characteristics of 'tsoureki', a rich-dough baked Greek product. *Journal of the Science of Food and Agriculture*, 103(8), 3984-3996. https://doi.org/https://doi.org/10.1002/jsfa.12351

Majzoobi, M., Pashangeh, S. and Farahnaky, A. (2013). Effect of Different Particle Sizes and Levels of Wheat Bran on the Physical and Nutritional Quality of Sponge Cake. *International Journal of Food Engineering*, 9(1), 29-38. https://doi.org/https://doi.org/10.1515/ijfe-2012-0160

Makarova, K., Sajkowska-Kozielewicz, J.J., Zawada, K., Olchowik-Grabarek, E., Ciach, M.A., Gogolewski, K., Dobros, N., Ciechowicz, P., Freichels, H. and Gambin, A. (2021). Harvest time affects antioxidant capacity, total polyphenol and flavonoid content of Polish St John's wort's (*Hypericum perforatum* L.) flowers. *Scientific Reports*, 11(1), 3989. https://doi.org/10.1038/s41598-021-83409-4

Market Expertz. (2023). *Hypericum* Perforatum Extract Market Size, Type Analysis, Application Analysis, End-Use, Industry Analysis, Regional Outlook, Competitive Strategies And Forecasts, 2023-2032.. Retrieved from Market Expertz website: https://www.marketexpertz.com/report/hypericum-perforatum-extract-market

Mintel. (2023). Mintel report Global Food and Drink Trends 2023. Retrieved from Mintel Group Ltd. Website: https://mpost.io/wp-content/uploads/MINTEL-Global_Food_and_Drink_Trends-2023.pdf.

Mohagheghzadeh, A., Badr, P., Mohagheghzadeh, A. and Hemmati, S. (2023). *Hypericum perforatum* L. and the Underlying Molecular Mechanisms for Its Choleretic, Cholagogue, and Regenerative Properties. *Pharmaceuticals*, 16(6), 887. https://doi.org/10.3390/ph16060887

Mullaicharam, A.R. and Nirmala, H. (2018). St John's wort (*Hypericum perforatum* L.): A Review of its Chemistry, Pharmacology and Clinical properties. *International Journal of Research In Phytochemical And Pharmacological Sciences*, 1(1), 5-11. https://doi.org/10.33974/ijrpps.v1i1.7

Mustafa, R., He, Y., Shim, Y.Y. and Reaney, M.J.T. (2018). Aquafaba, wastewater from chickpea canning, functions as an egg replacer in sponge cake. *International Journal of Food Science and Technology*, 53(10), 2247-2255. https://doi.org/https://doi.org/10.1111/ijfs.13813

Orčić, D.Z., Mimica-Dukić, N.M., Francišković, M.M., Petrović, S.S. and Jovin, E.Đ. (2011). Antioxidant activity relationship of phenolic compounds in *Hypericum perforatum* L. *Chemistry Central Journal*, 5(1), 34. https://doi.org/10.1186/1752-153x-5-34

Petrusha, O., Daschynska, O. and Shulika, A. (2017). Development of the measurement method of porosity of bakery products by analysis of digital image. *Technology Audit and Production Reserves*, 2, 61-66. https://doi.org/10.15587/2312-8372.2018.129520

Sengera, G.O., Kenanda, E.O. and Onyancha, J.M. (2023). Antibacterial, Antioxidant Potency, and Chemical Composition of Essential Oils from Dried Powdered Leaves and Flowers of *Hypericum revolutum* subsp. *keniense* (Schweinf.). *Evidence-Based Complementary and Alternative Medicine*, 2023, 4125885. https://doi.org/10.1155/2023/4125885

Seo, M.J., Park, J.E. and Jang, M.S. (2010). Optimization of sponge cake added with turmeric (*Curcuma longa* L.) powder using mixture design. *Food Science and Biotechnology*, 19(3), 617-625. https://doi.org/10.1007/s10068-010-0087-x

Setyaningsih, D.N., Fathonah, S., Putri, R.D.A., Auda, A.K. and Solekah, N. (2019). The influence of baking duration on the sensory quality and the nutrient content of mung bean biscuits. *Food Research* 3(6), 777-782. https://doi.org/https://doi.org/10.26656/fr.2017.3(6).089

Sherif, M.M., Elshikh, H.H., Abdel-Aziz, M.M., Elaasser, M.M. and Yosri, M. (2023). *In Vitro* Antibacterial and Phytochemical Screening of *Hypericum perforatum* Extract as Potential Antimicrobial Agents against Multi-Drug-Resistant (MDR) Strains of Clinical Origin. *BioMed Research International*, 2023, 6934398. https://doi.org/10.1155/2023/6934398

Singh, S. (2023). Global Stress relief Supplements Market Overview. Stress Relief Supplements Market Research Report: Information By Source (Ashwagandha, Chamomile, Lavender, Melatonin, Rhodiola, L-theanine and Others), By Form (Capsules and Tablets, Oils, Powder and Others), By Category (Conventional and Organic), By Distribution Channel (Store-Based And Non-Store-Based) And By Region (North America, Europe, Asia-Pacific, And Rest Of The World) - Market Forecast Till 2032. Retrieved from Market Research Future® website: https://www.marketresearchfuture.com/reports/stress-relief-supplements-market-10640

Soares, S., Kohl, S., Thalmann, S., Mateus, N., Meyerhof, W. and De Freitas, V. (2013). Different Phenolic Compounds Activate Distinct Human Bitter Taste Receptors. *Journal of Agricultural and Food Chemistry*, 61(7), 1525-1533. https://doi.org/10.1021/jf304198k

Song, K.Y., O, H., Joung, K.Y., Shin, S.Y. and Kim, Y.S. (2017). Effects of basil (*Ocimum basilicum* L.) seed mucilage substituted for fat source in sponge cake: Physicochemical, structural, and retrogradation properties. *Italian Journal of Food Science*, 29(4), 681-696. https://doi.org/https://doi.org/10.14674/IJFS-784

Sozer, N., Dogan, H. and Kokini, J.L. (2011). Textural Properties and Their Correlation to Cell Structure in Porous Food Materials. *Journal of Agricultural and Food Chemistry*, 59(5), 1498-1507. https://doi.org/10.1021/jf103766x

Verified Market Research. (2022). Global Cakes Market Size By Modes of Availability (Packaged, Unpackaged/Artisanal), By Product Type (Sponge Cakes, Desert Cakes, Cupcakes), By Distribution Channel (Supermarkets, In-store bakeries, Online Stores), By Geographic Scope And Forecast. Retrieved from Verified Market Research website: https://www.verifiedmarketresearch.com/product/cakes-market/

Volkova, A.V., Sysoev, V.N. and Makushin, A.N. (2020). The use of wild medicinal raw materials in food production. *BIO Web Conference*, 17, 00048. https://doi.org/10.1051/bioconf/20201700048

Wu, J.-J., Zhang, J., Xia, C.-Y., Ding, K., Li, X.-X., Pan, X.-G., Xu, J.-K., He, J. and Zhang, W.-K. (2023). Hypericin: A natural anthraquinone as promising therapeutic agent. *Phytomedicine*, 111, 154654. https://doi.org/https://doi.org/10.1016/j.phymed.2023.154654

Xiao, C.-Y., Mu, Q. and Gibbons, S. (2020). The Phytochemistry and Pharmacology of *Hypericum*. In Kinghorn, A.D., Falk, H., Gibbons, S., Kobayashi, J.i., Asakawa, Y. and Liu, J.-K. (Eds.). Progress in the Chemistry of Organic Natural Products. Vol. 112, p. 85-182. Cham, Netherlands: Springer. https://doi.org/10.1007/978-3-030-52966-6_2

Yang, X. and Foegeding, E.A. (2011). The stability and physical properties of egg white and whey protein foams explained based on microstructure and interfacial properties. *Food Hydrocolloids*, 25(7), 1687-1701. https://doi.org/10.1016/j.foodhyd.2011.03.008

Yen, G.C. and Duh, P.D. (1994). Scavenging Effect of Methanolic Extracts of Peanut Hulls on Free-Radical and Active-Oxygen Species. *Journal of Agricultural and Food Chemistry*, 42(3), 629-632. https://doi.org/10.1021/jf00039a005

Zirak, N., Shafiee, M., Soltani, G., Mirzaei, M. and Sahebkar, A. (2019). Hypericum perforatum in the treatment of psychiatric and neurodegenerative disorders: Current evidence and potential mechanisms of action. *Journal of Cellular Physiology*, 234(6), 8496-8508. https://doi.org/https://doi.org/10.1002/jcp.27781

Złotek, U. (2018). Antioxidative, potentially anti-inflammatory, and antidiabetic properties, as well as oxidative stability and acceptability, of cakes supplemented with elicited basil. *Food Chemistry*, 243, 168-174. https://doi.org/10.1016/j.foodchem.2017.09.129

https://doi.org/10.26656/fr.2017.8(6).008