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Protein enriched foods and healthy ageing
Effects of protein fortification on muffin characteristics

KEYWORDS: Elderly, protein fortification, muffin, sensory characteristics, acceptance.

Abstract

Sarcopenia is a common problem among elderly. To maintain muscle mass, strength and function adequate dietary protein intake is of importance.
The aim is to enable the development of high-quality fortified foods to improve protein status in elderly. Current study aimed to investigate how sensory and physical characteristics of a popular snack in the form of muffins change when increasing protein content. A reference muffin was compared to muffins fortified with soy flour, almond flour or whey protein, respectively. A focus group evaluated the sensory properties. Physical properties included colour measurement, water activity, weight and heights. All fortifiers affected the muffins differently, sensory as well as physical characteristics, showing the complexity of adding different fortifiers to muffins.

INTRODUCTION

The number of people over 80 years will increase 71% until 2050 (1). By increased age the prevalence of sarcopenia increases. A condition defined by decline in muscle mass, strength and function, caused by age related transformation of body composition with increased body fat and corresponding decline in muscle mass (2, 3).
It may affect the ability to cope with activities of daily living, reducing independence and increasing need for help.
The requirements of dietary protein are therefore higher among older compared to younger adults (4, 5, 6).
Protein fortification of foods may increase the daily dietary intake. However, the level of fortification should not exceed the limit of when characteristics of the original food product alters to a degree not acceptable by the consumer. In Sweden, coffee time is highly appreciated and muffins are the most popular choice among elderly to complement their coffee (personal communication, Christina Karlsson, nutritional manager, ICA, Sweden, 2014).
As a part of a larger project on fortified high quality foods for elderly aiming to improve nutritional status, the objective of this study was to investigate how sensory and physical characteristics of muffins change when adding proteins in the form of almond flour, soy flour or whey protein powder to a basic muffin formula.

MATERIALS AND METHODS

Muffins

A basic muffin formula was developed with the ingredients: 300 g Engelhardt's muffin mix (sugar, wheat flour, whole egg powder, potato starch, baking powder E450 an E500, aromas, NaCl and beta-carotene), 120 g rapeseed oil, 6 g vanilla sugar, 40 g water (20°C), 100 g quark, 45 g sugar and 3 g baking powder. The ingredients were stirred in a KitchenAid® artisan for three minutes at highest speed, thereafter 20 g batter was added to baking forms. The muffins were baked in a convection oven at 175°C for 11 minutes. The protein content of the reference muffin (REF) was 6.4 g protein per 100 g.
The basic formula was used as base when developing muffins with three different fortifiers: almond flour (AFM), soy flour (SFM) and whey protein powder (WPM) and additional water (Table 1). The quantities of the fortifiers and water was chosen in order to give the same protein content per 100 g.
The limiting factor was addition of almond flour which set the amount of protein to 9.4g per 100 g. In addition, one extra whey protein fortified muffin was developed to reach a higher protein content, 14.1g protein per 100 g (WPM14.1).
The protein content per 100 g in almond flour was 21 g, in soy flour 39 g and in whey powder 77 g. The ratio between the fortified product and water was chosen to give a similar batter consistency as the reference. Three batches were baked of each muffin type and then analysed due to sensory and physical characteristics, Figure 1.

Ingredients	REF	AFM	SFM	WPM	WPM14.1
	g (%)	g (%)	g (%)	g (%)	g (%)
Muffin mix	300 (48.9)	300 (35.3)	300 (42.4)	300 (41.2)	300 (34.3)
Rapeseed oil	120 (19.5)	120 (14.1)	120 (16.9)	120 (16.5)	120 (13.7)
Quark	100 (16.3)	100 (11.8)	100 (14.1)	100 (13.7)	100 (11.4)
Sugar	45 (7.3)	45 (5.3)	45 (6.4)	45 (6.2)	45 (5.1)
Vanilla sugar	6 (1.0)	6 (0.7)	6 (0.8)	6 (0.8)	6 (0.7)
Baking powder	3 (0.5)	3 (0.4)	3 (0.4)	3 (0.4)	3 (0.3)
Water	40 (6.5)	90 (10.6)	70 (9.9)	120 (16.5)	200 (22.9)
Fortifier	0 (0.0)	185 (21.8)	64 (9.0)	35 (4.8)	100 (11.4)
Total	**614 (100)**	**849 (100)**	**708 (100)**	**729 (100)**	**874 (100)**

Table 1. Muffin recipes, proportions of ingredients.
REF (reference, 6.1g protein/100g), AMF (almond flour fortified muffin, 9.4g protein/100g), SFM (soy flour fortified muffin, 9.1g protein/100g), WPM (whey protein fortified muffin, 9.1g protein/100g), WPM 14.1 (whey protein fortified muffin, 14.1g protein/100g)

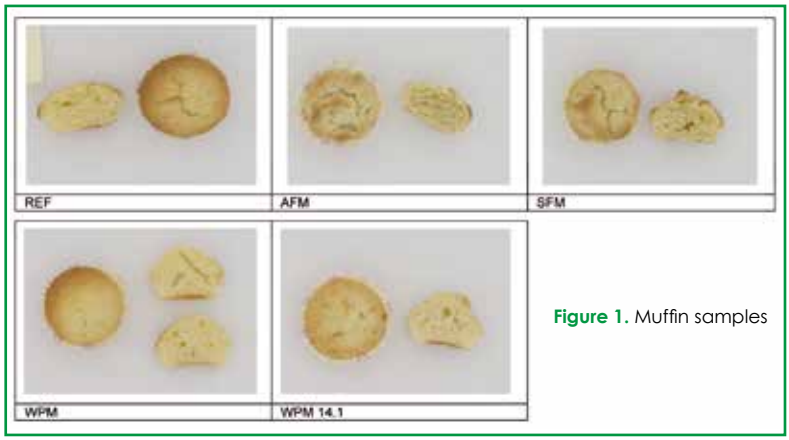

Figure 1. Muffin samples

Sensory Characteristics

Sensory characteristics were discussed in a focus group including seven respondents, five women and two men, 60-69 years old. Each respondent received one each of the 4 muffin types. First the respondents tasted each muffin by their own in order to give verbal comments and to be able to discuss the characteristics based on their individual perception. After approximately 15 min the common discussion began, in which overall impression, appearance, odour, flavour, taste and texture were discussed until consensus was achieved. Also liking was discussed as well as acceptance. The focus group discussion lasted for 75 min and was recorded.

Physical Characteristics

Weight loss was calculated as the percentage difference between batter and final muffin, the weighing was done in triplicates 15 min after removal from oven. Muffin volume was measured by mean height and width in 5 replicates, specific volumes were calculated by division of volume by weight (cm^3/g). Crust colour was measured by L-value (DigiEye, Vervide, Leicester, UK). Three muffins of each type were measured for crust colour, each measurement done twice on each muffin.

The water activity was determined by AquaLab, Decagon Devices, Pullman, USA. The moisture content was determined by weighing samples before and after being placed overnight in vacuum oven (900 mbar, 80°C). Both water activity and moisture content were measured on three muffins of each type, each measurement done twice.

RESULTS AND DISCUSSION

Protein fortification had great impact on muffins' characteristics (Tables 2 and 3). REF was associated to home-baked muffins, while WPMs were considered artificial due to its peaky and glazed surface. AFM was not perceived as a muffin due to texture. SFM was thought to be both taste- and scentless.

Appearance: The WPMs had no cracks in the crust, which was the case in the other muffins. This is in line with earlier results (7). The REF and SFM had similar yellow colour, with darker surface and lighter crumb. WPMs had a slightly lighter yellow colour straight through, while AFM had darker crumb which was considered to be a result of sogginess and high fat content. Crust colour of baked goods are formed by the Maillard reactions, between reducing carbohydrates and free amino acid, eg lysine (8, 9). Except for WPM 14.1 and REF, all muffins had the same protein content but different content of carbohydrates based on the recipes (Table 3). REF had highest carbohydrate content, lowest protein content and was darkest, while WPM 14.1 had the lowest carbohydrate content, highest protein content and lightest crust colour. Light crust colour may be theoretically explained by a lower surface temperature and a higher water content in WPM 14.1. Interestingly, AFM and WPMs have similar L-values regardless of the higher carbohydrate and lysine content of WPMs compared to almond proteins (10, 11). The peaky shape of the WPMs can be understood from the large impact of starch gelatinization, protein denaturation and aggregation (12). Sugar and moisture content is also of importance (10) for the peaky shape.

Sensory Character-istics	REF	AFM	SFM	WPM	WPM14.1
Overall impression	Almost like home-baked	Least muffin like Heavy texture	Rather tasteless	Artificial	Artificial
Appearance Whole muffin	Small cracks Glased Dark yellow Porous	Many cracks Flat Thick and Dry crust	Quite many cracks Quite peaky Thick and Dry crust Dark yellow	Peaky Glased No cracks Golden crust	Very peaky Glased No cracks Light Golden crust
Appearance Sliced muffin	Small air bubbles Light yellow crumb	Doughy No visible air bubbles Compact Yellow-grey crumb	Very doughy No visible air bubbles Compact Light yellow crumb	Large air bubbles Golden crumb	Very large air bubbles Golden crumb
Odour	Lemon Egg			Lemon Egg	Lemon Egg
Flavour	High vanilla Caramel Slight lemon flavour	Nutty Almond Slight vanilla flavour	Low flavour Insipid Some vanilla Slight flavour of beans	Medium vanilla Caramel Off flavours	Medium vanilla Caramed Off flavours
Taste	High sweetness	Sweetness Bitterness	Low sweetness	Sweet Bitterness	Sweet Bitterness
Texture	Crust: Crispy Sticky Crumb: Elastic Very moisty, Sticky Springy	Hard Dry Compact Tough Astringent Chewy Moisty	Crust: Thick, Hard Crumb: Dry, Very rumbly, Compact. Chewy Sticky Astringent	Very dry Hard No crumbs Large gas bubbles Chewy Astringent Very Elastic Springy	Very dry Hard No crumbs Very large gas bubbles Very chewy Astringent Very elastic Springy
Liking	Highest liking	High Liking. For some this was the most liked muffin	Low liking	Medium liking	Medium liking
Acceptance	Highest acceptance	Not acceptable as a muffin	High acceptance	Acceptable	Acceptable

Table 2. Sensory characteristics of muffins collected from the focus group.

Physical Characteristics	REF	AFM	SFM	WPM	WPM14.1
Weight loss (%)	7.9±0.1	6.5±0.6	7.4±0.4	7.6±0.4	8.2±0.3
Volume (cm^3)	58.7±2.0	37.6±2.6	40.6±1.4	46.4±1.8	45.6±2.8
Specific volume (cm^3/g)	3.3±0.2	2.0±0.1	2.3±0.1	2.6±0.1	2.6±0.2
Crust colour as Lightness (L-value)	68.2±19.2	73.7±11.1	71.3±13.6	73.9±14.5	75.1±13.5
Water activity (%)	0.83±0.01	0.88±0.01	0.86±0.01	0.90±0.00	0.93±0.00
Moisture content (%)	18.6±0.4	19.3±0.2	21.9±0.5	27.8±0.6	32.4±0.3
Carbohydrate (g/100g) (Calculated)	51.2	38.5	45.7	43.2	36.6

Table 3. Physical characteristics of muffins given as means and standard deviations.

Odour and Flavour: REF had a slight scent of lemon, even though there was no added lemon flavouring. Overall, REF had the strongest flavours, especially vanilla. This is explained by a dilutive effect of the added fortifiers and water in the other muffins. SFM was perceived as insipid and neutral, with a flavour reminding of beans, probably formed during soybean processing (14).

Taste: Sweetness was perceived in all muffins, highest in REF and lowest in SFM. A lower sweetness in the muffins with added fortifiers could be explained by a dilutive effect and different protein characteristics.
The WPMs were high in bitter taste causing dry mouth and astringency in line with Burrington (2012) who reported an association of whey protein and astringency (10).

Texture: All fortified muffins were considered dry, even though the fortified muffins had higher moisture content and higher water activity than the REF. It can be noted that the muffins with added whey protein were perceived as very dry, which is in accordance with an earlier study showing that whey protein had simultaneously a high water binding capacity, the highest water activity and a large volume (10).

SFM and AFM had thick and hard crusts. The texture differed distinct between crust and crumb. Soy flour addition has been shown to give bread a harder crust and crumb, and a more compact structure (9). Whey proteins have functional properties such as foaming, gelling and water binding capacity (8) which affects texture. In this study the WPMs had the highest springiness, which could also be associated with protein aggregation (15).

Incorporation of gas bubbles in muffins is important for the texture. Stabilization of air bubbles is dependent on fat crystals and egg proteins, together with batter viscosity and emulsification of ingredients (12,13). REF had small air bubbles making it porous, while AFM and SFM contained few air bubbles making them compact. The WPMs had the peakiest shape and largest number and size of air bubbles, giving an aerated structure. Even if WPMs had the smallest proportion of fat, the foaming and emulsifying properties of whey protein allowed an increased stabilization of air bubbles and an aerated structure (8,10).

Liking: Liking was discussed in order to give an indication of this. A reliable measurement of liking demands a larger number of respondents. The majority liked AFM, due to its flavour, although the visual appearance was considered as poor. SFM was not liked due to insipid flavour and non-appealing texture. This is in line with the findings of Sabanis et al. (2009) that soy flour enriched bread has a non-desirable flavour and increased hardness (9). WPMs were neither considered to be tasteful nor bad tasting although the texture was too elastic.

Acceptance: The acceptance was discussed from the perspective of very old people (age 85+) and how they would accept the muffins out of their abilities to taste, chew and swallow. REF was highly accepted since it resembled a traditional muffin. Also SFM was considered to be acceptable out of its compact texture.

CONCLUSION

In general protein fortification caused drier and less sweet muffins, but other characteristics were affected differently. All proteins affected the sensory characteristics negatively in one or several ways, showing the complexity of different types of protein fortifications in a basic muffin formula. Future studies are needed to develop tasty and nutritious foods meeting the requirements of elderly to maintain muscle mass and function.

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About the author

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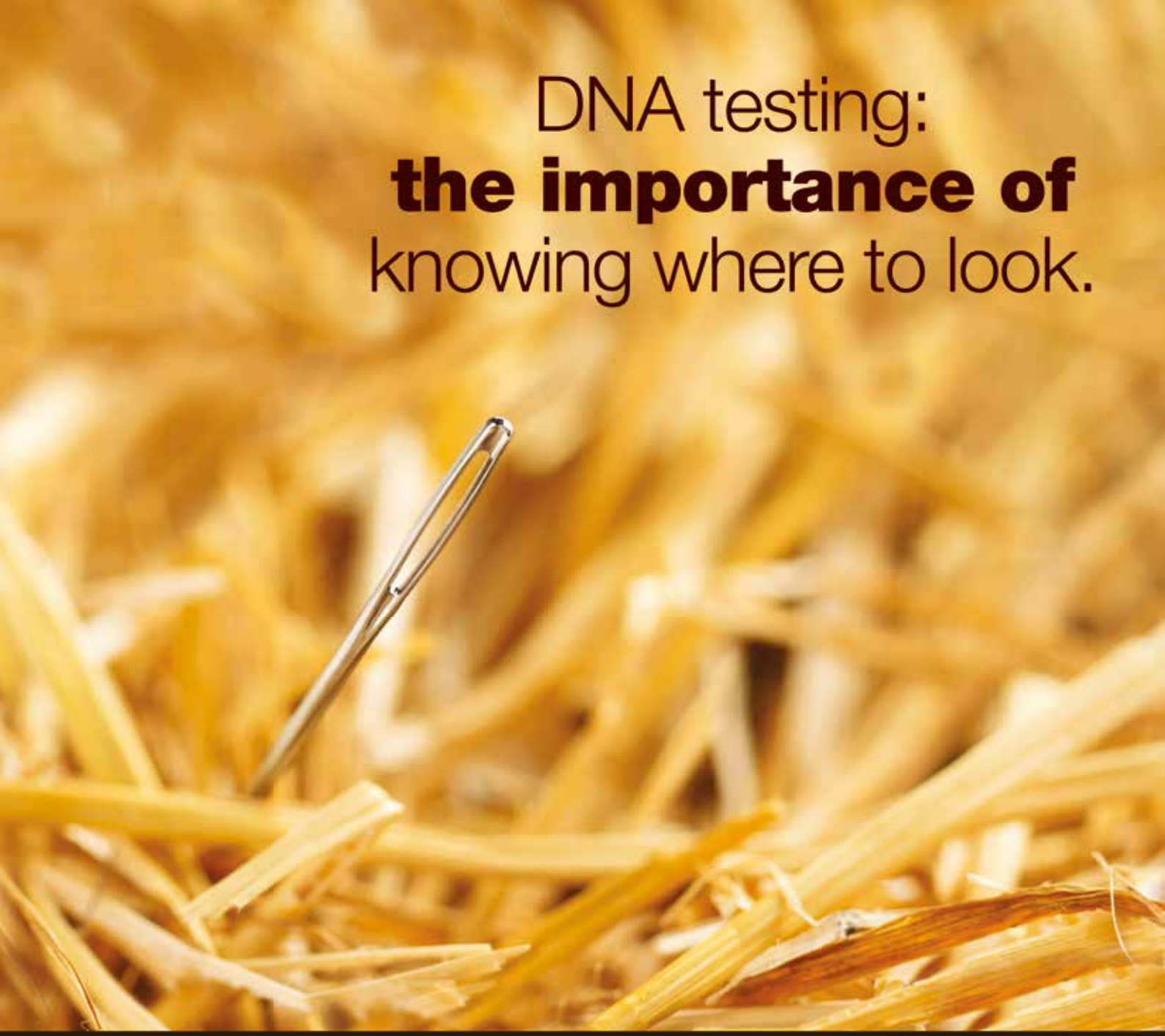

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