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# SENSORY PROFILE AND CONSUMER PREFERENCE OF NOVEL PROBIOTIC YOGHURT ENRICHED WITH ORANGE SWEET POTATO (*Ipomoea batatas*)

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**ABSTRACT**

Due to increased consumer demand for appealing healthy foods, there is a rising global trend of developing nutritious commercial yoghurts with attractive sensory attributes. The success of formulating a food product is dependent not only on improving human health systems but also its palatability. Yoghurts fortified with plant-based foods (fruits and spices) have been acceptable in the market, but there are minimal products with vegetables and root crops such as orange sweet potato. The present study evaluated the sensory profile and consumer preference of novel probiotic yoghurts enriched with pro-vitamin A (beta carotene) rich orange sweet potato (OSP). Milk was fermented using commercial mixed probiotic yoghurt starter cultures [Christian Hansen, Denmark, ABT 12 with *Lactobacillus acidophilus* (LA-5), *Streptococcus thermophilus* (TH-4) and *Bifidobacterium animalis* subsp. *lactis* (BB12)]. The resulting yoghurts were enriched with purees from two different varieties of OSP tubers (Tainung or SPK 004) at 15 and 25 % (w/v) concentrations. Sensory profiling of the formulated yoghurt was conducted using 9 trained panelists at University of Reading, Sensory Science Center, UK. Consumer acceptability of the formulated yoghurts was assessed by scoring questionnaire with 5 modality attributes using 9-point hedonic scale while intent to purchase by 5-point hedonic scale at Karatina community, Kenya. The panelists reported 26 quantitative descriptive sensory attributes significantly different ($p<0.01$) between the fortified yoghurts and control yoghurt (no OSP) with Tainung variety scoring highest in specks, orange colour, powdery appearance, mouthfeel, and after taste (starchy and musty). Consumer preferences records from four different demographic cohort groups ($n=120$) aged 6–65 years and of different socioeconomic status, showed high overall mean liking hedonic scores of 5-8 out of 9.0 for the modalities (appearance, colour, odour, taste and texture) in all the fortified yoghurts, with significant differences ($p<0.05$) between the two varieties and concentration of the OSP purees, but no difference within the cohorts. The purchase intent score varied significantly ($p<0.05$) between both yoghurt samples and the study community cohorts, with Op puree enriched sweetened yoghurts recording the highest value. The study demonstrated that probiotic yoghurts enriched with nutritious OSP purees have unique sensory attributes that are acceptable to consumers but preference differed based on variety of OSP and concentration of the fortifying purees.

**Key words:** Orange sweet potato, Probiotic yoghurt, sensory profile, Consumer acceptability, Fortification

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## INTRODUCTION

Commercial yoghurts produced by fermentation of milk using *Streptococcus thermophillus* and *Lactobacillus delbrukii* subsp. *bulgaricus* as starter cultures have become popular more than any other fermented milk due to their mild acidic taste and aroma [1]. Nevertheless, with growing interest in health promoting foods (functional foods), new ranges of yoghurts fermented with probiotics, live microbes that positively modulate gut microbiota [2] and/or enriched with different natural plant-based ingredients with phytochemical ingredients and varying sensory characteristics of flavour and colour, have gained global popularity. Among the most widely used probiotic microbes with GRAS status are *Lactobacillus* and *Bifidobacterium* species [2, 3]. The symbiotic bacterial fermentations of milk by the yoghurt starter cultures initially favour *Streptococcus* growth, which increases acidity and provides a suitable environment for *Lactobacillus* and *Bifidobacterium* growth by releasing amino acids (valine, leucine, histidine and methionine) from milk protein [4].

The sensory characteristics of yoghurts are influenced by multiple volatile and non-volatile compounds derived from milk, or its fermentation metabolites, and/or added natural /synthetic food additives such as fruits and flavours. Acetaldehyde and lactic acid from bacteria fermentation of milk have been identified as the main flavour (taste and odour) compounds in yoghurt, which also causes the texture to become viscous and gel-like concurrently as the milk protein configuration changes through hydrolysis to amino acids [5]. This leads to the firm, adhesiveness and viscous yoghurt texture that prevent syneresis (whey separation).

Consumer food liking and preference based on sensory attributes, are greatly influenced by their demographic factors and packaging brand/ information on nutrition/health related issues [6, 7, 8, 9]. Despite yoghurts differing in nutritional composition, consumer acceptability based on sensory attributes (sweetness, sourness and texture) which are caused mainly by milk fat, fermentation cultures, processing conditions and added ingredients have been shown to be a predominant determinant factor of preference [10, 11, 12].

Although people often categorise sweet potato, yams, cassava, arrow roots and Irish potato into one category called “potatoes”, orange sweet potatoes (*Ipomoea batatas*: Lam; OSP) are very different in terms of flavour, colour, texture and nutritional composition [13]. Some OSP foods and food products have been developed such as alcoholic beverages, baby foods and bakery [14, 15] but to the best of our knowledge, there are no commercial OSP fortified dairy products. Sensory perception of a food may have little influence on consumer buying power, in developing nations which experience food and nutrition insecurity. Nevertheless, previous studies conducted in Africa using OSP home-prepared foods (such as porridge, crisps and doughnuts), reported differences in level of liking with the pale (cream)-fleshed sweet potato for appearance, taste and texture [16, 17, 18]. Food neophobia, which results from consumers’ reluctance to consume either new/novel or unusual foods, may also be of concern. Nevertheless, previous studies show that this phobia can be overcome by repeated

exposure/consumption and/or giving information on the content and nutritional benefits of the food product [19].

Previous studies during formulation of the novel probiotic yoghurts demonstrated that the nutritious OSP puree in terms of pro-vitamin A and dietary fibre could be fortified in the yoghurts without causing negative physiochemical effect such as syneresis. However, there was need to evaluate consumer perception of the desirable sensory attributes of the yoghurt for determination of acceptability in the market. The present study, therefore, seeks to evaluate the sensory profile attributes of the formulated yoghurts at Sensory Science Centre, UK and consumers' level of preference of a case study at Karatina community in Central Kenya.

## METHODOLOGY

The study was given a favorable opinion to proceed by the University of Reading, UK Ethics committee and the Kenyan Government National Science & Research Council. Sweetened and unsweetened OSP enriched yoghurt samples and controls (no OSP) were freshly prepared under good manufacturing practice (GMP) and labeled using 3-digit random number codes.

### Preparation of OSP enriched probiotic yoghurts

Full fat milk (3.2% fat content) was used to prepare set yoghurts by heating milk at 90–93 °C for 10 minutes before cooling to fermentation temperature of 43 °C. The milk was fermented for 6 hours with a mixed probiotic yoghurt culture (ABT 12; Christian Hansen, Denmark), containing *Lactobacillus acidophilus* LA-5®, *Streptococcus thermophilus* TH-4® and *Bifidobacterium animalis* subsp. *lactis* BB-12®, as recommended by the manufacturer. Two varieties of OFSP tubers, SPK 004 (Rp) and Tainung (Op) sourced from Kenya Agricultural Research Institute, Embu Center, Kenya were used to prepare the purees under good manufacturing practice (GMP). The purees were produced by first cleaning about 500 g tubers, followed by steaming with peels for 30 min till soft. After cooling, tubers were peeled, blended to a puree on addition of 500 mL water and cooled to refrigeration temperature of 4° C. The experimental yoghurts were prepared, by adding to the control yoghurt OSP puree of the two varieties [Tainung (Op) or SPK 004 (Rp)] at different concentrations and subsequently storing under refrigeration at 4 °C. From a previous study, 100ml of yoghurts fortified using two concentrations [15% and 25% (w/v)] provided the recommended dietary allowance of vitamin A [20]. Sweetened yoghurts were prepared by adding the typical level of 5% (w/v) cane sugar before heating the milk to 90 °C.

### Sensory profiling of OSP puree enriched probiotic yoghurts

A trained panel (n=9) at the Sensory Science Centre, University of Reading evaluated 5 sensory modalities (Appearance, Odour, Flavour, Mouthfeel and After effect) using descriptive sensory profiles of the five unsweetened experimental yoghurts [four enriched with 2 varieties of OSP puree, each at 2 concentrations, and a non-enriched control] in three sessions. Yoghurt samples (~ 30–40 ml) served at 4–5 ºC in transparent polystyrene cups were presented in a balanced monadic sequential manner to each panellist in separate sensory booths, under artificial daylight. Water and crackers were

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also provided as palate cleansers. A consensus of 26 sensory attributes vocabulary was agreed upon by the panellists (Table 1). Data were obtained using 150 mm unstructured line scales anchored with terms of low and high intensity at either end and captured using Compusense software (version 5, Ontario, Canada).

**Consumer preference study at Karatina community, Kenya**

An advert of the study seeking to recruit participants was posted at Karatina University notice board whereas relevant Kenya government authorities recommended primary and secondary schools in Karatina Community. Yamane's Formula was used in determination of representative sample of entire diverse population of the study community which is given by the formula:

$$n = N / (1 + Ne^2)$$

Where. n= corrected sample size, N = Community population size, and e = Margin of error (MoE), e = 0.05 based on the research condition.

The calculated representative sample of volunteers (n=120) was subdivided into four equal number of strata (ŋ = 30), which broadly represent the healthy Kenyan population, in terms of age, gender, educational profile and socioeconomic status, with the exception of elderly people (>65 years of age) and young children (< 6 years of age). The 4 groups were as follows:

(i) Primary school pupils; 6–13 years old
(ii) Secondary school students; 14–18 years old
(iii) University staff; 18–65 years old and
(iv) Rural community; 18–65 years old

The recruited volunteers signed consent to participate in the study after screening for health, (smoking and allergies to dairy products) and providing their demographic information. The primary and secondary school students who had to also get consent from parents/guardians did not have to complete the demographic questionnaire form.
The recruited consumers were presented randomly with 30–40 ml (coded with random three-digit numbers) aliquots of six samples of sweetened (as often consumed in the community) and unsweetened yoghurt samples in transparent plastic cups in individual well-lit (daylight), quiet booths. Water and crackers were provided for palate cleansing. Each consumer rated the liking of each yoghurt sample using a nine point hedonic scale categorized from "dislike extremely" at 1 to "like extremely" at 9 for each of five sensory modalities: appearance (A), colour (C), odour (O), taste (S) and texture (T). Translation was provided by a trained member of the research team whenever a volunteer had difficulties in reading/understanding the English language. Data were captured on paper questionnaires.

**Statistical analysis**

Sensory profile data were analysed by SENPAQ (version 3.2, Reading UK) using two-way analysis of variance (ANOVA), where treatment effects (sample and panellist) were tested against interaction and multiple pairwise comparisons done using Tukey's

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Honestly Significant Difference (HSD) test ($p$<0.05). All hedonic data collected from consumer study was analysed with XLStat Addinsoft (version 2012, Paris, France) using two-way ANOVA with treatment effects as cohort and yoghurt sample, followed by multiple pairwise comparisons using Tukey HSD at $p$≤0.05.

## RESULTS AND DISCUSSION

There were noticeable visual differences of orange colour in the 10 samples of fortified probiotic yoghurts of the two varieties of OSP (Tainung & SPK 004) puree at different concentrations (5 – 25% w/v) and control sample (no OSP), but none had syneresis (spontaneous appearance of milk serum separated from curd) (Figure 1).

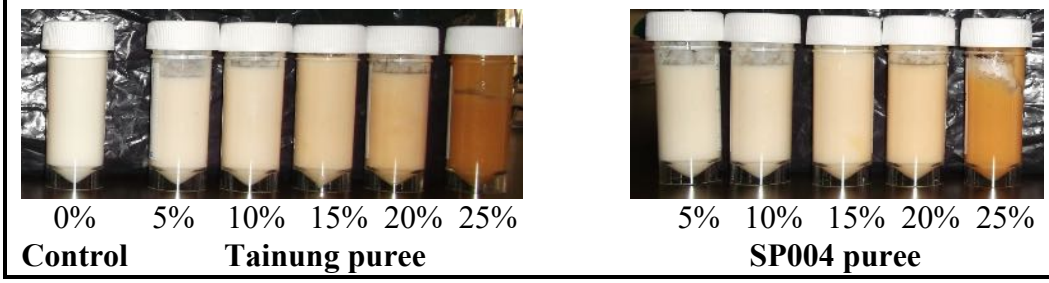


**Figure 1: Samples of different formulated yoghurts with two varieties of OSP (Tainung and SP 004) at different concentrations**

### Descriptive sensory profiling

The sensory panel identified 26 consensus vocabulary attributes (Table 1) that were significantly different ($p$<0.01) between the experimental yoghurts (control and five of the unsweetened yoghurt samples). No significant difference ($p$>0.05) was observed in body appearance; cheesy and creamy odour; creamy flavour; strength of odour & bitterness; or throat catching and bitterness after effect (Table 2). A closely related study on probiotic yoghurt enriched with different prebiotic food ingredients equally reported aroma, taste (sweetness and sourness) and mouthfeel (chalky and viscosity) as significantly different ($p$<0.05) [21]. It is worth noting that control yoghurt (no OSP) recorded the highest score in sour/lactic taste and odour. Sweet taste is known to suppress the perception of sour taste [22]. This may have been the cause of the sweet-type odours in the OSP puree suppressing the perception of sour/lactic in the formulated fortified yoghurts. The yoghurts fortified with Tainung puree (OpY25) recorded higher scores in mouth coating and powdery mouthfeel as well as tongue coating, musty and mouth drying after effect than control yoghurt probably due to the effect of high starch and fiber content in the OSP puree. The musty sensation was noted only as an after effect rather than as a flavor attribute when the product was in the mouth in the OSP yoghurts (OpY not RpY). Musty, defined with descriptors such as earthy and mushroomy; is typically perceived from food with compounds such as chloroanisoles, borneol and ketones or root crops [23]. Nine attributes had distinctive significant differences at $p$<0.001, with Tainung puree enriched yoghurt (OpY25) registered the highest level in all the attributes of appearance except the rate of clearance of mouth feel (Figure 2). These may be attributed to the high amount of orange β-carotene content in that variety of tubers. This

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concurs with a previous study [20] which reported high CIE Hunter's spectrophotometry colour score for a* (red) and b* (yellow) in the yoghurts.

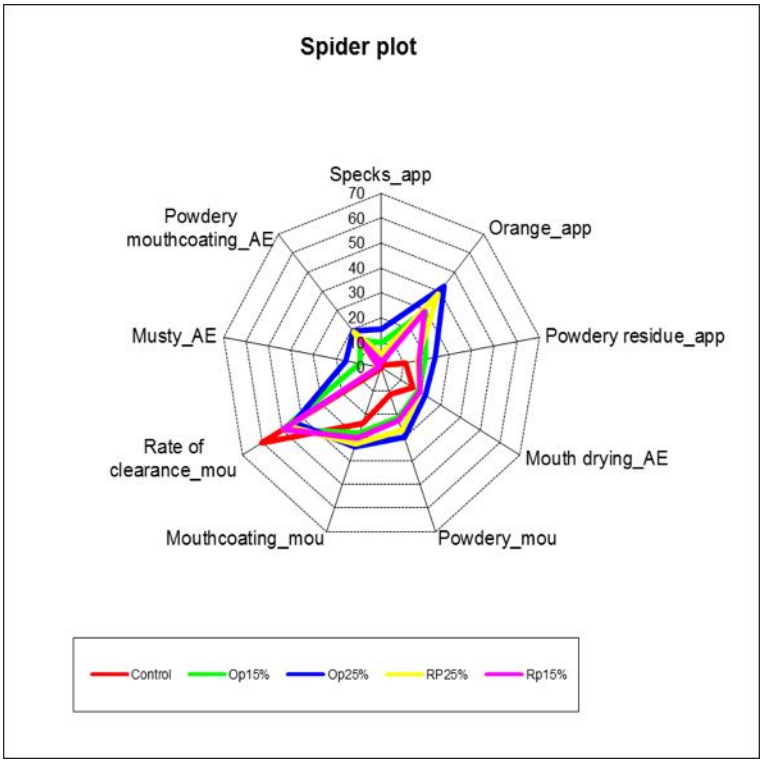


**Figure 2: Star diagram plot of the sensory attributes significantly different at *p*<0.001. Control yoghurt, red and Tainung (Op) and SP 004 (Rp) variety at two concentration (15 and 25 %) ; Op15, green; Op25, blue; Rp15, pink; and Rp25, yellow.( AE- after effect; app- appearance; mou- mouthfeel)**

**Consumer demographic information**

The 120 volunteers who were successfully recruited at Karatina community to participate in the study were equally distributed in the four cohorts (n=30), with almost equal balance of gender, male (49%) and female (51%) (Table 3). The age of participants was skewed according to the cohorts, but well distributed across the whole study population. Almost half (51.6%) were in the lower age category (6–18 years) and the remainder split between young adults, 19–35 years) (35%,) and older adults 36–65 years (13.3%). The socioeconomic status varied as expected, with the university community having the highest level of education, income and skilled workers and the rural community the lowest. However, a larger proportion (56.7%) in the university community were not willing to comment on their income, compared to members of rural community (26.7%). Dairy milk consumption was common in the community. All 60 adults who completed the questionnaire (University staff and rural community members) confirmed weekly consumption of both dairy products and yoghurt, while 10% of rural community cohort never consumed yoghurt. Regular intake (> 6 times a week) in the form of fresh milk was recorded by > 50% of adults, and less regular consumption of yoghurt (most

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commonly 1–2 times a week) by the majority (67–70%) – probably due to lack of refrigerated storage in homes and rural shopping centres.

The findings are closely related to consumption patterns from a previous study of milk and milk products in Eastern Kenya that indicated popularity of fresh milk (99% and 84% in rural and urban households, respectively) over processed fermented milk, with households of higher income and level of education consuming more yoghurts [24]. Studies in Africa based on sweet potato foods eaten at home found that higher consumption was associated with low income households [25, 26]. Hence processing OSP to purees to enrich yoghurts may offer a good strategy to promote its consumption across all socioeconomic groups in Africa as well as adding economic value to both commodities (OSP and milk).

**Consumer acceptability of formulated yoghurts**

Results of participants consumer preference study of the 6 experimental yoghurts, unsweetened and sweetened (control and the two varieties 25% w/v OSP fortified) are presented in Table 4 and Figure 3 and 4. The mean liking scores of all the five modalities (appearance, colour, texture, taste and odour) was high, with significant differences ($p<0.05$) between the 6 yoghurt samples. However, no significant differences in the liking of the modalities attributes were recorded within the cohort groups and no cohort - sample interaction ($p>0.05$) except for the odour liking.

**Figure 3: Pictorial of primary school pupils assessing the experimental yoghurts**

**Appearance:** Appearance is a critical modality that gives the first impression of a food to a consumer. Syneresis is one of the common sensory defects which can make yoghurt less appealing, though none was observed in any of the formulated yoghurts during the study. The mean appearance liking score ranged from 5.5 to 7.5. The differences between yoghurts in liking of appearance did not seem to follow a consistent pattern based on variety of OSP puree. It was interesting to note that Tainung enriched yoghurts had the highest mean liking scores in all the cohort groups despite the sensory panellists reporting more specks, powdery and lumpy appearance from previous results in Table 1.

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**Colour:** Although colour is part of appearance attributes, orange colour is important because it is distinctive to OSP and has been correlated to pro-vitamin A (β-carotene) [18]. The mean liking scores of colour differed significantly ($p$<0.05) between yoghurts, with mean score ranging from 6.1 to 7.7. As expected from the results on sensory profile (Table 2), both the yoghurts enriched with deep orange Tainung puree (OpY25) had the highest score. It is worth noting that there were unexplainable significant differences ($p$<0.05) between liking of colour of sweetened and unsweetened yoghurts (Table 4). On the contrary, the liking of colour of SPK 004 (RpY) enriched yoghurts (with slight orange colour) were not significantly different compared to the control yoghurts (which were relatively white), in sweetened or unsweetened yoghurts. Therefore, it appears like colour was not a major overriding driver of appearance liking of the yoghurts.

**Texture:** Texture has been reported to be critical in determining the quality and consumer preference of yoghurts [12, 27]. There were significant differences ($p$<0.0001) in the liking of texture between yoghurts, with the mean scores ranging from 5.4 to 7.6. The liking of texture of the unsweetened yoghurts were not significantly different from each other (control, OpY25 and RpY25) but were lower than that for the sweetened yoghurts. Tainung sweetened recorded the highest score (7.6). Yoghurts are considered as pseudo-plastic products in terms of flow properties, with several factors, such as dry matter content, starter culture, processing conditions (homogenisation, heat treatment, stirring, cooling and packing) influencing rheological properties [11]. Although the firmness of the texture of OSP puree enriched yoghurts decreased compared to control without puree, this did not seem to influence the level of liking, neither the high powdery mouthfeel nor tongue coating after effect.

**Taste:** There were significant differences ($p$<0.0001) in liking of taste between the formulated yoghurts. Unlike the liking for other sensory modalities, Op unsweetened yoghurt recorded the lowest score (5.0) although it was not significantly different to the score of Rp unsweetened yoghurt (5.3). It is worthwhile noting that liking scores of taste were not significantly different between all sweetened yoghurts, though Op sweetened recorded the highest score (7.7). Sweetening of yoghurts appeared to have suppressed perception of other flavour compounds from OSP, as discussed previously. The higher scores for sweetened yoghurt (compared to unsweetened yoghurts) may also be attributed to the fact that yoghurt in the study community is normally taken sweetened.

**Odour:** Odour was the only sensory modality where liking scores differed significantly between the yoghurts ($p$<0.001). The odour of the sweetened yoghurts were liked more than their corresponding unsweetened yoghurts, with unsweetened control scoring the lowest mean score (5.3) and sweetened OpY the highest (7.5). The odour of the yoghurt is attributed by endogenous metabolites and OSP flavour compounds. As discussed previously in the taste modality, some flavour compounds from fermentation of milk may have been suppressed by adding sugar, while others may have been enhanced and/or new ones created through various interactions with OSP ingredients. Sweetness is known to suppress acidic taste and fermented odours from the yoghurt [22]. This might have led to the higher scores of odour in sweetened yogurts compared to unsweetened yoghurts.

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**Overall liking of yoghurts**

The overall mean liking scores of the 25 % yoghurt, across the modalities showed that all the six yoghurt samples were highly scored with an above average score of (5.8-7.5 ± 1) The large standard deviation value suggests a wide view of acceptability across the consumers (Table 4). Similarly, the overall consumer liking of the yoghurts were significantly different ($p$=0.037) between the different cohorts (Figure 4). However, there was no significant interaction between cohort and yoghurt sample ($p$=0.13). Tainung (Op) puree enriched sweetened yoghurts had the highest score in all four cohorts, with overall mean score of 7.45 ± 0.96; although not significantly different between the 3 sweetened yoghurts. Generally, the unsweetened control yoghurt had the least overall mean score, with Rp puree enriched unsweetened yoghurt scoring the lowest in the rural community.

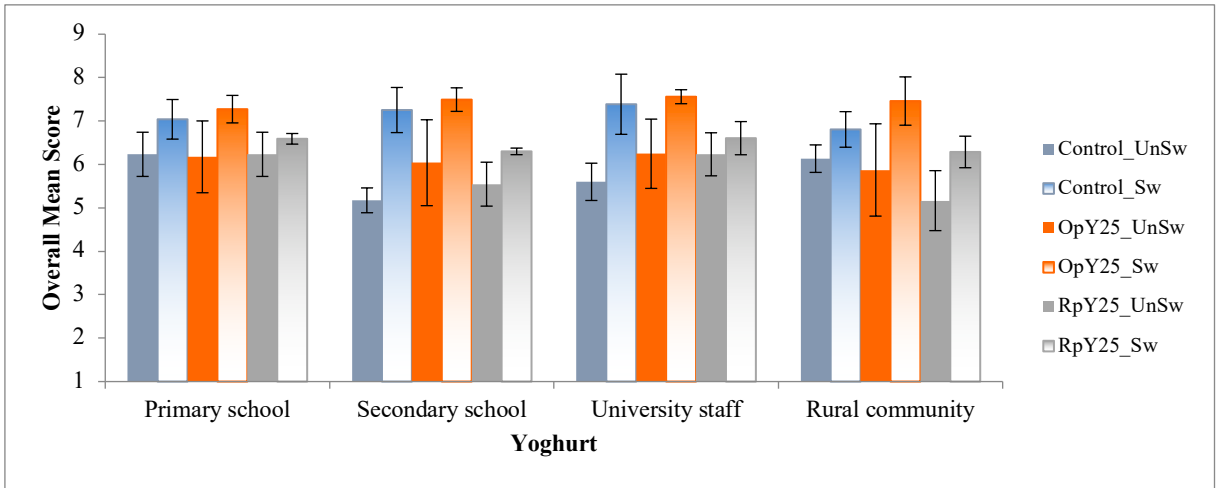


**Figure 4: Overall mean liking scores of the different yoghurts for the four cohort groups. Data are presented as means with SD (error bars). Blue, control; orange, OpY25; grey, RpY25; solid colour bars, unsweetened yoghurt; and graduated/patterned colour bars, sweetened yoghurt**

**Intent to purchase**

The consumers' intent to purchase the six yoghurts differed significantly both between the yoghurt samples and the cohort groups ($p$<0.0001). Table 5 shows the mean score of intent to purchase varying from 4.6 (sweetened Op puree in primary school community) to lowest 2.46 (unsweetened control in secondary school community). Primary school pupils tended to score all the yoghurts highly and rural community members scored the lowest. Significant differences ($p$<0.0001) were recorded between sweetened yoghurts and unsweetened, but not between ($p$< 0.05) within any of the three unsweetened yoghurts. These observations correlate well to the overall liking scores of the yoghurts where the consumers had a high inclination of liking towards sweetened yoghurts.

## CONCLUSION

The sensory attributes profiled varied significantly between the control yoghurt (no enrichment) and the two variety of OSP puree (Tainung and SPK 004) yoghurts fortified at two different concentrations (15% and 25%). Orange colour, powdery taste, specks

and tongue coating after- effect were the prominent differing sensory attributes. Although the demographic data indicated the community did not frequently consume yoghurt, findings show the formulated yoghurts were acceptable with no significant differences within the four cohort groups of different age and socioeconomic status. Food neophobia did not seem to have affected overall liking of yoghurts. Probiotic yoghurt enriched with OSP purees have unique acceptable sensory attributes that be promoted in Karatina community. Further research of consumer acceptability should be escalated in other regions of Kenya in addition to feasibility studies of commercialisation and health impacts to humans.

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**Table 1: The 26 selected sensory attributes vocabulary**

| Sensory modality | Selected sensory attribute |
|---|---|
| Appearance | Specks, Frothiness, orange colour, bubbly and lumpy |
| Odour | Sour/lactic, sweetness and caramel (cooked sugar) |
| Flavour | Sweet, sour/lactic, cheesy (cottage cheese), starchy (raw potato) and caramel (cooked sugar) |
| Mouthfeel | Body, rate of clearance, powdery, salivating, mouth coating, frothy and astringency |
| After effect | Musty, powdery, starchy, tongue coating and mouth drying |

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**Table 2: Sensory attributes which differed significantly between the 5 yoghurts ($p$<0.01-0.001)**

| Attribute | Descriptor (anchors) | Control | OpY15 | OpY25 | RpY15 | RpY25 |
|---|---|---|---|---|---|---|
| **Appearance** | | | | | | |
| Specks | Presence of coloured particles (none-many) | 0.1$^{a}$ | 9.8$^{b}$ | 15.4$^{c}$ | 2.2$^{ae}$ | 5.4$^{e}$ |
| Frothy | Foam on surface (none-lots) | 6.3$^{a}$ | 13.0$^{b}$ | 13.4$^{b}$ | 11.0$^{ab}$ | 12.4$^{b}$ |
| Orange | Depth of orange colour (light – dark) | 1.1$^{a}$ | 29.8$^{b}$ | 42.6$^{c}$ | 29.5$^{b}$ | 38.5$^{c}$ |
| Bubbly | Presence of bubbles (none-many) | 6.5$^{ab}$ | 6.9$^{ab}$ | 7.8$^{a}$ | 4.8$^{b}$ | 6.5$^{ab}$ |
| Powdery residue | Presence of powder, visible in stirring (none-lots) | 10.9$^{a}$ | 19.4$^{bc}$ | 23.8$^{c}$ | 16.9$^{ab}$ | 16.0$^{ab}$ |
| Lumpy | Presence of lumps (none – lots) | 5.2$^{a}$ | 10.6$^{b}$ | 10.3$^{ab}$ | 5.6$^{ab}$ | 7.1$^{ab}$ |
| **Odour** | | | | | | |
| Sour/Lactic | Aromatics associated with lactic acid (not – very) | 30.5$^{a}$ | 23.7$^{b}$ | 24.2$^{b}$ | 27.2$^{ab}$ | 24.0$^{b}$ |
| Sweet | Aromatics associated with candy floss [Furaneol: 4-Hydroxy-2,5-dimethyl-3-furanone] (not - very) | 17.2$^{a}$ | 21.8$^{b}$ | 19.2$^{ab}$ | 21.8$^{b}$ | 22.3$^{b}$ |
| Caramel | Aromatics associated with caramel confectionary (not - very) | 1.6$^{a}$ | 6.0$^{ab}$ | 5.6$^{ab}$ | 5.6$^{ab}$ | 7.8$^{b}$ |
| **Flavour** | | | | | | |
| Sweet | Fundamental taste associated with sucrose (not - very) | 14.6$^{ab}$ | 15.8$^{ab}$ | 13.7$^{a}$ | 18.8$^{bc}$ | 21.6$^{c}$ |
| Sour/lactic | Fundamental taste associated with lactic acid (not - very) | 34.1$^{a}$ | 31.8$^{ab}$ | 27.0$^{bc}$ | 27.3$^{bc}$ | 24.5$^{c}$ |
| Cheesy | Flavour associated with cottage cheese (not - very) | 18.6$^{a}$ | 14.2$^{ab}$ | 13.0$^{ab}$ | 12.1$^{ab}$ | 10.9$^{b}$ |
| Starchy | Flavour associated with raw potato (not - very) | 0.0$^{a}$ | 4.8$^{bc}$ | 6.2$^{c}$ | 0.2$^{a}$ | 2.7$^{ab}$ |
| Caramel | Flavour associated with caramel confectionary (not - very) | 0.1$^{a}$ | 2.2$^{ab}$ | 1.6$^{ab}$ | 2.5$^{ab}$ | 2.8$^{b}$ |
| **Mouthfeel** | | | | | | |
| Body | Perception of thickness (thin - thick) | 37.6$^{a}$ | 42.6$^{ab}$ | 42.7$^{ab}$ | 44.2$^{b}$ | 47.0$^{b}$ |
| Rate of clearance | Speed of clearance from mouth after swallowing (slow - fast) | 60.3$^{a}$ | 49.3$^{b}$ | 43.8$^{b}$ | 49.6$^{b}$ | 46.9$^{b}$ |
| Powdery | Perception of particles in the mouth (none – lots) | 11.5$^{a}$ | 21.6$^{b}$ | 29.7$^{c}$ | 22.6$^{b}$ | 26.7$^{bc}$ |
| Salivating | Causes mouth to salivate (not – very) | 24.0$^{a}$ | 20.8$^{ab}$ | 15.6$^{b}$ | 23.7$^{a}$ | 22.1$^{ab}$ |
| Mouthcoating | Coats the surface of the mouth (not – very) | 23.7$^{a}$ | 28.2$^{ab}$ | 33.9$^{c}$ | 30.1$^{bc}$ | 32.8$^{bc}$ |
| Frothy | Feeling of foam in the mouth (none – lots) | 6.2$^{a}$ | 12.7$^{b}$ | 15.3$^{b}$ | 10.6$^{ab}$ | 13.6$^{b}$ |
| Astringency | Extent to which the mouth feels dry and puckering whilst | 19.3$^{ab}$ | 19.6$^{ab}$ | 20.6$^{a}$ | 18.2$^{ab}$ | 14.6$^{b}$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | product is in the mouth (not - very) | | | | | |
| **After effect** | | | | | | |
| Musty | An earthy flavor left in the mouth after swallowing (not – very) | 0.0[a] | 9.3[b] | 15.7[b] | 1.1[a] | 1.3[a] |
| Powdery | Perception of particles in the mouth after swallowing the product (none – lots) | 7.9[a] | 14.4[b] | 19.2[b] | 14.7[b] | 18.7[b] |
| Starchy | Flavour associated with raw potato, after swallowing (not - very) | 0.0[a] | 2.4[ab] | 5.8[b] | 0.3[a] | 1.0[a] |
| Tongue coating | Tongue feels furry after swallowing (not – very) | 6.4[a] | 9.7[ab] | 17.6[c] | 10.4[ab] | 13.6[bc] |
| Mouth drying | Extent to which the mouth feels dry after swallowing product (not - very) | 16.0[a] | 18.6[ab] | 22.2[b] | 19.5[ab] | 19.4[ab] |

Data are presented as means. Different superscripted letters within the same row indicate significantly ($p < 0.01$)

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**Table 3: Consumers demographic information of the four cohort groups at Karatina community**

| Profile of consumers | School students | | University staff | Rural community |
|---|---|---|---|---|
| | Primary | Secondary | | |
| **Number of consumers** | 30 | 30 | 30 | 30 |
| **Age:** | | | | |
| 6-18 years (51.7%) | 100 | 100 | 0 | 6.7 |
| 19-35 years (35.0%) | 0 | 0 | 73.3 | 66.7 |
| 36-65 years (13.3%) | 0 | 0 | 26.7 | 26.7 |
| **Gender** | | | | |
| Male (49%) | 40 | 67 | 47 | 43 |
| Female (51%) | 60 | 33 | 53 | 57 |
| **Occupation** | | | | |
| Unemployed | N/A | N/A | 0 | 2 |
| Employed: | | | 100 | 98 |
| (i) Health & Nutrition | | | 5.7 | 0 |
| (ii) Self-employed/farmer | | | 0 | 48.0 |
| (iii) Administration/academic | | | 40.0 | 6.7 |
| (iv) Support staff | | | 44.3 | 30.0 |
| (v) Unskilled worker | | | 10.0 | 13.3 |
| **Highest education level** | | | | |
| Primary | 0 | 100 | 10.0 | 16.7 |
| Secondary | | | 6.7 | 36.7 |
| College | | | 83.3 | 46.7 |
| **Mean annual wage** | N/A | N/A | | |
| Below average | | | 3.3 | 16.7 |
| Average | | | 6.7 | 30.0 |
| Above average | | | 33.3 | 26.7 |
| No comment | | | 56.7 | 26.7 |
| **Dairy products consumption, weekly** | N/I | N/I | | |
| 1-2 | | | 16.7 | 20.0 |
| 3-5 | | | 30.0 | 26.7 |
| 6+ | | | 53.3 | 53.3 |
| Never | | | 0 | 0 |
| **Fermented milk consumption, weekly** | N/I | N/I | | |
| 1-2 | | | 50.0 | 40.0 |
| 3-5 | | | 43.3 | 36.7 |
| 6+ | | | 6.7 | 23.3 |
| Never | | | 0 | 0 |
| **Yoghurt consumption, weekly** | N/I | N/I | | |
| 1-2 | | | 67.3 | 70.0 |
| 3-5 | | | 26.7 | 15.0 |
| 6+ | | | 6.0 | 5.0 |
| Never | | | 0 | 10.0 |

(N/A-not applicable and N/I- not included in the questionnaire)

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**Table 4: Consumer liking of specific sensory modalities**

| Yoghurt | Mean liking rating (scale 1–9) | | | | | Overall mean score |
|---|---|---|---|---|---|---|
| | Appearance | Colour | Texture | Taste | Odour | |
| Control_UnSw | $6.2^{ab}$ | $6.2^{a}$ | $5.4^{a}$ | $5.8^{a}$ | $5.3^{a}$ | $5.8 \pm 1.7^{a}$ |
| Control_Sw | $6.4^{bc}$ | $6.7^{bc}$ | $7.4^{b}$ | $7.5^{b}$ | $7.0^{bc}$ | $7.1 \pm 1.4^{bc}$ |
| OpY25_UnSw | $7.2^{bc}$ | $7.1^{bc}$ | $5.4^{a}$ | $4.0^{a}$ | $5.7^{ab}$ | $6.1 \pm 1.4^{a}$ |
| OpY25_Sw | $7.5^{c}$ | $7.7^{c}$ | $7.6^{b}$ | $7.7^{b}$ | $7.5^{c}$ | $7.5 \pm 1.0^{c}$ |
| RpY25_UnSw | $5.5^{a}$ | $6.1^{a}$ | $5.7^{ac}$ | $5.3^{a}$ | $6.3^{b}$ | $5.8 \pm 1.6^{a}$ |
| RpY25_Sw | $6.7^{bc}$ | $6.7^{bc}$ | $6.8^{bc}$ | $7.1^{b}$ | $6.8^{bc}$ | $6.8 \pm 1.5^{b}$ |
| Mean score | 6.6 ± 2.2 | 6.7 ± 2.0 | 6.4 ± 2.4 | 6.4 ± 2.4 | 6.4 ± 2.3 | N/A |
| *p* value | <0.0001 | <0.0001 | <0.0001 | 0.0005 | 0.001 | |

Data are presented as means of consumer liking scores of different sensory modalities and the overall mean score ± SD for each sensory modality. Different superscripted letters in columns indicate significant difference ($p<0.05$). OpY- Tainung, RpY- SP004, UnSw, unsweetened yoghurt; Sw, sweetened yoghurt

**Table: 5: Intent to purchase score (1-5) of different yoghurts in the 4 cohort groups**

| Yoghurt | Mean score | Primary school | Secondary school | University staff | Rural community |
|---|---|---|---|---|---|
| Control, unsweetened | $2.98^{a}$ | $3.60^{b}$ | $2.47^{a}$ | $2.90^{a}$ | $2.97^{a}$ |
| Control, sweetened | $4.22^{b}$ | $4.40^{b}$ | $4.23^{b}$ | $4.37^{b}$ | $3.87^{b}$ |
| Rp puree enriched, unsweetened | $3.12^{a}$ | $3.30^{b}$ | $3.00^{a}$ | $3.37^{a}$ | $2.80^{a}$ |
| Rp puree enriched, sweetened | $3.94^{b}$ | $4.33^{b}$ | $4.13^{b}$ | $3.90^{b}$ | $3.40^{b}$ |
| Op puree enriched, unsweetened | $3.08^{a}$ | $3.47^{b}$ | $3.10^{a}$ | $3.00^{a}$ | $2.73^{a}$ |
| Op puree enriched, sweetened | $4.30^{b}$ | $4.60^{b}$ | $4.33^{b}$ | $4.33^{b}$ | $3.93^{b}$ |

Data present means of purchase score. Different letters in a column indicate significantly different ($p< 0.05$)

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