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Development of bakery products with added vegetables. Technological and nutritional approaches

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Abstract

Incorporating spinach into a sweet bakery product may combine colour differentiation with additional micronutrients and dietary fibre, although performance must be verified for the actual formulation and process. This study examines a sweet spinach cake concept and develops a framework for innovation and fortification using a plant ingredient. The approach comprises documentary analysis, verification of primary literature, proposed formulations and a differential nutrient balance based on USDA data. The source presentation provides no ingredient quantities, yields or analytical results; the quantitative formulations and modelled graphs are design proposals rather than experimental findings. Four formulations containing 0, 5, 10 and 15% spinach purée are proposed for a 1,000 g batch, replacing an equal mass of milk. At 15%, the input model estimates increases of 4.02 mg iron, 283.50 µg folate and 3.30 g dietary fibre per batch relative to the control, alongside decreases of 0.435 g protein and 21 mg calcium. Assuming a 90% mass yield, 75% retention of spinach-derived folate and full retention of folate from the displaced milk, the estimated increase is 23.42 µg folate/100 g. The analysis distinguishes fortification potential from baking retention and bioavailability. The process flow identifies control points for purée preparation, batter aeration, baking and cooling. Independent-batch trials assessing colour, texture, nutrients and acceptability are proposed to select a formulation and substantiate any nutrition claims.

Keywords: spinach; cake; food innovation; fortification; folate; dietary fibre; nutrient balance.

Introduction

Incorporating spinach purée into cake aims to differentiate colour and increase the contribution of selected nutrients. Studies on bread and cakes containing spinach powder support feasibility, although inclusion levels and effects depend on the food matrix. Green colour does not quantify folate content or iron absorption. The objective is to relate formulation to processing and nutrient retention while maintaining texture and acceptability. The proposed innovation involves standardising the plant ingredient and jointly assessing nutritional benefits and technological trade-offs.

Materials and methods

The analysis considers four formulations of 1,000 g each. Spinach purée replaces an equal mass of milk. Spinach is weighed after washing and draining, with no water added during puréeing. The composition values underpin the differential nutrient balance. Ingredient quantities are proposed for experimental testing.

Table 1. Proposed ingredient quantities for a 1,000 g batch

Ingredient (g)	V0	V5	V10	V15
Wheat flour	300	300	300	300
Whole egg, without shell	250	250	250	250
Sugar	220	220	220	220
Whole milk	208	158	108	58
Spinach purée	0	50	100	150
Baking powder	12	12	12	12
Vanillin sugar	8	8	8	8
Food flavouring	2	2	2	2
TOTAL	1000	1000	1000	1000

V0: control. V5–V15: 5–15% spinach purée in the batter.

Technological process flow

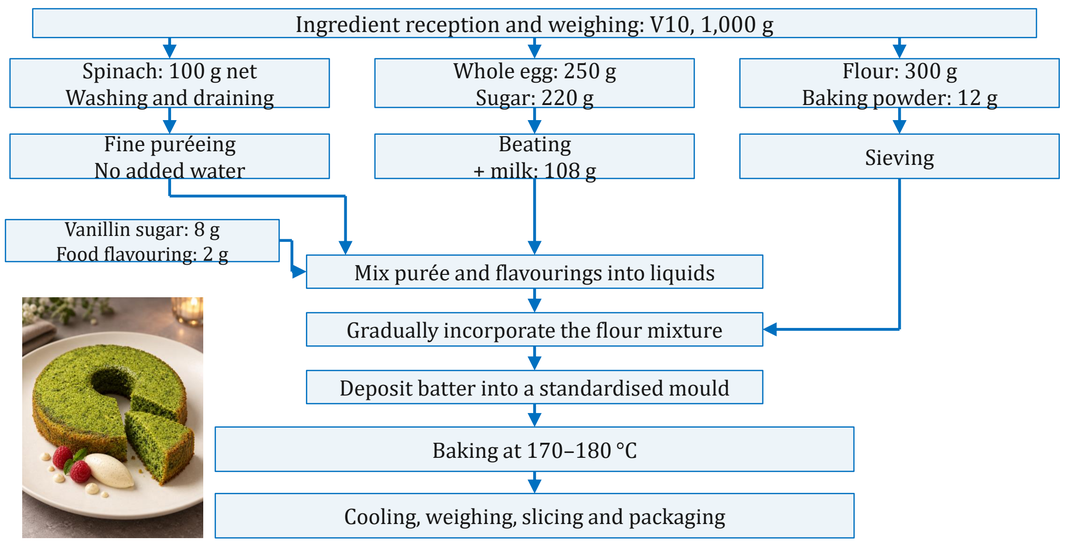


Fig. 1. Proposed process flow diagram.

Results and discussion

When a mass d of milk is replaced with purée, the input increment is $\Delta Q = d(cs - cl)/100$, where cs and cl are the nutrient concentrations per 100 g of ingredient. This linear relationship describes the balance and does not establish product acceptability.

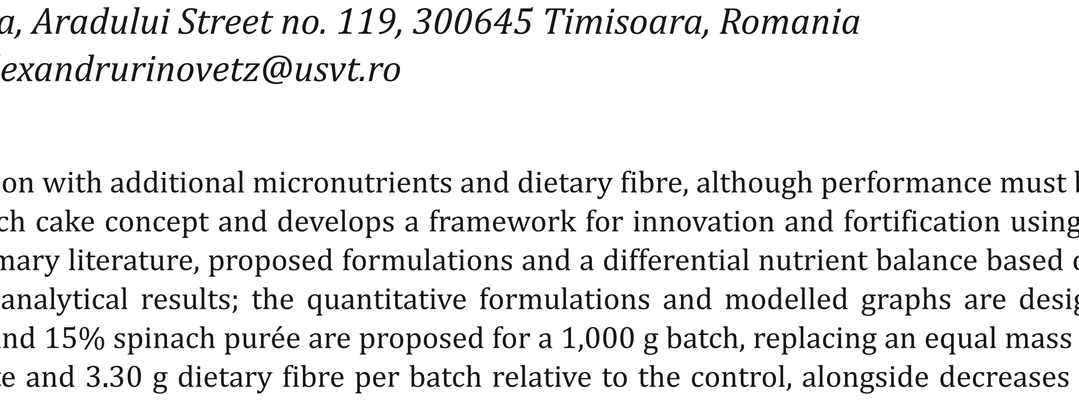


Fig. 2. Estimated changes in iron, folate and dietary fibre before baking, relative to V0.

For V15, estimated increases are 4.02 mg iron, 283.50 µg folate and 3.30 g dietary fibre per batch. However, substitution reduces protein by 0.435 g and calcium by 21 mg per batch. Fortification should be assessed using several indicators and subsequently verified in the finished product.

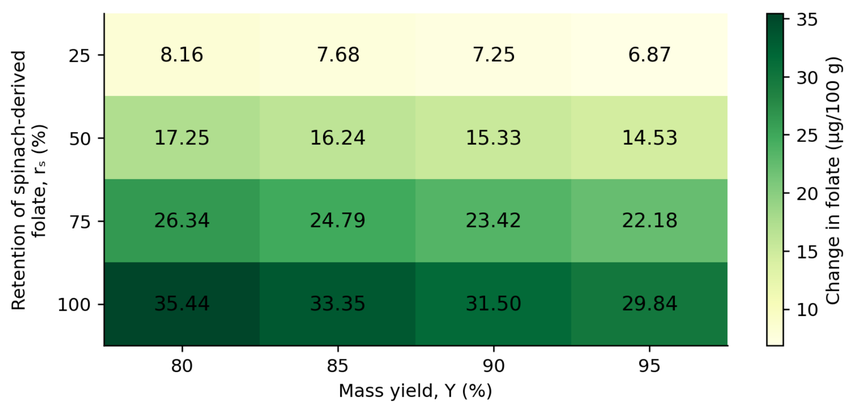


Fig. 3. Estimated folate changes in V15 at different retention levels and mass yields.

At Y = 90%, rs = 75% and rl = 100%, the estimated increase is 23.42 µg folate/100 g. This is a modelled increment, not a measured total content. The model assumes comparable final product masses. Retention must be determined in the actual food matrix.

Conclusions

Spinach purée offers potential for colour innovation and additional nutrient provision. At least three independent batches are proposed, including a control and assessments of mass yield, CIELAB colour, texture, folate and acceptability. Green colour and fortification potential do not establish acceptability, bioavailability or beneficial health effects. Innovation is supported by designing a sustainable product and process. Fortification must be demonstrated quantitatively against a control, distinguishing the ingredient added, the nutrient retained and the biologically available nutrient.

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