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Effect size measurement in functional milk product marketing

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Summary

The paper presents the application possibility of "Effect size" and Cohen's-d index in the case of introduction of new milk products on the market. The field and online survey were used to establish the potential interest of final consumers for new functional food product of dairy company in Slovenia - milk with phytosterols additives. Two techniques possibilities of Cohen-d index were calculated; manual and using the Cohen's-d calculator. Further, the application is focused on two main questions in survey regarding observed problem: 1) Would you buy milk with phytosterols additives, which scientifically proven lowers concentration of cholesterol in blood? 2) Would you pay for it at a higher price? The sample includes 419 surveys, 150 surveys were conducted on field (control group) and 269 surveys were provided online (experimental group). The Cohen's-d index (d) results show by using manual and Cohen's-d calculator for both groups "small" effect (d=0.35, i.e. d=0.34), and "zero or near zero" effect (d=0.15, i.e.= 0.15) when deciding to buy new milk product.

Key words: effect size, Cohen's-d index, functional food, milk

Introduction

The functional food industry, consisting of food, beverage and supplement sectors, is one of the several areas of the world food industry that is experiencing fast growth in recent years. The tenet "Let food be thy medicine and medicine be thy food," exposed by Hippocrates nearly 2,500 years ago, is receiving renewed interest. In particular, there has been an explosion of consumer interest in the health enhancing role of specific foods or physiologically-active food components, so-called functional foods. Clearly, all foods are functional, as they provide taste, aroma, or nutritive value. Within the last decade, however, the term functional as it applies to food has adopted a different connotation - that of providing an additional physiological benefit beyond that of meeting basic nutritional needs. The term functional foods was firstly introduced in Japan in the mid-1980s and refers to processed foods containing ingredients that aid specific bodily functions in addition to being nutritious (Hasler, 1998).

Functional foods stand for a new category of remarkably promising foods bearing properties (i.e., low cholesterol, antioxidant, anti-aging, anticancer, etc.) that have already rendered them quite appealing. There are many classes of functional foods (pro- and pre-biotics, dietary fibber, low fat, etc.), and their definition is occasionally confused with that of nutraceuticals and novel foods (Arvanitoyannis and Van Houwelingen-Koukaliaroglou, 2005).

Although the vast number of naturally occurring health-enhancing substances are of plant origin, there are a number of physiologically-active components in animal products that deserve attention for their potential role in optimal health. There is no doubt that dairy products are functional foods. They

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are one of the best sources of calcium, an essential nutrient which can prevent osteoporosis and possibly colon cancer. Phytosterols added to low-fat fermented milk may also help lower LDL cholesterol levels. Researchers found that daily consumption of the low-fat milk containing phytosterols was effective in reducing LDL levels by 8 % after six weeks (Hansel et al., 2007).

One of Slovene dairy companies, decided to launch new product on Slovenian market, namely milk with phytosterol additives. After examination of similar products presence on the market, it was found that such form of functional dairy product is not yet present on Slovene market, but pallet of different fermented yoghurts with functional additives, including additive of phytosterols, exist. Also many forms of functional milk can be found on Slovene shelves (by addition of coenzyme Q10, calcium supplement, omega 3 supplement ingredients, etc). In neighbouring markets, majority of similar products often appear in the form of hundred-gram of fermented yoghurt, containing such quantity of phytosteroles in order to satisfy the need of daily intake (Hari, 2009). Further, Hari (2009) conducted a consumer random sample survey about milk, and especially about their potential interest for milk with phytosterol additives. It should be pointed out, that the term "functional food" is not recognised well among interviewed consumers - only 20 % of consumers know its meaning, whilst knowledge of the concept depends on the age and education level (based on the results of chi2 test).

Consumers' main scepticism regarding functional foods resides in the veracity of health claims and in the low and often inadequate control of their claimed properties. Moreover, the labelling of functional foods is far from informative, providing scanty information about nutritional value, storage, and cooking recipes. It is anticipated that technological advances in the food industry, in conjunction with extensive clinical trials and governmental control, will eventually guarantee the credibility of health claims and ensure consumers' confidence in functional foods (Arvanitoyannis and Van Houwelingen-Koukaliaroglou, 2005). In this light, there is a question which appropriate methodological approach could be used to tackle this problem. Standardized measures of effect size, such as Cohen's-d, are not yet commonly used in ecological and agricultural studies, although they are becoming increasingly popular (Garamszegi, 2006), largely because they can be compared between studies. "Effect size" is simply a way of quantifying the size of the difference between two analysed groups. It is particularly valuable for quantifying the effectiveness of a particular intervention, relative to some comparison. By placing the emphasis on the most important aspect of an intervention - the size of the effect - rather than its statistical significance (which conflates effect size and sample size), it promotes a more scientific approach to the accumulation of knowledge (Coe, 2002). For these reasons, effect size is an important tool in reporting and interpreting effectiveness. The routine use of effect sizes, however, has generally been limited to meta-analysis - for combining and comparing estimates from different studies: most in educational (Keselman et al., 1998), psychological (Huberty, 2002; Wilkinson et al., 1999) and medicinal researches (Miller et al., 2011; Ferguson, 2009) and ecological studies (Blanar et al., 2009). However, the application of the "Effect size" concept in agri-food research field is a rather challenging issue. Due to this fact, two surveys types (i.e. control and experimental group) and their results are presented and expressed by Cohen-d index here to conduct the effect size measurement. On this basis, the calculation of Cohen's-d index in the case of introduction of a new dairy product on the market was justified.

Methodology

Whereas statistical tests of significance tell us the likelihood that experimental results differ from chance expectations, effect-size measurements tell us the relative magnitude of the experimental treatment. They tell us the size of the experimental effect. Effect sizes are especially important because they allow us to compare the magnitude of experimental treatments from one experiment to another. Although some improvements can be used to compare experimental treatments to control treatments, such calculations are often difficult to interpret and are almost always impossible to use in fair comparisons across experimental paradigms (Thalheimer and Cook, 2002).

"Effect size" is a measure of the difference between two groups - an experimental or treated group, and an untreated control - divided by the pooled standard deviation (S.D.). Effect sizes are commonly used in meta-analysis because they provide a standardized measure of the impact/effectiveness of a given treatment that is independent of sample size. They are also easy to interpret: for instance, Cohen's d is a common estimator of effect size that is roughly equivalent to the Z-score of a standard normal distribution, meaning that an effect size of 0.8 indicates that the mean response of the treatment group is 0.8 S.D. different from that of the control group (Cohen, 1969, 1994; Cohen et al., 1982).

With respect to available data Cohen's d index can be calculated as:

$$d = \frac{\overline{X}_t - \overline{X}_c}{S_{pooled}} \quad (1)$$

or

$$d = \frac{\overline{X}_t - \overline{X}_c}{\sqrt{\frac{(n_t - 1)*\left(SE_t\sqrt{n_t}\right)^2 + (n_c - 1)*\left(SE_c\sqrt{n_c}\right)^2}{n_t + n_c}}} \quad (2)$$

Where:

d = Cohen's d effect size

X = average mean (average mean of treated - X_t or comparison - X_c conditions)

n = number of treated - n_t or comparison - n_c subjects

$$S_{pooled} = \sqrt{\frac{(n_t - 1) * S_t^2 + (n_c - 1) * S_c^2}{n_t + n_c}} \quad (3)$$

Where:

S_{pooled} = standard deviation

S = standard deviation for treated - S_t or comparison - S_c subjects

"Effect size" was calculated using Cohen's d index using the difference between treated - X_t and comparison - X_c group, divided by the pooled standard deviation. In first phase the assessment was provided in Microsoft Excel spread sheet. Further, the analysis was provided with the same input data also online "Effect size calculator" (http://en.wikiversity.org/wiki/Cohen%27s_d). The differences between manual and online Cohen's-d index calculation were compared and discussed.

Results and discussion

Effect size is a statistical concept which measures the strength of the relationship between two variables expressed by a numeric scale. In this paper the method application is focused on two main questions in survey regarding the problem observed. The first question was: Would you buy milk with phytosterols additives, which scientifically proved lowers concentration of cholesterol in blood?; and the second one was: Would you pay for it at a higher price? The random sample includes 419 surveys, 150 surveys are field surveys, which represent control group and 269 surveys were provided online, e.g., experimental group.

Table 1 and 2 present the calculated parameters needed for Cohen's-d index assessments using Microsoft Excel spread sheet environment. The statistical parameters are based on their definitions and Cohen's-d index is based on the definition of mathematical relationships between input parameters (i.e. survey data). All iterations are calculated for heterogeneous sample groups.

As presented in Table 1, the average mean of online survey (i.e. treated - X_t group) is calculated (X_t = 1.87) and field survey (i.e. comparison - X_c group) is calculated (X_c = 1.57). The calculated standard deviation is, regarding the group size, higher in online survey, where more consumers expressed their willingness to buy milk with phytosterols additives.

Calculated statistical parameters for the second question are presented in table 2. The value of X_t and X_c present beside the standard deviations (S_t and S_c) one of main input data for further assessments using Cohen's-d calculator (Tables 1 and 2). The analysis shows that clear empirical differences arise in the effect size for both questions under scrutiny (Table 3, Figures 1 and 2). As expected, ranking of the manual Cohen's d index calculation results and Cohen's - d calculator results are equal.

As gleaned from Table 3 and Figure 1, there exist some minor differences between both calculation techniques of Cohen's-d index. It is presumed that the differences are caused by number rounding up process (Cohen's d index = 0.34 vs. 0.35).

Table 1. Calculation of statistical parameters for the first question being analysed

Would you buy milk with phytosterols additives, which scientifically proved lowers concentration of cholesterol in blood? (online survey)

Answer	Class (x)	Frequency (f)	f (%)
Yes	1	128	48.85
No	2	39	14.89
I don't know	3	95	36.26
Total (N_t)		**262**	**100**
$\mathbf{X_t = 1.87}$	$\mathbf{S_t = 0.91}$		

Would you buy milk with phytosterols additives, which scientifically proved lowers concentration of cholesterol in blood? (field survey)

Answer	Class (x)	Frequency (f)	f (%)
Yes	1	99	66.00
No	2	17	11.33
I don't know	3	34	22.67
Total (N_t)		**150**	**100**
$\mathbf{X_c = 1.57}$	$\mathbf{S_c = 0.84}$		

Table 2. Calculation of statistical parameters for the second question being scrutinised

Would you pay it for a higher price? (online survey)

Answer	Class (x)	Frequency (f)	f (%)
Yes	1	62	23.57
No	2	66	25.10
I don't know	3	135	51.33
Total (N_t)		**263**	**100**
$\mathbf{X_t = 2.28}$	$\mathbf{S_t = 0.82}$		

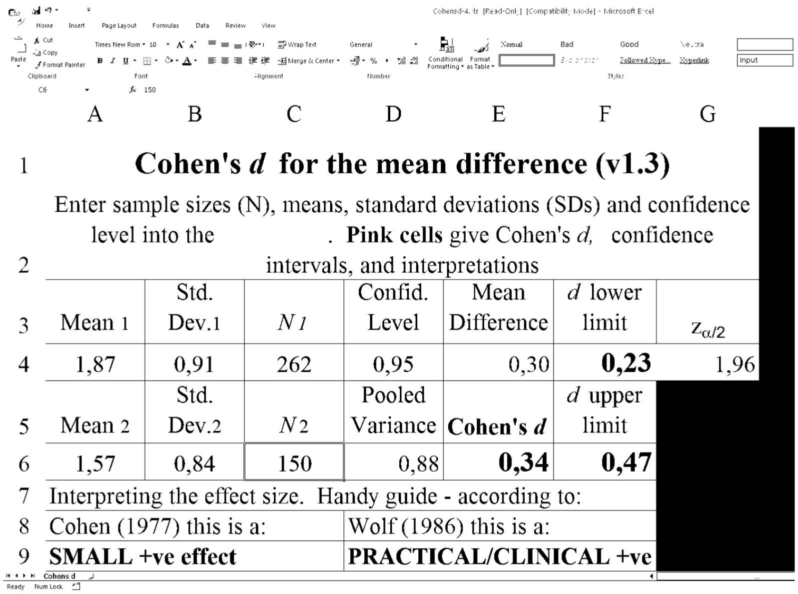
Would you pay it for a higher price? (filed survey)

Answer	Class (x)	Frequency (f)	f (%)
Yes	1	51	34.00
No	2	26	17.33
I don't know	3	73	48.67
Total (N_t)		**150**	**100**
$\mathbf{X_c = 2.15}$	$\mathbf{S_c = 0.90}$		

Table 3. Results of manual Cohen's d index calculation

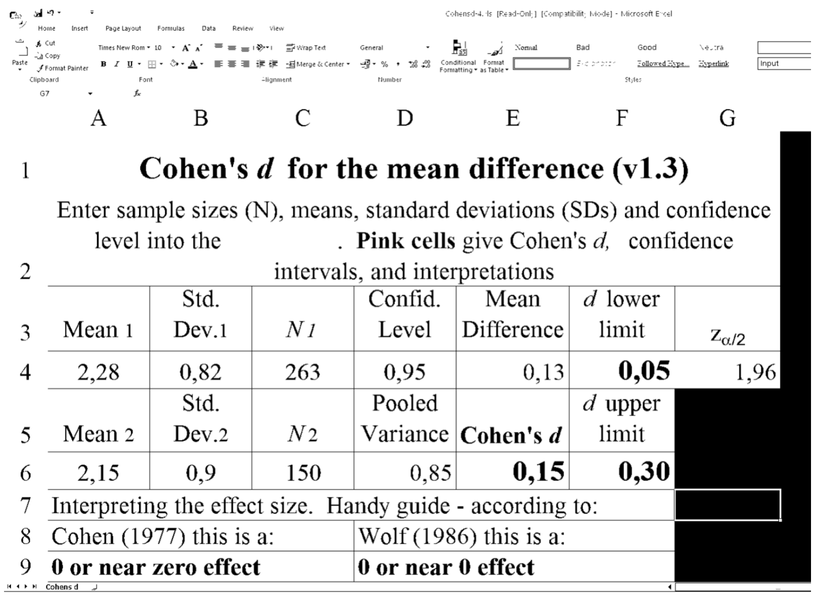
Question	S_{pooled}	Cohen's d index*
1. Would you buy milk with phytosterols additives, which scientifically proved lowers concentration of cholesterol in blood?	0.88	0.35
2. Would you pay it for a higher price?	0.85	0.15

*The results were calculated using Microsoft Excel spread sheet



	A	B	C	D	E	F	G
1	**Cohen's *d* for the mean difference (v1.3)**						
2	Enter sample sizes (N), means, standard deviations (SDs) and confidence level into the . **Pink cells** give Cohen's *d*, confidence intervals, and interpretations						
3	Mean 1	Std. Dev.1	*N1*	Confid. Level	Mean Difference	*d* lower limit	$z_{\alpha/2}$
4	1,87	0,91	262	0,95	0,30	**0,23**	1,96
5	Mean 2	Std. Dev.2	*N2*	Pooled Variance	**Cohen's *d***	*d* upper limit	
6	1,57	0,84	150	0,88	**0,34**	**0,47**	
7	Interpreting the effect size. Handy guide - according to:						
8	Cohen (1977) this is a:			Wolf (1986) this is a:			
9	**SMALL +ve effect**			**PRACTICAL/CLINICAL +ve**			

Figure 1. Cohen's-d calculator results for the first question being analysed



	A	B	C	D	E	F	G
1	**Cohen's *d* for the mean difference (v1.3)**						
2	Enter sample sizes (N), means, standard deviations (SDs) and confidence level into the . **Pink cells** give Cohen's *d*, confidence intervals, and interpretations						
3	Mean 1	Std. Dev.1	*N1*	Confid. Level	Mean Difference	*d* lower limit	$z_{\alpha/2}$
4	2,28	0,82	263	0,95	0,13	**0,05**	1,96
5	Mean 2	Std. Dev.2	*N2*	Pooled Variance	**Cohen's *d***	*d* upper limit	
6	2,15	0,9	150	0,85	**0,15**	**0,30**	
7	Interpreting the effect size. Handy guide - according to:						
8	Cohen (1977) this is a:			Wolf (1986) this is a:			
9	**0 or near zero effect**			**0 or near 0 effect**			

Figure 2. Cohen's-d calculator results for the second question being analysed

As seen in Figure 2 detailed calculator results for the second survey question are demonstrated. Considering the 5 % risk, the Cohen's-d index reaches the value 0.15. The calculated value of standard deviation (S_{pooled}) results appears in the case of both questions with the equal value as by manual calculating.

Effect size calculation among two survey types ranged from 0.35 to 0.15. Based on both analysed groups effect sizes of expressed willingness to buy milk with additives tend to be stronger (regarding Cohen (1977) defines as "small effect") than the stated willingness to buy the same milk by higher price (regarding Cohen (1977) defines as "zero or near zero effect"). The obtained empirical results provide very suitable information for the company decision management when deciding to introduce new milk products on the market.

By interpreting "Effect size" results, a certain question may arise "How big is big?". Rosenthal and Rubin (1982) emphasize that there are no simple answers also to the second question: "How large should an Effect size be?". The proper question should rather be instead: "For what purpose?". Stemming from the empirical evidence derived here, the answer on all questions does not solely depend on statistical considerations, but also on the utility, impact, costs and benefits incurred for the decision management in functional milk product marketing.

Empirical results obtained here also point at another important information; in contrast to manual results calculation, using a special programs with programming functions and in- and/or out-put mathematical functions, specially developed and specific problem solving destined support tools (in presented case applied Cohen's-d calculator) are user friendly tool of quick results calculation, where the user does not have to need a necessary computer programming knowledge and skills.

Conclusion

The "Effect size" is a relatively simple way of empirical evaluation for difference between two groups that has many advantages over the use of tests of statistical significance alone. "Effect size" indicates and emphasizes the size of the difference rather than confounding this with sample size. More generally, accounting for Cohen's d index in the computation of effect sizes is important in non-education and non-medical settings as well. The agri-food sector is a typical case where this methodology could be applied. The "Effect size" could be presented as a useful supplement to statistical significance testing, especially by measuring the standardized differences between the means. Moreover, "Effect sizes" with confidence intervals may be calculated elsewhere in empirical work (i.e., meta-analyses), which is a challenge for further research. In doing so, a special importance shall be given to detailed ranking of "small effect" - in particular, answering the key question: is "small effect" for users important or not?

Mjerenje veličine učinka pri proizvodnji funkcionalnog mlijeka

Sažetak

U ovom radu prikazan je primjer mogućosti primjene "Utjecaja veličine" i Cohen-d indeksa u slučaju plasiranja novog mliječnog proizvoda na tržište. Terenska i *online* anketa korištene su za ocjenjivanje potencijalnog interesa potrošača za kupnju novog, funkcionalnog mliječnog proizvoda u Sloveniji - mlijeko s aditivom fitosterolom. Korišten je izračun za dvije vrste Cohen-d indeksa, ručno i pomoću Cohen's-d kalkulatora na primjeru dvaju glavnih pitanja: 1) Zainteresirani ste za kupnju mlijeka s aditivom fitosterola, koji znanstveno dokazuje sniženje koncentracije kolesterola u krvi i 2) Spremni ste platiti za taj proizvod veću cijenu? Uzorak obuhvaća 419 anketa, od toga provedeno je 150 anketa na terenu (kontrolna skupina), dok je 269 anketa provedeno online (eksperimentalna skupina). Cohen-d indeks (d) rezultati prikazani su za dva prije spomenuta načina izračuna, "mali" učinak (d=0,35, odnosno d=0,34) i "nula ili blizu nule" učinak (d=0,15, odnosno = 0,15).

Ključne riječi: utjecaj veličine, Cohen-d indeks, funkcionalna hrana, mlijeko

References

1. Arvanitoyannis, I., Van Houwelingen-Koukaliaroglou, M. (2005): Functional Foods: A Survey of Health Claims, Pros and Cons, and Current Legislation: A review. *Critical Reviews in Food Science and Nutrition 45* (5), 385-404, 420.
2. Blanar, A.C., Munkittrick, R.K., Houlahan, J., MacLatchy, D., Marcogliese, J.D. (2009): Pollution and parasitism in aquatic animals: A meta-analysis of effect size. *Aquatic Toxicology 93*, 18-28.
3. Coe, R. (2002): It's the Effect Size, Stupid. The Annual Conference of the British Educational Research Association. University of Exeter, England, September 12-14.
4. Cohen, J. (1969): Statistical Power Analysis for the Behavioural Sciences, *NY: Academic Press*.
5. Cohen, J. (1977): Statistical Power Analysis for the Behavioral Sciences (revised edition), *NY*: *Academic Press*.
6. Cohen, J. (1994): The Earth is Round (p<.05). *American Psychologist 49*, 997-1003.

7. Cohen, P.A., Kulik, J.A., Kulik, C.C. (1982): Educational outcomes of tutoring: a meta- analysis of findings. *American Educational Research Journal 19*, 237-248.
8. Ferguson, C.J. (2009): Is Psychological Research Really as Good as Medical Research? Effect Size Comparisons between Psychology and Medicine: A review. *Review of general Psychology 13* (2), 130-136.
9. Garamszegi, L.Z. (2006): Comparing effect sizes across variables: generalization without the need for Bonferroni correction. *Behavioral Ecology 17*, 682-687.
10. Hansel, B., Nicolle, C., Lalanne, F., Tondu, F., Lassel, T., Donazzolo, Y., Ferrieres, J., Krempf, M., Schlienger, J.L., Verges, B., Chapman, M.J., Bruckert, E. (2007): Effect of low-fat, fermented milk enriched with plant sterols on serum lipid profile and oxidative stress in moderate hypercholesterolemia. *American Journal of Clinical Nutrition 86*, 790-796.
11. Hari, S. (2009). Uvajanje funkcionalnega živila na slovenski trg: primer Pomurskih mlekarn. Thesis, Faculty of Agriculture and Life Sciences, Slovenia, 36 pp.
12. Hasler, C.M. (1998): A new look at an ancient concept. *Chemistry & Industry 3*, 84-89.
13. Huberty, C.J. (2002): A history of effect size indices. *Educational and Psychological Measurement 62* (2), 227-240.
14. Keselman, H.J., Huberty, C.J., Lix, L.M., Olejnik, S., Cribbie, R.A., Donahue, B., Kowalchuk, R.K., Lowman, L.L., Petoskey, M.D., Keselman, J.C., Levin, J.R. (1998): Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses: A review. *Review of Educational Research 68* (3), 350-386.
15. Miller, T.D., Hendrie, D., Derzon, J. (2011): Exact method for computing absolute percent change in a dichotomous outcome from meta-analytic size: Improving impact and cost-outcome estimates. *Value in Health 14* (1), 144-151.
16. Rosenthal, R., Rubin, D.B. (1982): A simple, general purpose display of magnitude of experimental effect. *Journal of Educational Psychology 74*, 166-169.
17. Thalheimer, W., Cook, S. (2002): How to calculate effect sizes from published research: A simplified methodology: A Work-Learning Research Publication. Harvard University, ZDA, 2-8.
18. Wilkinson, L. (1999): Statistical Methods in Psychology Journals: Guidelines and Explanations. *American Psychologist 54* (8), 594-604.