The Analysis of Hypothesis Testing on Rare Sugars

Hiromasa Takeyasu *, Daisuke Takeyasu **,Kazuhiro Takeyasu***

* Kagawa Junior College, ** The Open University of Japan, ***Tokoha University

Abstract. The Rare Sugars exist naturally and have many kinds (more than 50). They have good effect for health such as prevention of increasing the blood‐sugar level after eating, suppression of fat accumulation, suppression of increasing the blood pressure, and anti-oxidative effect etc. It is in the spotlight for many people especially for those who are in the metabolic syndrome. There are few related papers concerning the marketing research and its utilization of this matter. In this paper, a questionnaire investigation is executed to the student of Kagawa Junior College in order to clarify consumers' current condition and their consciousness, and to seek the possibility of utilizing the Rare Sugars. Hypothesis testing was executed based on that. Some interesting and instructive results were obtained.

Key Words: rare sugars, health, consumer, hypothesis testing

1. Introduction

The Rare Sugars' study has launched on 1980th by Professor Takeshi Izumori (Kagawa University). The way to the mass production was developed by the method of enzymatic reaction. The International Society of Rare Sugars was established in 2001. Local government of Kagawa Prefecture comes to assist this research activity on this big innovation newly born in Kagawa Prefecture. The Rare Sugars have advantage that a blood-sugar level does not increase so much after eating, in spite of it being a sugar. And it also holds the upturn of the blood pressure. Therefore it is expected as a new functional material for the prevention of metabolic syndrome.

By the way, one kind of the Rare Sugar D-psicose has the following characteristics.

① a sweetening made by the natural starch
② non calorie and its sweetness is 70% to those of sugar
③ organoleptic property of coolness and sharpness in taste

Many medical research papers are published on the Rare Sugars as follows.

Analysis of the function of D-psicose ; [1], [3], [4], [10], [12], [13]

Analysis of the function of D-allose ; [2], [5], [6], [7], [8], [9], [11], [14]

On the other hand, these are few papers analyzed by the viewpoint from consumers. The Rare Sugars is good for the health and is sold in the market as a sweetening, seasoning or functional ingredient for food.

In this paper, a questionnaire investigation is executed to the student of Kagawa Junior College in order to clarify the recognition level among consumers and to pursue the future possibility of the Rare Sugars. Basic statistical analysis and hypothesis testing are conducted. The following three main issues are set.

A) Those who have interest in the Rare Sugars have also interest in health.

B) Those who do not know the Rare Sugars feel anxiety for them.

C) Generally, female have much more interest in the Rare Sugars than male.

Then, 6 sub issues are set and hypothesis testing is executed.

The rest of this paper is organized as follows. In section 2, outline of the questionnaire investigation and its basic statistical results are exhibited. After that, hypothesis testing is performed in section 3, which is followed by the remarks of section 4.

2. Outline and the Basic Statistical Results of the Questionnaire Research

2.1 Outline of the Questionnaire Research

A questionnaire investigation is executed to the student of Kagawa Junior College in order to clarify the recognition level among consumers and to pursue the future possibility of the Rare Sugars. The outline of the questionnaire research is as follows.

(1)	Scope of investigation	:	Student of Kagawa Junior College
(2)	Period	:	April – June 2015
(3)	Method	:	Leave until called for

(4) Collection : Number of distribution 186
Number of collection 186
(collection rate 100.0%)
Valid answer 186

2.2 Basic Statistical Results

Now, we show the main summary results by single variable.

(1) Basic characteristics of answerers

Q32 Sex

	Frequency	%
Male	19	10.98266
Female	154	89.01734
Total	173	100

Q33 Age

	Frequency	%
-19	139	80.34682
20-29	33	19.07514
50-59	1	0.578035
Total	173	100

Q34 Occupation

	Frequency	%
Student	171	98.84393
Housewife	1	0.578035
Miscellaneous	1	0.578035
Total	173	100

(2) Summary results for the items used in Hypothesis Testing

Q1

	Frequency	%
Know	150	86.7052
Do not Know	23	13.2948
Total	173	100

Q3

	Frequency	%
Know	107	61.84971
Do not Know	40	23.12139
Miscellaneous	26	15.0289
Total	173	100

Q6

	Frequency	%
Yes	111	64.16185
No	38	21.96532
Miscellaneous	24	13.87283
Total	173	100

Q10 I wont to use it in the cooking.

	Think it very much	Slightly think so	Can not say either	Slightly do not think so	Do not think so	Miscellaneous	Total
Frequency	41	55	62	11	2	2	173
%	23.69942	31.79191	35.83815	6.358382	1.156069	1.156069	100

Q18 I cannot grasp the concrete effect.

	Think it very much	Slightly think so	Can not say either	Slightly do not think so	Do not think so	Miscellaneous	Total
Frequency	36	53	38	28	17	1	173
%	20.80925	30.63584	21.96532	16.18497	9.82659	0.578035	100

Q20 Surrounding people do not use it so often.

	Think it very much	Slightly think so	Can not say either	Slightly do not think so	Do not think so	Miscellaneous	Total
Frequency	37	67	56	11	1	1	173
%	21.38728	38.72832	32.36994	6.358382	0.578035	0.578035	100

Q25 Do you take interest in a diet?

	Think it very much	Slightly think so	Can not say either	Slightly do not think so	Do not think so	Miscellaneous	Total
Frequency	65	52	24	15	15	2	173
%	37.57225	30.0578	13.87283	8.67052	8.67052	1.156069	100

2.3 Hypothesis testing

Hereinafter we make hypothesis testing based upon the questionnaire investigation data.

(1) Setting Hypothesis

First of all, we start from the hypothesis testing. Three main issues are set as follows.

A) Those who have interest in the Rare Sugars have also interest in health.
B) Those who do not know the Rare Sugars feel anxiety for them.
C) Generally, female have much more interest in the Rare Sugars than male.

Next, we set the following 6 themes (sub issues) before setting Null Hypothesis.

A-1) Those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention have eaten or drunk food in which the Rare Sugars is contained.
A-2) Those who have eaten or drunk food in which the Rare Sugars is contained have interest in diet.
B-1) Those who do not know the Rare Sugars do not understand the concrete effect of them.
B-2) Those who do not know the rare Sugars have acquaintances who do not use the Rare Sugars.
C-1) Female know the Rare Sugar much more than male.
C-2) Female want to use the Rare Sugars for cooking more than male.

Now, we set the following 6 Null hypothesis.

A-1) There is not so much difference concerning that they have experience of eating and drinking food in which the Rare Sugars are contained between those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention and those who do not know.

A-2) There is not so much difference concerning that they have interest in diet between those who have eaten or drunk food in which the Rare Sugars are contained and those who have not.

B-1) There is not so much difference concerning that they do not know the concrete effect of the Rare Sugars between those who know the Rare Sugars and those who do not.

B-2) There is not so much difference concerning that they do not have acquaintances who do not use the Rare Sugars between those who know the Rare Sugars and those who do not.

C-1) There is not so much difference concerning that they know the Rare Sugars well between male and female.

C-2) There is not so much difference concerning that they want to use the Rare Sugars for cooking between male and female.

(2) Hypothesis Testing

x^2 hypothesis testing is executed for about consumers' consciousness on the Rare Sugars. x^2 hypothesis testing is to clarify the difference between the expected value and the observed data, which is shown in Eq.(1).

$$x^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \tag{1}$$

Where O_i is an observed data and E_i is an expected value. The results of statistical hypothesis testing are as follows.

Null Hypothesis **A-1)**: There is not so much difference concerning that they have experience of eating and drinking food in which the Rare Sugars are contained between those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention and those who do not know.

Summary table for Null Hypothesis **A-1)** is exhibited in Table 1.

Table 1. Summary table for Null Hypothesis **A-1)**

| | \<Observed data\> | | | | \<Expected value\> | | | |
	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	86	21	107	YES	79.34014	27.65986	107	7.947469
NO	23	17	40	NO	29.65986	10.34014	40	P value
Total	109	38	147	Total	109	38	147	0.004815

(Rejection region is over 6.6349 for 1% significance level, 3.841 for 5% significance level, 3.537 for 6% significance level and 2.874 for 9% significance level by 1 degree of freedom.) The null hypothesis is rejected with 1% significance level. It can be said that those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention have eaten or drunk food in which the Rare Sugars is contained.

Null Hypothesis **A-2)**: There is not so much difference concerning that they have interest in diet between those who have eaten or drunk food in which the Rare Sugars are contained and those who have not.

Summary table concerning Null Hypothesis **A-2)** is exhibited in Table 2.

Table 2. Summary table for Null Hypothesis **A-2)**

| | \<Observed data\> | | | | \<Expected value\> | | | |
	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	79	18	97	YES	79.152	17.848	97	0.007082
NO	23	5	28	NO	22.848	5.152	28	P value
Total	102	23	125	Total	102	23	125	0.932933

The null hypothesis is not rejected. It can be said that there is not so much difference concerning that they have interest in diet between those who have eaten or drunk food in which the Rare Sugars are contained and those who have not.

Null Hypothesis **B-1)**: There is not so much difference concerning that they do not know the concrete effect of the Rare Sugars between those who know the Rare Sugars and those who do not.
Summary table concerning Null Hypothesis **B-1)** is exhibited in Table 3.

Table 3. Summary table for Null Hypothesis **B-1)**

	<Observed data>				<Expected value>			
	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	70	45	115	YES	76.3806	38.6194	115	11.19394
NO	19	0	19	NO	12.61944	6.380597	19	P value
Total	89	45	134	Total	89	45	134	0.000821

The null hypothesis is rejected with 1% significance level. It can be said that those who do not know the Rare Sugars do not understand the concrete effect of them.

Null Hypothesis **B-2)**: There is not so much difference concerning that they do not have acquaintances who do not use the Rare Sugars between those who know the Rare Sugars and those who do not.
Summary table concerning Null Hypothesis **B-2)** is exhibited in Table 4.

Table 4. Summary table for Null Hypothesis **B-2)**

	<Observed data>				<Expected value>			
	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	90	12	102	YES	91.44828	10.55172	102	1.837104
NO	14	0	14	NO	12.551722	1.448276	14	P value
Total	104	12	116	Total	104	12	116	0.175291

The null hypothesis is not rejected. It can be said that There is not so much difference concerning that they do not have acquaintances who do not use the Rare Sugars between those who know the Rare Sugars and those who do not.

Null Hypothesis **C-1)**: There is not so much difference concerning that they know the Rare Sugars well between male and female.
Summary table concerning Null Hypothesis **C-1)** is exhibited in Table 5.

Table 5. Summary table for Null Hypothesis **C-1)**

	<Observed data>				<Expected value>			
	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	13	137	150	YES	16.47399	133.526	150	6.190157
NO	6	17	23	NO	2.526012	20.47399	23	P value
Total	19	154	173	Total	19	154	173	0.012846

The null hypothesis is rejected with 2% significance level. It can be said that female know the Rare Sugar much

more than male.

Null Hypothesis **C-2)**: There is not so much difference concerning that they want to use the Rare Sugars for cooking between male and female.
Summary table concerning Null Hypothesis **C-2)** is exhibited in Table 6.

Table 6. Summary table for Null Hypothesis **C-2)**

<Observed data>   <Expected value>

	Think so	Do not think so	Total		Think so	Do not think so	Total	x^2 value
YES	8	88	96	YES	7.926606	88.07339	96	0.00621
NO	1	12	13	NO	1.073394	11.92661	13	P value
Total	9	100	109	Total	9	100	109	0.937185

The null hypothesis is not rejected. It can be said that there is not so much difference concerning that they want to use the Rare Sugars for cooking between male and female.

3. Remarks

The Results for Hypothesis Testing are as follows. Main issue A consists of 2 sub issues (**A-1**,**A-2**). One of their Null Hypotheses was rejected and another one was not rejected. It can be said that those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention have eaten or drunk food in which the Rare Sugars is contained. 2 sub issues were set for the main issue B (**B-1**, **B-2**). One of their Null Hypotheses was rejected and another one was not rejected. It can be said that those who do not know the Rare Sugars do not understand the concrete effect of them. 2 sub issues were set for the main issue C (**C-1**, **C-2**). One of their Null Hypotheses was rejected and another one was not rejected. It can be said that female know the Rare Sugar much more than male.

4. Conclusion

The Rare Sugars exist naturally and have many kinds (more than 50). They have good effect for health such as prevention of increasing the blood-sugar level after eating, suppression of fat accumulation, suppression of increasing the blood pressure, and anti-oxidative effect etc. It is in the spotlight for many people especially for those who are in the metabolic syndrome. There are few related papers concerning the marketing research and its utilization of this matter. In this paper, a questionnaire investigation was executed to the student of Kagawa Junior College in order to clarify consumers' current condition and their consciousness, and to seek the possibility of utilizing the Rare Sugars. Hypothesis testing was conducted based on that. We have set three main issues as follows.

A) Those who have interest in the Rare Sugars have also interest in health.

B) Those who do not know the Rare Sugars feel anxiety for them.

C) Generally, female have much more interest in the Rare Sugars than male.

For the A part, it consists of 2 sub issues. One of their Null Hypotheses was rejected and another one was not rejected. It can be said that those who know that the Rare Sugars are effective for obese prevention and/or diabetes prevention have eaten or drunk food in which the Rare Sugars is contained. For the B part, 2 sub issues were set and one of their Null Hypotheses was rejected and another one was not rejected. It can be said that those who do not know the Rare Sugars do not understand the concrete effect of them. For the C part, 2 sub issues were set and one of their Null Hypotheses was rejected and another one was not rejected. It can be said that female know the Rare Sugar much more than male.

Further study on this should be executed such as multivariate analysis. Various cases should be investigated here after.

Acknowledgements

References
[1] Rare sugar D-psicose improves insulin sensitivity and glucose tolerance in type 2 diabetes Otsuka Long-Evans Tokushima Fatty (OLETF) rats. Hossain MA, Kitagaki S, Nakano D, Nishiyama A, Funamoto Y, Matsunaga T, Tsukamoto I, Yamaguchi F, Kamitori K, Dong Y, Hirata Y, Murao K, Toyoda Y, Tokuda M. Biochem Biophys Res Commun. 2011 Feb 4;405(1):7-12.
[2] Rare sugar d-allose strongly induces thioredoxin-interacting protein and inhibits osteoclast differentiation in Raw264 cells. Yamada K, Noguchi C, Kamitori K, Dong Y, Hirata Y, Hossain MA, Tsukamoto I, Tokuda M, Yamaguchi F. Nutr Res.

2012 Feb;32(2):116-23.

[3] Study on the postprandial blood glucose suppression effect of D-psicose in borderline diabetes and the safety of long-term ingestion by normal human subjects. Hayashi N, Iida T, Yamada T, Okuma K, Takehara I, Yamamoto T, Yamada K, Tokuda M. Biosci Biotechnol Biochem. 2010;74(3):510-9.

[4] Failure of d-psicose absorbed in the small intestine to metabolize into energy and its low large intestinal fermentability in humans. Iida T, Hayashi N, Yamada T, Yoshikawa Y, Miyazato S, Kishimoto Y, Okuma K, Tokuda M, Izumori K. Metabolism. 2010;59(2):206-14.

[5] Anti-oxidative effects of D-allose, a rare sugar, on ischemia-reperfusion damage following focal cerebral ischemia in rat. Nakamura T, Tanaka S, Hirooka K, Toyoshima T, Kawai N, Tamiya T, Shiraga F, Tokuda M, Keep RF, Itano T, Miyamoto O.

[6] Reactivity of rare sugar D-allose during glycation of human serum albumin. Kajikawa T, Tada S, Kitanaka A, Tokuda M, Taminat T. J Analy. Bio-Sci. 2010; 33(3) 227-236.

[7] Analysis of the inhibitory mechanism of D-allose on MOLT-4F leukemia cell proliferation. Hirata Y, Saito M, Tsukamoto I, Yamaguchi F, Sui L, Kamitori K, Dong Y, Uehara E, Konishi R, Janjua N, Tokuda M. J Biosci Bioeng. 2009 May;107(5):562-8.

[8] Growth inhibition of head and neck carcinomas by D-allose. Mitani T, Hoshikawa H, Mori T, Hosokawa T, Tsukamoto I, Yamaguchi F, Kamitori K, Tokuda M, Mori N. Head Neck. 2009 Aug;31(8):1049-55.

[9] Rare sugar D-allose enhances anti-tumor effect of 5-fluorouracil on the human hepatocellular carcinoma cell line HuH-7. Yamaguchi F, Kamitori K, Sanada K, Horii M, Dong Y, Sui L, Tokuda M. J Biosci Bioeng. 2008 Sep;106(3):248-52.

[10] Development of an amperometric flow analysis sensor for specific detection of D-psicose. Miyanishi N, Sato N, Nakakita S, Sumiyoshi W, Morimoto K, Okuma H, Tokuda M, Izumori K, Watanabe E, Hirabayashi J. Biosens Bioelectron. 2008 Apr 15;23(9):1347-52.

[11] Rare sugar D-allose induces specific up-regulation of TXNIP and subsequent G1 cell cycle arrest in hepatocellular carcinoma cells by stabilization of p27kip1. Yamaguchi F, Takata M, Kamitori K, Nonaka M, Dong Y, Sui L, Tokuda M. Int J Oncol. 2008 Feb;32(2):377-85.

[12] Preventive effect of D-psicose, one of rare ketohexoses, on di-(2-ethylhexyl) phthalate (DEHP)-induced testicular injury in rat. Suna S, Yamaguchi F, Kimura S, Tokuda M, Jitsunari F. Toxicol Lett. 2007 Sep 10;173(2):107-17.

[13] D-Psicose inhibits the expression of MCP-1 induced by high-glucose stimulation in HUVECs. Murao K, Yu X, Cao WM, Imachi H, Chen K, Muraoka T, Kitanaka N, Li J, Ahmed RA, Matsumoto K, Nishiuchi T, Tokuda M, Ishida T. Life Sci. 2007 Jul 26;81(7):592-9.

[14] Cryoprotective effects of D-allose on mammalian cells. Sui L, Nomura R, Dong Y, Yamaguchi F, Izumori K, Tokuda M. Cryobiology. 2007 Oct;55(2):87-92.