Liking of health-functional foods containing lupin kernel fibre following repeated consumption in a dietary intervention setting

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Part of this data was presented in the following abstract: Hall, R. S. & Johnson, S. K. Acceptability of foods incorporating lupin kernel fibre after repeated consumption in a dietary setting 2005. Proceedings of the 38th Annual Australian Institute of Food Science and Technology Convention, Sydney, May 2005

Abstract

Liking of a particular food after repeated consumption may be reduced, limiting the effectiveness of health-functional foods requiring on-going consumption to deliver their benefits. This study examined the effect of repeated consumption of foods containing the novel ingredient, Australian sweet lupin (*Lupinus angustifolius*) kernel fibre (LKFibre) on sensory acceptability in the dietary intervention setting. In a single-blind randomised crossover 4 week intervention, participants consumed both control and equivalent LKFibre-containing products daily on separate interventions separated by a 4 week period on habitual diet. Seven products: muesli, bread, muffin, chocolate brownie, chocolate milk drink, pasta and instant mashed potato were assessed twice (days 4 and 18 of intervention), by 38 participants for appearance, texture, flavour and general acceptability using a structured graphic hedonic scale. Overall the results showed there was no reduction (P = 0.594) in general acceptability of LKFibre foods after repeated consumption, suggesting potential for long term consumption. The control food products were however generally preferred (P < 0.001) over the LKFibre foods; the mean difference for general acceptability between being less than 6 % (0.82 cm) of the 15 cm hedonic scale used, suggesting LKF addition did not severely affect product palatability.

Key words: Lupin; Fibre; Acceptability; Functional foods.

Introduction:

Functional foods is one of the most rapidly expanding sectors of the food industry predicted to have a global market value of US$90.5 billion by 2013 (Just-Food, 2008). Functional foods can only achieve their health-enhancing effects if they are regularly consumed as part of the diet. Palatability of these foods is therefore extremely important in determining whether they will be repeatedly consumed and can thus assist in the long term prevention of disease (Drewnowski & Gomez-Carneros, 2000). Cardello and Schultz (2003) highlighted the importance to consumers of palatability of foods even when potential health benefits are apparent. Therefore the incorporation of dietary fibre ingredients into food products is a balance between product acceptability and the dose required for disease risk reduction.

Sensory-specific satiety is relevant to understanding the desire for repeated consumption of functional foods since it describes the decrease in both short-term “liking” and “ wanting” of a food after its consumption compared to that for unconsumed food (Havermans, Janssen, Giesen, Roefs, & Jansen, 2009). In addition, this phenomenon has been suggested to influence consumers’ likelihood of repeat purchase of a food product (Manthey & Vickers, 1996). However the extent of short-term reduction in the acceptability of a food immediately after consumption may not reflect its “desire-to-eat” after repeated long term consumption (Zandstra, deGraaf, Mela, & Van Straveren, 2000b). Studies in both military personnel and refugees in care have provided evidence that lack of variety of foods (monotony) can lead to reduced acceptability of these foods (Kramer, Lesher, & Meiselman, 2001; Meiselman, deGraaf, & Lesher, 2000; Meiselman & Schutz, 2003; Rolls & de Waal, 1985). Even highly palatable food products such as those based on chocolate have been shown to decrease in perceived pleasantness after repeated consumption (Havermans et al., 2009; Hetherington, Pirie, & Nabb, 2002). Importantly however, it has been reported that lesser preferred foods as judged immediately after initial consumption can, after repeated consumption over extended time, become relatively more desirable (Zandstra et al., 2000b). Since it may only represent a momentary or immediate perception, the relevance of initial hedonic judgements, as used commonly by food industry, to long term preference and willingness for repeated consumption is questionable (Lévy & Köster, 1999).

It is generally recognised that dietary fibre intake in most Western countries is less than adequate for prevention of major non-communicable diseases (Marlett, McBurney, & Slavin, 2002). Dietary fibre fortification of food products began in the 1970's, with the fortification of bread products for the weight loss market (Gelroth & Ranhotra, 2001). Food manufacturers have since used a wide variety of dietary fibre ingredients for both technologically and physiologically functional purposes to improve textural properties and provide potential health benefits. Dietary fibres can be used in a range of food matrices such as bakery products, breakfast cereals, pasta and noodles, beverages, meat products and dairy products. There is currently a paucity of data investigating the effect on acceptability of repeated consumption of dietary fibre-enriched food products in the context of the whole diet. Manthey and Vickers (1996), however have suggested that there is no sensory specific satiety associated with consumption of food products containing additional dietary fibre.

Lupin kernel fibre (LKFibre) is a novel legume component with potential as a functional food ingredient demonstrating beneficial effects in human clinical studies on cholesterol (Hall, Johnson, Baxter, & Ball, 2005), insulin response (Johnson, McQuillan, Sin, & Ball, 2003), satiety response and post-meal food intake (Archer, Johnson, Devereux, & Baxter, 2004), bowel function and faecal chemistry (Johnson, Chua, Hall, & Baxter, 2006) and colonic microfloral balance (Smith et al., 2006). LKFibre has demonstrated acceptable palatability in single sample conventional sensory evaluation trials when incorporated into a range of food products, though lower palatability of the LKFibre variant of some food types compared to the control was reported (Clark & Johnson, 2002). Similar acceptable palatability ratings were also found in single-meal feeding trials (Archer et al., 2004; Johnson et al., 2003). However the effect of repeated consumption in a dietary setting on the acceptability of LKF containing foods, particularly in light of previous finding that initially less desired foods can become relatively more desired after repeated consumption (Zandstra et al., 2000b), was unknown and was therefore the aim of this study.

METHOD

Participants

As part of a larger study also investigating the effect of LKFibre on blood lipids, glucose and insulin (Hall et al., 2005), 44 healthy male participants were recruited through newspaper articles, radio announcements, posted notices and direct personal communication in Melbourne, Australia. After giving written informed consent, volunteers were screened for suitability using a health questionnaire. Exclusion criteria were cigarette smoking; an allergy to any food ingredients used in the study or to legumes such as soy and peanuts; a history of gastrointestinal problems, cardiovascular disease or diabetes; and use of medications known to affect lipid and carbohydrate metabolism. Thirty-eight participants completed the study with a mean age of 41 (SEM 2, range 24–64) years and mean body mass index of 26.7 (SEM 0.5, range 20.9–33.5 kg/m^2).

Of the six participants who did not complete the study, two discontinued after 1 wk of the LKFibre diet due to feelings of abdominal bloating, and the remainder left at various stages of the study due to personal reasons. The study was conducted according to the Helsinki Declaration of 1975, as revised in 2000. Deakin University Ethics Committee granted approval for the study.

Procedure and design

A single-blind, randomized, crossover, dietary intervention design in free-living participants was used in this study (Figure 1). The dietary intervention has been described in detail elsewhere (Hall et al., 2005). In brief, it consisted of two semi-controlled diets equal in total energy to each participant’s habitual diet, one a high fibre diet including seven LKFibre-containing experimental foods, and the other a lower fibre control diet of otherwise equivalent nutritional profile but with the seven placebo foods containing no LKFibre. The intervention menu consisted of a 3-day repeating cycle. Participants were block randomized, in groups of four, to one of the diets (LKFibre or control) for a period of 28 d, then returned to their habitual diet for a washout period of a minimum of 28 d before undertaking the alternate 28 d test diet. An equal number of participants (n = 19) completed each diet order.

During each of the two dietary interventions, participants were required to complete a palatability questionnaire twice, once at the beginning of the diet (day 4) and once toward the later part of the diet (day 18). Day 4 represented a time-point where the participants had consumed all of the experimental food products contained within the diet at least once. Day 18 represented when participants had consumed all of the foods at least 6 times. The serving size, serving frequency and serving suggestions for each experimental food is given in Table 1.

Food products

All experimental foods (LKFibre and control) were manufactured by George Weston Foods (Enfield, New South Wales, Australia). The LKFibre was manufactured by Food Science Australia (Werribee, Victoria, Australia) and its composition details are given in Table 2. To establish the maximum incorporation rate of LKFibre for inclusion in the experimental food formulations, a preliminary sensory evaluation panel (n=4) was undertaken (data not presented). The nutrient composition of the final formulations for the experimental foods was directly analysed using standard procedures of the AOAC (AOAC, 2000) and this data is presented in Table 3. All products were used within 3 months of manufacture (as per the manufacturers directions), to reduce the likelihood of any possible deterioration in product quality. The bread, muffin and brownies were received within one day of manufacture and were immediately stored at -18^{o}C until distributed to participants. All other products (muesli, chocolate milk drink powder, pasta and instant mashed potato) were stored in a dry, dark room at approximately 21^{o}C.

Food product serving suggestions

All seven products were delivered to the participants on a weekly basis. The participants were supplied with an extensive list of directions and suggestions for preparing and serving each of the products. It was assumed that participants undertook similar preparation with each product variant (LKFibre and control). The bread, muffin and chocolate brownies were given to the participants frozen and participants were instructed to keep these products in the freezer and to thaw the amounts needed for the following day, overnight in their refrigerator. All other products were provided at room temperature with instructions to keep them in a cool, dark and dry place until consumed. Cooking methods for both pasta and instant mashed potato were provided. Instructions were given to consume the muesli with a prescribed amount of reduced fat milk. The chocolate milk drink was supplied as a dry powder and a mixing “shaker” provided to assist with combining with a suggested amount of reduced fat milk.

Sensory questionnaire

The participants were required to complete the palatability questionnaires on both day 4 and day 18 of each dietary intervention of their current perception of the acceptability of each of the seven food products. Foods were not re-tasted at the time of the completion of questionnaires that were completed retrospectively at participants' homes. Participants were required to rate their current perception of the foods using 15 cm structured graphic hedonic scale (Clark & Johnson, 2002). The left anchor of the graphic scale was marked with 'Extremely unacceptable'. 'Very unacceptable', 'Unacceptable', 'Neither acceptable or not acceptable', 'Acceptable' and 'Very acceptable' were marked at 2.5-cm intervals along the scale. The far right of the scale was marked with 'Extremely acceptable'. The attributes of overall appearance, texture (in the mouth), flavour and general acceptability were evaluated in each study. Participants were instructed to mark the points anywhere along the scale that best fitted their perception of the acceptability of the products. Participants' graphic scale responses were enumerated by manually measuring their marks on the scale in centimetres (to 1 decimal place) from the far-left anchor.

Statistical analysis

All statistical analyses were conducted using SPSS software, Release 11.5 (SPSS Inc, Chicago, IL, USA). Normality of variables was evaluated using Kolmogorov-Smirnov tests and data was assumed to be normal if $P > 0.05$. Data was transformed using Log and Reflect to improve normality prior to the Univariate procedure under General Linear Model to investigate the overall effect of LKFibre incorporation on general acceptability of food products. In this model, overall acceptability scores were the dependent variable; food product (eg. muesli, bread, etc), product variant (LKFibre and control) and time (day 4 and day 18) were fixed factors; and subject ID was a random effect factor. The ANOVA was repeated including one interaction term of variant*time to test for change over time in relative preference for control vs LKFibre foods. $P < 0.05$ was considered significant.

Comparisons within specific food products (between LKFibre and control variants) and same variant (between day 4 and day 18) were analysed using a 2-related samples non-parametric test. Non-parametric tests were used as the palatability data was unacceptably non-normal even after various transformations. Initially, $P < 0.05$ was considered significant, however, in order to attempt to prevent type 1 error due to multiple comparisons, Bonferonni's correction was also used. For each acceptability measure fourteen pair-wise comparisons were made therefore after correction, $P < 0.004$ was considered significant.

Results

Overall effects on general acceptability ratings

The analysis of variance of general acceptability ratings showed a significant effect of food product $F(6,988) = 15.531$; $P < 0.001$, a significantly lower rating at 18 days than 4 $F(1,988) = 9.556$; $P = 0.002$, and a significantly lower rating for LKFibre variants than control $F(1,988) = 13.570$; $P < 0.001$. However, the mean difference for general acceptability between the control and the LKFibre products was small being no more than 6 % (0.82 cm) of the 15 cm hedonic scale, as indicated by the upper bound of the 95% CI (Mean difference = 0.535, 95% CI: 0.249, 0.820). The interaction variant*time was not significant $F(1,988) = 0.285$; $P = 0.59$.

Ratings of Individual food products

The mean acceptability data for individual control and LKFibre food products are presented in Tables 4-7.

Both the LKFibre and control muesli products were rated greater than 10 ('Acceptable' on the graphic scale) for appearance, texture, flavour and general acceptability on both test days (Table 4-7). No significant differences ($P > 0.05$) existed between the two muesli variants at either time point, nor between the two time points.

For all parameters, at both time points, the LKFibre and control breads were rated similarly ($P > 0.05$), and their mean acceptability scores were greater than 10 (Table 4-7). In addition, the appearance of the LKFibre bread (Table 4) was rated lower ($P = 0.010$) on day 18 compared to day 4; however this effect was no longer significant when the Bonferroni corrected alpha level was used.

Both variants of muffin were rated greater than 10 for appearance, texture, flavour and general acceptability on both day 4 and day 18 (Tables 4-7). Comparing the LKFibre muffin with the control, there was a significantly lower appearance on both days (*P* = 0.004, day 4; *P* = 0.002, day 18), that remained significant when the Bonferonni corrected alpha level was used (Table 4). The general acceptability rating of the LKFibre muffin was lower (*P* = 0.021, day 4; *P* = 0.040, day 18) than the control (Table 7), however these differences were no longer significant when the corrected alpha level was used.

Both variants of chocolate brownie were rated greater than 10 for all parameters on both day 4 and day 18 (Table 4-7). The LKFibre chocolate brownie was rated lower than the control for texture on day 18 (*P* = 0.017) (Table 5), and flavour on day 4 (*P* = 0.036) (Table 6). In addition, the flavour rating of the control was lower on day 4 than day 18 (*P* = 0.010) (Table 6). None of these differences, however, remained significant when the corrected alpha level was used.

The control chocolate milk drink acceptability was rated greater than 10 for all parameters on both day 4 and day 18 (Table 4-7). However, the LKFibre variant was rated between 10 (“Acceptable’) and 7.5 (‘Neither acceptable or not acceptable’) for all parameters on both days except appearance (day 4 and day 18) (Table 4) and for flavour (day 4) (Table 6), which were rated greater than 10. The LKFibre chocolate milk drink was rated lower than the control variant for texture on day 4 (*P* = 0.011) (Table 5) and flavour on day 18 (*P* = 0.004) (Table 6). In addition, acceptability of flavour of the LKFibre product was lower on day 18 than day 4 (*P* = 0.027) (Table 6). Only the lower day 18 flavour rating of the LKFibre compared to the control remained significant when the corrected alpha level was used.

The control pasta was rated greater than 10 for appearance (day 4 and 18), texture (day 4 and 18), flavour (day 4) and general acceptability (day 4) (Table 4-7). However, the LKFibre variant was rated less than 10 but greater than 7.5 for all parameters on both days except appearance on day 18 and general acceptability on day 4, which were rated greater than 10 (Tables 4-7). The LKFibre pasta was rated lower than the control for texture on both day 4 (*P* = 0.013) and day 18 (*P* = 0.030) (Table 5). These differences were not significant when the corrected alpha level was used.

Both the LKFibre and control instant mashed potato were rated lower than 10 for all acceptability parameters at both time points except for the control's appearance (day 4), control's texture (day 4) and control's flavour (day 4) (Table 4-7). Acceptability of texture for both variants was rated lower on day 18 than on day 4 (LKFibre variant *P* = 0.037; control variant *P* = 0.040) (Table 5) and flavour acceptability of the control was rated lower on day 18 than it was on day 4 (*P* = 0.007) (Table 6). On day 18, the general acceptability of the LKFibre variant was rated lower than that of the control (*P* = 0.021) (Table 7). None of these differences remained significant when the corrected alpha level was used.

Discussion

Repeated consumption of foods in the present study led to an overall effect of reduced rating for general acceptability concurring with previous findings (Kramer et al., 2001; Meiselman et al., 2000; Meiselman & Schutz, 2003; Rolls & de Waal, 1985; Zandstra, de Graaf, & van Trijp, 2000a), even in highly palatable foods such as chocolate (Hetherington et al., 2002). The results of the ANOVA interaction of variant*time on general acceptability shows that there was no change in the relative preference of the control versus the LKFibre food products with repeated consumption, even though LKFibre foods were overall less preferred than control. In contrast to our finding, Zandstra *et al.* (2000b) have previously shown that in lesser preferred foods, such as reduced salt bread, relative desire to eat can actually increase with repeated exposure.

Hetherington, Pirie and Nabb (1998) suggested that monotony or boredom of food may be influenced by a variety of factors including, duration of exposure, initial acceptability of the food and normal intake of the food item. Kramer *et al.* (2001) suggested that the study of monotony needs to include the notion of choice, since the repetitive serving of the same food with and without choice may be a different phenomena. The current study design failed to fully account for the effect of choice, as would occur in a real-life setting, on acceptability, as the experimental foods were prescribed within the diet.

The results of individual foods in this study indicate the possibility of a monotony effect of reduced acceptability rating for: LKFibre bread (appearance); LKFibre chocolate milk drink (flavour); LKFibre mashed potato (texture); control mashed potato (texture and flavour). In addition a monotony effect of increase acceptability rating was observed for control chocolate brownie (flavour). These findings should be treated with some caution however, since when a Bonferonni's corrected alpha level was used to account for the multiple pair-wise comparisons used, only the monotony effect of the LKFibre chocolate milk drink remained significant.

A possible explanation for these monotony effects is that as well as slightly reducing the acceptability of some foods, addition of LKF may have slightly increased the intensity of the product flavour; more intense favours having previously been reported to demonstrate greater loss of acceptability on repeated consumption (Essed et al., 2006). When food products were compared individually, this study provided some evidence that LKfibre foods demonstrated lower acceptability but greater reductions than control foods in acceptability through a monotony effect. This finding is in contrast to the previously report that less desirable foods may become relatively more desirable after repeated consumption (Zandstra et al., 2000b).

The addition of LKFibre to bread to appears less deleterious to sensory acceptability than the addition of another legume dietary fibre ingredient, namely guar gum for which 5.0g/100g is the upper limit before the product becomes unacceptable (Ellis, Wang, Rayment, Ren, & Ross-Murphy, 2001). Guar gum, due to its viscous soluble nature, may affect the texture of high moisture products such as breads more than of low moisture foods such as biscuits (Ellis et al., 2001). This to some extent concurs with the data of the current study, where LKFibre had a more negative effect on the high moisture chocolate milk drink, instant mashed potato and pasta products. In addition the higher soluble:insoluble dietary fibre ratio of the LKFibre ingredient used in the present study, compared with previously reported (Clark & Johnson, 2002) may have adversely affected texture.

Palatability is increasingly measured in detail in dietary intervention studies to ensure that any clinical advantage offered in consuming the diet is matched by dietary acceptance. Leading examples include Jenkins *et al.* (2002a; 2002b) who included measures of dietary acceptance in order to identify whether their dietary protocols were feasible for the general population. However these measurements were only reported at a fixed point in time and therefore did not consider the effect of repeated consumption.

In conclusion, the present study provides some indication that LKFibre foods are less acceptable, and also more susceptible to reduction in acceptability though monotony effect, than the equivalent control foods. Reformulation of these foods with reduced LKFibre levels is therefore recommended for this fibre source to have potential as an effective health-enhancing ingredient for long-term, repeated consumption.

Acknowledgements

We are grateful to Food Science Australia for manufacturing the LKFibre and to George Weston Foods for manufacturing the experimental food products and conducting microbiological and nutritional analysis of these foods. We thank Madeleine Ball for advice on the dietary design and Damien Jolley for statistical advice. We are indebted to the study participants for their commitment to the study protocol. This research was financially supported by the Grains Research and Development Corporation, the Australian Research Council – Strategic Partnerships with Industry – Research and Training Scheme**,** the Department of Agriculture and Food Western Australia and Deakin University.

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Table 1

LKFibre[1] and control food serving information (based on a 12 MJ diet) during dietary intervention

Product (LKFibre[1] or control variant)	Serving Size (g)	Day 1[2] (Serves)	Day 2[2] (Serves)	Day 3[2] (Serves)	Prescribed Servings (4 days)	Prescribed Servings (18 days)	Serving suggestion
Muesli	60	1	1	1	4	18	Breakfast cereal with milk
Bread	30	4	4	4	16	72	Sandwiches or toast
Muffin	68	-	2	2	4	24	Snack or desert
Chocolate brownie	80	2	1	-	5	18	Snack or desert
Chocolate milk drink	57	1	-	1	3	12	As milk drink
Pasta	100	-	-	1	1	6	In Italian or Asian dishes
Instant mashed potato	35	1	-	-	2	6	Side dish with meat

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]day number in three-day rotating menu of experimental diet (LKFibre or control diet).

Table 2

Composition of LKFibre ingredient used in study

Component	Amount
Energy (kJ/100g)[2]	883
Protein (g/100g)[3]	5.9
Available carbohydrate (g/100g)[3]	<0.1
Total dietary fibre (g/100g)[3]	88.0
Soluble dietary fibre (g/100g)[3]	44.7
Insoluble dietary fibre (g/100g)[3]	43.1
Fat (g/100g)[3]	2.1

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]calculated using Atwater factors and assuming dietary fibre energy is equivalent to 8kJ/g, [3]analyses based on the methods of the AOAC (AOAC, 2000).

Table 3

Composition of experimental foods used in study

Product	Variant	Protein (% as is)	Fat (% as is)	Available Carbohydrates (% as is)	Dietary Fibre (% as is)	Water (% as is)
Muesli	LKFibre[1]	8.3	26.2	44.9	15.5	4.0
	Control	7.9	26.5	54.7	7.8	2.1
Bread	LKFibre[1]	9.6	2.0	38.2	5.6	43.0
	Control	8.1	2.1	49.0	2.4	36.8
Muffin	LKFibre[1]	6.5	6.4	46.2	5.7	33.6
	Control	6.8	6.6	55.7	2.5	26.6
Chocolate brownie	LKFibre[1]	6.1	10.3	46.2	7.1	29.0
	Control	6.5	12.9	48.8	2.7	27.8
Chocolate milk drink powder	LKFibre[1]	17.4	2.0	66.3	10.6	2.6
	Control	16.8	1.7	76.2	0.5	3.5
Pasta (dry)	LKFibre[1]	10.9	1.6	61.9	12.4	12.6
	Control	11.8	1.4	71.6	2.9	11.8
Instant mashed potato (dry)	LKFibre[1]	7.5	9.5	53.1	17.6	6.9
	Control	8.2	11.0	61.2	6.3	8.0

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre.

Table 4

Appearance acceptability of foods with and without LKFibre[1] incorporation after repeated consumption[2]

Product	Variant	Appearance Day 4	Appearance Day 18
Muesli	LKFibre[1]	10.54 (10.40) ± 0.39	10.82 (10.30) ± 0.44
	Control	11.33 (11.80) ± 0.43	11.13 (12.10) ± 0.39
Bread	LKFibre[1]	10.58 (11.50) ± 0.50	10.12 (10.50) ± 0.47[4]
	Control	11.18 (11.80) ± 0.37	10.46 (10.30) ± 0.37
Muffin	LKFibre[1]	10.30 (10.20) ± 0.40	10.22 (10.60) ± 0.37
	Control	11.60 (12.20) ± 0.28[3]	11.25 (10.50) ± 0.32[3]
Chocolate brownie	LKFibre[1]	11.03 (11.30) ± 0.40	10.85 (11.75) ± 0.50
	Control	11.45 (11.85) ± 0.40	11.22 (12.10) ± 0.41
Chocolate milk drink	LKFibre[1]	10.06 (10.35) ± 0.52	10.25 (10.15) ± 0.44
	Control	10.90 (10.50) ± 0.39	10.46 (10.15) ± 0.37
Pasta	LKFibre[1]	9.90 (10.00) ± 0.31	10.48 (10.30) ± 0.36
	Control	10.24 (10.20) ± 0.37	10.06 (10.35) ± 0.39
Instant mashed potato	LKFibre[1]	9.49 (10.00) ± 0.54	9.48 (9.95) ± 0.50
	Control	10.13 (10.20) ± 0.44	9.53 (9.95) ± 0.47

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]Mean (Median) ± SEM; n = 38, [3]control variant of product significantly different ($P < 0.05$) to LKFibre variant on the same day (either day 4 or day 18) (Wilcoxon signed rank test), [4]variant of product is significantly different ($P < 0.05$) to same variant on day 4 (Wilcoxon signed rank test).

Table 5

Texture acceptability of foods with and without LKFibre[1] incorporation after repeated consumption[2]

Product	Variant	Texture Day 4	Texture Day 18
Muesli	LKFibre[1]	10.76 (11.40) ± 0.39	10.65 (10.25) ± 0.44
	Control	11.18 (11.85) ± 0.46	10.84 (11.30) ± 0.43
Bread	LKFibre[1]	10.52 (11.50) ± 0.51	10.62 (11.00) ± 0.49
	Control	11.02 (11.00) ± 0.36	10.37 (10.45) ± 0.40
Muffin	LKFibre[1]	10.63 (10.30) ± 0.38	10.35 (10.25) ± 0.34
	Control	11.26 (11.80) ± 0.29	10.80 (11.20) ± 0.33
Chocolate brownie	LKFibre[1]	10.82 (11.40) ± 0.42	10.85 (11.10) ± 0.45
	Control	11.55 (12.40) ± 0.43	11.28 (12.20) ± 0.39[3]
Chocolate milk drink	LKFibre[1]	9.88 (10.00) ± 0.41	9.65 (10.05) ± 0.47
	Control	11.47 (12.10) ± 0.38[3]	10.59 (10.55) ± 0.42
Pasta	LKFibre[1]	9.64 (10.00) ± 0.46	9.84 (10.10) ± 0.39
	Control	10.64 (11.20) ± 0.32[3]	10.07 (10.25) ± 0.43[3]
Instant mashed potato	LKFibre[1]	9.60 (10.00) ± 0.56	8.96 (10.00) ± 0.56[4]
	Control	10.24 (10.50) ± 0.44	9.33 (9.85) ± 0.54[4]

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]Mean (Median) ± SEM; n = 38, [3]control variant of product significantly different ($P < 0.05$) to LKFibre variant on the same day (either day 4 or day 18) (Wilcoxon signed rank test), [4]variant of product is significantly different ($P < 0.05$) to same variant on day 4 (Wilcoxon signed rank test).

Table 6

Flavour acceptability of foods with and without LKFibre[1] incorporation after repeated consumption[2]

Product	Variant	Flavour Day 4	Flavour Day 18
Muesli	LKFibre[1]	11.26 (12.20) ± 0.42	11.45 (11.90) ± 0.37
	Control	12.00 12.40) ± 0.32	11.85 (12.20) ± 0.29
Bread	LKFibre[1]	10.41 (11.40) ± 0.57	10.25 (11.25) ± 0.58
	Control	11.29 (11.30) ± 0.39	10.56 (10.45) ± 0.39
Muffin	LKFibre[1]	11.25 (11.90) ± 0.37	10.80 (11.05) ± 0.36
	Control	11.72 (12.40) ± 0.28	11.32 (11.85) ± 0.33
Chocolate brownie	LKFibre[1]	11.30 (12.20) ± 0.49	11.05 (11.90) ± 0.51
	Control	12.09 (12.75) ± 0.38[3]	11.46 (12.40) ± 0.41[4]
Chocolate milk drink	LKFibre[1]	10.34 (10.70) ± 0.58	9.64 (10.35) ± 0.53[4]
	Control	11.36 (11.70) ± 0.38	11.22 (11.55) ± 0.36[3]
Pasta	LKFibre[1]	9.89 (10.00) ± 0.44	9.78 (10.10) ± 0.45
	Control	10.44 (10.40) ± 0.41	9.82 (10.25) ± 0.46
Instant mashed potato	LKFibre[1]	9.20 (10.10) ± 0.68	8.94 (10.00) ± 0.60
	Control	10.51 (10.50) ± 0.45	9.38 (10.40) ± 0.57[4]

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]Mean (Median) ± SEM; n = 38, [3]control variant of product significantly different (*P* < 0.05) to LKFibre variant on the same day (either day 4 or day 18) (Wilcoxon signed rank test), [4]variant of product is significantly different (*P* < 0.05) to same variant on day 4 (Wilcoxon signed rank test).

Table 7

General acceptability of foods with and without LKFibre[1] incorporation after repeated consumption[2]

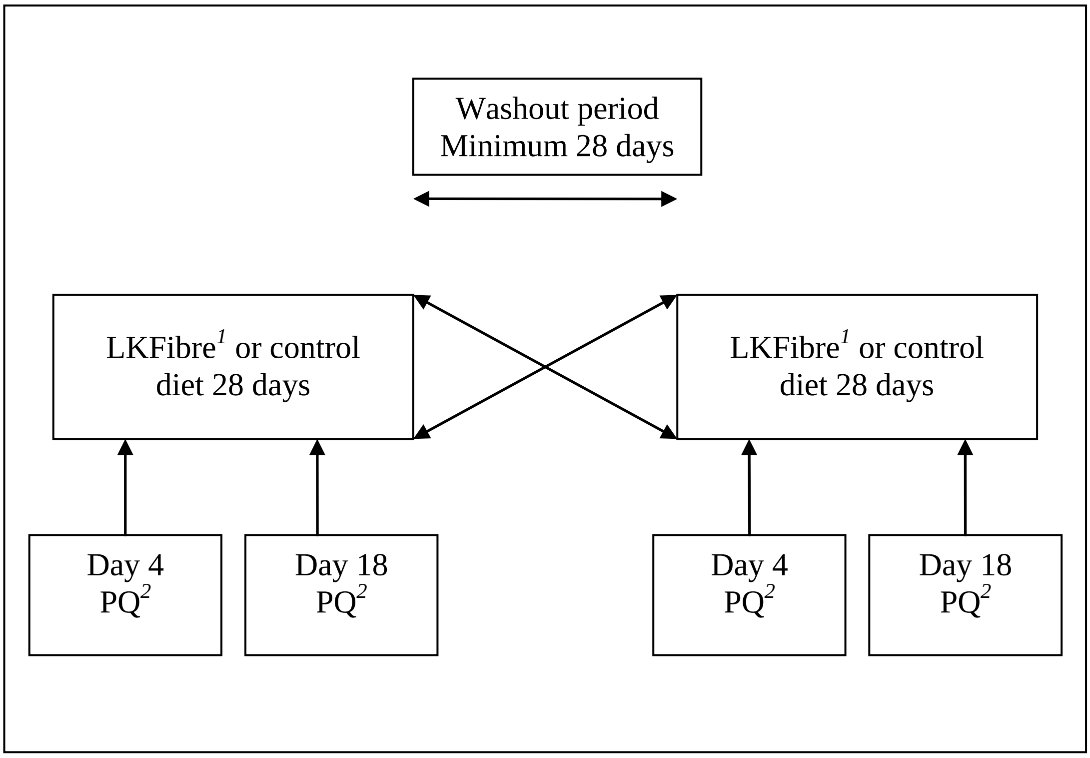
Product	Variant	General acceptability Day 4	General acceptability Day 18
Muesli	LKFibre[1]	11.30 (11.50) ± 0.37	11.04 (11.35) ± 0.45
	Control	11.46 (11.90) ± 0.38	11.18 (11.25) ± 0.39
Bread	LKFibre[1]	10.31 (11.20) ± 0.56	10.46 (10.95) ± 0.52
	Control	11.16 (11.50) ± 0.40	10.39 (10.50) ± 0.46
Muffin	LKFibre[1]	11.01 (11.70) ± 0.37	10.53 (10.25) ± 0.37
	Control	11.63 (11.70) ± 0.29[3]	11.17 (11.85) ± 0.31[3]
Chocolate brownie	LKFibre[1]	11.26 (12.20) ± 0.44	10.75 (10.75) ± 0.52
	Control	11.80 (12.35) ± 0.43	11.42 (12.20) ± 0.42
Chocolate milk drink	LKFibre[1]	9.86 (10.05) ± 0.58	9.73 (10.00) ± 0.55
	Control	11.37 (11.70) ± 0.37	10.70 (11.30) ± 0.43
Pasta	LKFibre[1]	10.05 (10.00) ± 0.42	9.67 (10.00) ± 0.50
	Control	10.30 (10.30) ± 0.37	9.88 (10.40) ± 0.43
Instant mashed potato	LKFibre[1]	9.18 (10.10) ± 0.65	8.59 (9.60) ± 0.63
	Control	9.97 (10.30) ± 0.46	9.25 (10.00) ± 0.58[3]

[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]Mean (Median) ± SEM; n = 38, [3]control variant of product significantly different ($P < 0.05$) to LKFibre variant on the same day (either day 4 or day 18) (Wilcoxon signed rank test), [4]variant of product is significantly different ($P < 0.05$) to same variant on day 4 (Wilcoxon signed rank test).

Figure legend

Fig 1. Schematic diagram of experimental protocol used in study

Fig 1.



[1]Australian sweet lupin (*Lupinus angustifolius*) kernel fibre, [2]palatability questionnaire.