

Analytical Hierarchy Process (AHP): A Steady Method for Quality Decision Making: A Case Study in Snack Food Industry

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Abstract

If several hours pass between meals and blood glucose levels fall, snacks are the supplement that gives you an energy boost. It assists in reducing appetite and avoiding overeating at the subsequent meal. When choosing particular snacks like fresh fruit or nuts, it also provides additional nutrients. Over the years, the snacking business has undergone significant development, emerging as one of the promising industries contributing to the expansion of the national economy. Faced with increasingly aware, discerning and demanding costumers I have applied a multi-criteria decision-making methodology that is Analytical Hierarchy Process (AHP) to meet the best needs of industrialists as well as costumers. Thus, the objective of this work is to determine the bestselling snack company.

Keywords: Multi-Criteria Decision Making, Analytical Hierarchy Process (AHP), Snack Company.

INTRODUCTION

The pandemic has had extensive economic consequences apart from its overwhelming peal on health care areas. While it led to the downfall of many industries, a few managed to expand and stay submerged amid the crisis brought about by the pandemic. One such industry is the snacks industry in India that has observed an enormous increase over the past couple of years. With altered consumer choices, rising urbanization and a shift towards eating habits, the snacking industry has undergone massive change over the years to emerge as one of the promising areas adding to the development of the country's economy. As per reports, the snack market in India is likely to reach rupees one billion by the end of 2024 and is probable to grow with a double-digit Compound Annual Growth Rate from 2018 to 2024. The change in consumption patterns along with altering consumer lifestyles is leading to rising demand for snacks with new flavors and tastes. This is significantly increasing the development of the industry and its upcoming indeed seems promising. Snacks market size in India is Rs. 44,000 crores with snacks contributing 80% of snacks products or snacks brands sold is from India's top 10 snacks companies. Currently, American corporation PepsiCo, which owns Lays and Kurkure, and the indigenous Haldirams dominate the market share in India's organized snack market.

In operations research, multi-criteria decision making (MCDM) is a topic that is frequently studied. It can handle problems with various criteria and make relevant and high-quality decisions, especially when choosing the best option. The Analytic Hierarchy Process (AHP) is a mathematical and psychology-based system for organizing and analyzing complex decisions. It was developed in the late 1970s by Thomas L. Saaty and has subsequently been enhanced. Snacking behavior varies across the different regions of the globe. With the fast development and changing people lifestyle, the habit of eating also changed. There have been studies from developed countries regarding snacking and eating behavior of school- and college-going students and adolescents in general. Cros et. al [1] from the United States of America reported that 87-88% of adolescents aged 12-18 years

consumed at least one snack per day with snacks contributing approximately 25% of their daily energy intake. They found that children and adolescents select snacks based on taste over nutrition or more often choose salty, crunchy foods as snacks over healthier alternatives. A study by Anderson et. al [2] in Scotland reported an average of 5.5 eating occasions per day (2.7 main meals and 2.8 snacks), these eating occasions being concentrated towards the end of the day.

A similar study by Marques et. al [3] showed that Portuguese youth (aged 5–15 years) consumed 1.5 snacks per day. L. S. Adair and B. M. Popkin [4] reported that In Asian countries, snacking rates among youth (aged 2–19 years) are more variable. For example, in the Philippines, Russia, and China, 86%, 71%, and 10% of youth consume at least one snack on a daily basis, with snacks providing 18%, 16%, and 1% of their total daily energy, respectively. Falbe et. al [5] found that the increase in screen time (i.e., television, electronic games, digital versatile discs (DVDs)/videos, and total screen time) was associated with increased consumption of foods and beverages of low nutritious quality and decreased consumption of fruits and vegetables.

Roy, Devesh et. al [6] implemented AHP method for comparison of dietary based on consumer location and characteristic. R. Miller et. al [7] concluded that Snacks, if added to habitual meal intake, with no compensation for snack energy contribution, are likely over time to lead to positive energy balance. S. L. Forbes et. al [8] concluded that for marketers, a key contribution of this study is the importance of the price attribute and certain product claims. One third of consumers do not consider their snacking behavior to be healthy, and one quarter of consumers choose to snack in secret. M. Shrivastav and S. Thomas [9] concluded that India is also facing this transition, and more college students and adolescents are adopting western dietary styles along with the snacking behaviour. According to a previous research, very high proportion (62.1%) of adolescents had the habit of snacking in between meals. L. Sominsky and S. J. Spencer concluded that Stress is also considered as an important factor which tends to influence snacking and eating patterns among young individuals. André Andrade Longaray et. al This study aims to describe the development stages of a decision support system for evaluating the quality of services provided by outsourced companies that serve organizations in the Brazilian retail sector. Shahroodi and Kambiz [10] This paper deals with a brief review of the literature regarding AHP technique and its relevancy to its application in supplier selection process. Supplier selection is a complicated process. After analysis of the results, he found that for manufacturing firms, supplier reliability, product quality and supplier experience are the top three supplier selection problems that needs to be taken up on priority for effective vendor selection. Asbon Hendre Azhar et. al [11] states that consumers have many difficulties in choosing what foods they will consume so that in choosing the food is only based on one criteria only and not some criteria. The method used for this research problem is Analytic Hierarchy Process. Ivana Blesic et. al [12] define the key motives when choosing a traditional Vojvodina dish by using analytic hierarchy process (AHP). The AHP method was developed by Satty T L to support decision-making problems with multiple criteria. Among the multi criteria decision making method the AHP is most well-known and used.

Data Collection & Survey

To gather the necessary information from the respondents, data is collected using both primary and secondary data collection techniques. For this research, we gathered data from 200+ individuals, including 90+ women and 130+ men from various supermarket including 15+ snack service providers. The data is gathered verbally during telephone and in-person interviews with the respondents. Exceptional care must be taken to get accurate information without any exceptions and errors.

Methodology

The analytic hierarchy process: To make a decision in an ordered way we need to create the following decision steps.

1. Defining the problem.
2. Construct the decision hierarchy from the top with the goal of the decision.
3. Construct comparison matrices.
4. Check the consistency.

5. Until the final priority obtained continue the process of adding and weighing.

With respect to the criteria, we make the comparisons to scale of numbers that indicates how many times more dominant one element is over to the other. Table 1 exhibits the scale.

After creating the decision network matrix of the problem, paired comparisons are formulated by assigning the 1-9 values developed by Satty [1], these ranking are carried out between pairwise compared criteria, “1” is considered the equal importance, “3” for slightly important than other criteria, “5” it is used when one criterion has strongly more important than others, “7” is for the criteria when its dominance can be observed, “9” when one criterion has opted strongly with highest validity and “2”, “4”, “6”, “8” values are used to when a compromise is needed in selection between two consecutive judgements.

Measurement of Inconsistency

$$\text{consistency index} = \frac{\lambda_{max} - n}{n - 1}$$

where λ_{max} is the average value of A_4 and

$$\text{consistency ratio} = \frac{\text{Consistency index}}{\text{Random index}}$$

Table 1: Scales

Attributes	3	4	5	6	7	8	9	10
Random Index	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.45

Problem Formulation

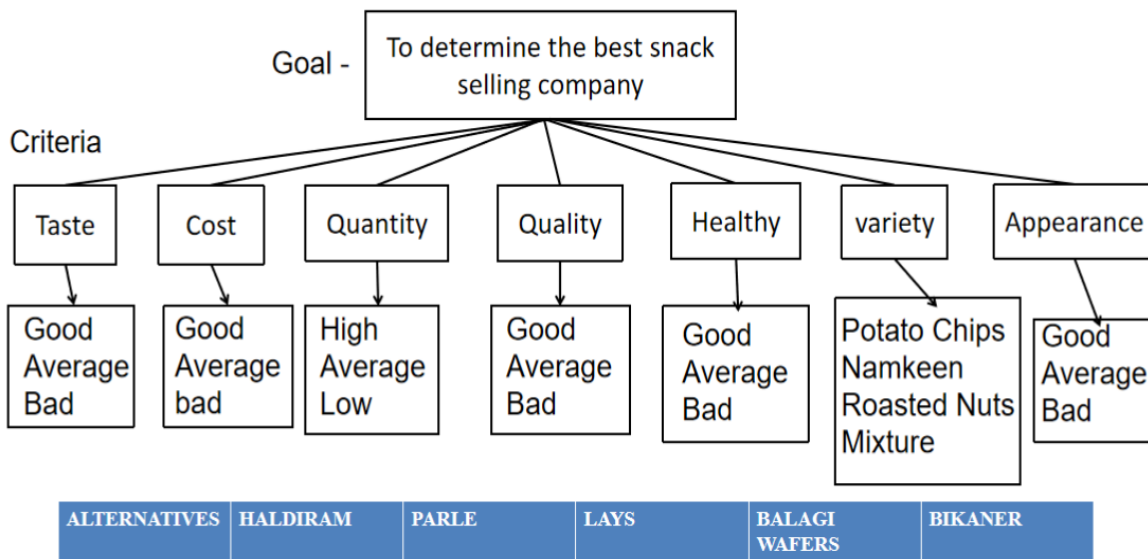


Fig : The Hierarchical structure of the criteria

Results And Discussion's

Comparison between Criteria's

Criteria	Taste	Cost	Quantity	Quality	Healthy	Variety	Appearance
Taste	1	5	6	2	7	3	4
Cost	1/5	1	2	1/4	3	1/3	1/2
Quantity	1/6	1/2	1	1/5	2	1/4	1/3
Quality	1/2	4	5	1	6	2	3
Healthy	1/7	1/3	1/2	1/6	1	1/5	1/4
Variety	1/3	3	4	1/2	5	1	2
Appearance	1/4	2	3	1/3	4	1/2	1

Consistency Check

$$A_3 = A_1 \times A_2$$

=	1	5	6	2	7	3	4	×	0.3516	=	2.5536
	1/5	1	2	1/4	3	1/3	1/2		0.0678		0.4862
	1/6	1/2	1	1/5	2	1/4	1/3		0.0448		0.3221
	1/2	4	5	1	6	2	3		0.2412		1.7294
	1/7	1/3	1/2	1/6	1	1/5	1/4		0.0310		0.2243
	1/3	3	4	1/2	5	1	2		0.1596		1.1430
	1/4	2	3	1/3	4	1/2	1		0.1040		0.7461

A_1

$(1 \times 5 \times 6 \times 2 \times 7 \times 3 \times 4)^{1/7} = 3.3800$
$(1/5 \times 1 \times 2 \times 1/4 \times 3 \times 1/3 \times 1/2)^{1/7} = 0.6518$
$(1/6 \times 1/2 \times 1 \times 1/5 \times 2 \times 1/4 \times 1/3)^{1/7} = 0.4313$
$(1/2 \times 4 \times 5 \times 1 \times 6 \times 2 \times 3)^{1/7} = 2.3183$
$(1/7 \times 1/3 \times 1/2 \times 1/6 \times 1 \times 1/5 \times 1/4)^{1/7} = 0.2957$
$(1/3 \times 3 \times 4 \times 1/2 \times 5 \times 1 \times 2)^{1/7} = 1.5341$
$(1/4 \times 2 \times 3 \times 1/3 \times 4 \times 1/2 \times 1)^{1/7} = 1$

SUM = 9.6112

A_2

$\frac{3.3800}{9.6112} = 0.3516$
$\frac{0.6518}{9.6112} = 0.0678$
$\frac{0.4313}{9.6112} = 0.0448$
$\frac{2.3183}{9.6112} = 0.2412$
$\frac{0.2957}{9.6112} = 0.0310$
$\frac{1.5341}{9.6112} = 0.1596$
$\frac{1}{9.6112} = 0.1040$

SUM = 1

$$A_4 = \frac{A_3}{A_2}$$

2.5536	0.3516	7.2627
0.4862	0.0678	7.1710
0.3221	0.0448	7.1897
= 1.7294	÷ 0.2412	= 7.1699
0.2243	0.0310	7.2354
1.1430	0.1596	7.1616
0.7461	0.1040	7.1740

AVERAGE OF $A_4 = 7.1949$

$\lambda_{max} = 7.1949$

MEASUREMENT OF INCONSISTENCY

$$\begin{aligned} \text{consistency index} &= \frac{\lambda_{max} - n}{n-1} \\ &= \frac{7.1949 - 7}{7-1} \\ &= 0.032348 \end{aligned}$$

$$\begin{aligned} \text{consistency ratio} &= \frac{\text{consistency index}}{\text{random index}} \\ &= \frac{0.03248}{1.35} \\ &= 0.02405 < 0.1 \end{aligned}$$

therefore , the weights assigned are the correct weights for the criteria .

weights of the criteria

Taste	0.3516	35%
Cost	0.0678	7%
Quantity	0.0448	5%
Quality	0.2412	24%
Healthy	0.0310	3%
Variety	0.1596	16%
Appearance	0.1040	10%

COMPARISON BETWEEN SUBCRITERIAS WITH RESPECT TO CRITERIAS

Taste-35%	Good	Average	Bad
Good	1	2	5
Average	1/2	1	3
Bad	1/5	1/3	1

$$A_1 = \begin{array}{|l|l|} \hline (1 \times 2 \times 5)^{1/3} & = 2.1544 \\ \hline (1/2 \times 1 \times 3)^{1/3} & = 1.1447 \\ \hline (1/5 \times 1/3 \times 1)^{1/3} & = 0.4055 \\ \hline \text{Sum} & = 3.7046 \\ \hline \end{array}$$

$$A_2 = \begin{array}{|l|l|l|} \hline 0.5815 & 58\% & \frac{58 \times 35}{100} = 20.30 \\ \hline 0.3090 & 31\% & \frac{31 \times 35}{100} = 10.85 \\ \hline 0.1095 & 11\% & \frac{11 \times 35}{100} = 3.85 \\ \hline \end{array}$$

Cost-7%	High	Average	Low
High	1	1/3	1/5
Average	3	1	1/4
Low	5	4	1

$$A_1 =$$

$(1 \times 1/3 \times 1/5)^{1/3}$	= 0.4055
$(3 \times 1 \times 1/4)^{1/3}$	= 0.9086
$(1 \times 4 \times 1)^{1/3}$	= 2.7144
Sum	= 4.0285

$$A_2 =$$

0.1007	10%	$\frac{10 \times 7}{100} = 0.7$
0.2255	23%	$\frac{23 \times 7}{100} = 1.61$
0.6738	67%	$\frac{67 \times 7}{100} = 4.69$

Quantity-5%	High	Average	Low
High	1	4	7
Average	1/4	1	3
Low	1/7	1/3	1

$$A_1 =$$

$(1 \times 4 \times 1/5)^{1/3}$	= 3.0366
$(1/4 \times 1 \times 3)^{1/3}$	= 0.9086
$(1/7 \times 1/3 \times 1)^{1/3}$	= 0.3625
Sum	= 4.3077

$$A_2 =$$

0.7049	71%	$\frac{71 \times 5}{100} = 3.55$
0.2109	21%	$\frac{21 \times 5}{100} = 1.05$
0.0842	8%	$\frac{8 \times 5}{100} = 0.4$

Quality-24%	High	Average	Low
Good	1	2	5
Average	1/2	1	3
Bad	1/5	1/3	1

$$A_1 = \begin{array}{|l|l|} \hline (1 \times 4 \times 5)^{1/3} & = 2.1544 \\ \hline (1/2 \times 1 \times 3)^{1/3} & = 1.1447 \\ \hline (1/5 \times 1/3 \times 1)^{1/3} & = 0.4055 \\ \hline \text{Sum} & = 3.7046 \\ \hline \end{array}$$

$$A_2 = \begin{array}{|l|l|l|} \hline 0.5815 & 58\% & \frac{58 \times 24}{100} = 13.92 \\ \hline 0.3090 & 31\% & \frac{31 \times 24}{100} = 7.44 \\ \hline 0.1095 & 11\% & \frac{11 \times 24}{100} = 2.64 \\ \hline \end{array}$$

Healthy-5%	Good	Average	Bad
Good	1	2	4
Average	1/2	1	3
Bad	1/4	1/3	1

$$A_1 = \begin{array}{|l|l|} \hline (1 \times 2 \times 4)^{1/3} & = 2 \\ \hline (1/2 \times 1 \times 3)^{1/3} & = 1.1447 \\ \hline (1/4 \times 1/3 \times 1)^{1/3} & = 0.4368 \\ \hline \text{Sum} & = 3.5815 \\ \hline \end{array}$$

$$A_2 = \begin{array}{|l|l|l|} \hline 0.5584 & 56\% & \frac{56 \times 3}{100} = 1.68 \\ \hline 0.3196 & 32\% & \frac{32 \times 3}{100} = 0.96 \\ \hline 0.1220 & 12\% & \frac{12 \times 3}{100} = 0.36 \\ \hline \end{array}$$

Variety - 16%	PC	N	RN	M
Potato Chips (PC)	1	2	5	4
Namkeen(N)	1/2	1	3	2
Roasted Nuts (RN)	1/5	1/3	1	1/3
Mixture (M)	1/4	1/2	3	1

$A_1 =$

$(1 \times 2 \times 5 \times 4)^{1/4}$	= 2.5149
$(1/2 \times 1 \times 3 \times 2)^{1/4}$	= 1.03161
$(1/5 \times 1/3 \times 1 \times 1/3)^{1/4}$	= 0.3861
$(1/4 \times 1/2 \times 3 \times 1)^{1/4}$	= 0.7825
Sum	= 4.9996

$A_2 =$

0.5030	50%	$\frac{50 \times 16}{100} = 8.00$
0.2632	26%	$\frac{26 \times 16}{100} = 4.16$
0.0772	8%	$\frac{8 \times 16}{100} = 1.28$
0.1565	16%	$\frac{16 \times 16}{100} = 2.56$

Appearance- 10%	Good	Average	Bad
Good	1	2	4
Average	1/2	1	3
Bad	1/4	1/3	1

$$A_1 =$$

$(1 \times 2 \times 4)^{1/3}$	= 2
$(1/2 \times 1 \times 3)^{1/3}$	= 1.1447
$(1/4 \times 1/3 \times 1)^{1/3}$	= 0.4368
Sum	= 3.5815

$$A_2 =$$

0.5584	56%	$\frac{56 \times 10}{100} = 5.6$
0.3196	32%	$\frac{32 \times 10}{100} = 3.2$
0.1220	12%	$\frac{12 \times 10}{100} = 1.2$

Comparison between alternatives w. r. t. criteria's

Where H = Haldirams P = Parle L = Lays BW = Balaji Wafers B = Bikaner

	TASTE 0.3516	COST 0.0678	QUANTITY 0.0448	QUALITY 0.2412	HEALTHY 0.0310	VARIETY 0.1596	APPEARANCE 0.1040
H	0.3988	0.1720	0.1720	0.4066	0.3988	0.4174	0.2634
P	0.1621	0.4322	0.4322	0.0827	0.1621	0.2634	0.1602
L	0.3022	0.2462	0.2462	0.1693	0.3022	0.0615	0.4174
BW	0.0879	0.0645	0.0645	0.2842	0.0489	0.1602	0.0975
B	0.0489	0.0851	0.0851	0.0573	0.0879	0.0975	0.0615

	TASTE 0.3516	COST 0.0678	QUANTITY 0.0448	QUALITY 0.2412	HEALTHY 0.0310	VARIETY 0.1596	APPEARANCE 0.1040	SUM	RANK
H	0.1402	0.0117	0.0077	0.0981	0.0124	0.0666	0.0274	0.3641	FIRST
P	0.0570	0.0293	0.0194	0.0199	0.0050	0.0420	0.0167	0.1893	THIRD
L	0.1063	0.0167	0.0110	0.0408	0.0094	0.0098	0.0434	0.2374	SECOND
BW	0.0309	0.0044	0.0029	0.0685	0.0015	0.0256	0.0101	0.1439	FOURTH
B	0.0172	0.0058	0.0038	0.0138	0.0027	0.0156	0.0064	0.0653	FIFTH

CONCLUSION

Rank	Taste	Cost	Quantity	Quality	Healthy	Variety	Appearance
First	Haldiram	Parle	Parle	Haldiram	Haldiram	Haldiram	Lays
Second	Lays	Lays	Lays	Balaji Wafers	Lays	Parle	Haldiram
Third	Parle	Haldiram	Haldiram	Lays	Parle	Balaji Wafers	Parle
Fourth	Balaji Wafers	Bikaner	Bikaner	Parle	Bikaner	Bikaner	Balaji wafers
Fifth	Bikaner	Balaji Wafers	Balaji Wafers	Bikaner	Balaji Wafers	Lays	Bikaner

By adding all the priority values of criteria to the understanding, “Haldiram” grabbed the first position, “Lays” is second, third is “Parle”, Fourth is “Balaji Wafers” and fifth is “Bikaner”.

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