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Investigating the Effect of Cabbage Variety on the Characteristics of Sauerkraut Produced Using Local Cabbage Varieties

Abstract

Sauerkraut is encumbered with a lot of nutrients and phytochemicals and yet it is relatively cheap to make (www.tonytantillo.com/health). Sub Saharan Africa still faces the challenge of prevalence of undernourishment and if fully exploited sauerkraut can bring considerable changes.

The research undertaken sought to establish the influence of cabbage variety on sauerkraut quality. Sauerkraut was produced using cabbage varieties grown under Zimbabwean climatic and growing conditions. The prominent aspects of sauerkraut ranging from lactic acid development and pH reduction were evaluated. Sensory evaluation techniques including the paired comparison test and quantitative descriptive analysis were used to determine and compare the organoleptic properties of the sauerkraut that was produced. The nine point hedonic scale was used to assess the consumer preference.

It was found out that different tests produced different results. The quantitative descriptive analysis showed that cabbage variety has no significant influence on the quality of sauerkraut produced from cabbages grown under the Zimbabwean soils. The paired comparison test and the hedonic scale showed that differences and consumer preferences can be perceived respectively. Regardless of the perceived characteristics from the array of analysis carried out it was concluded that all the vast nutritional benefits in cabbage can be obtained by increased consumption through value addition to cabbage in the sauerkraut produced from any variety grown in the country. The differences in the results from different methods employed could only be due to the differences in the purpose and characteristics of the method which may include its sensitivity and specificity.

8.1 Introduction

Sauerkraut is finely shredded cabbage that has been fermented by various lactic acid bacteria, including *Leuconostoc*, *Lactobacillus*, and *Pediococcus*. Fermentation of sugars in the cabbage will lead to a sour taste and a longer shelf life. Lactic acid is the major contributing factor to the taste and shelf life of sauerkraut (Axelsson, 1998).

Lactic acid fermentation of cabbage and other vegetables is a common way of preserving fresh vegetables in the western world, China, and Korea (where *kimchi* is a staple in the diet). It is a simple way of preserving food: the raw vegetable is sliced or shredded, and approximately 2 present salts is added. The salt extracts liquid from the vegetable, serving as a substrate for the growth of lactic acid bacteria (Wood and Hodge, 1985) (Matususaki et al, 1997) (Adams and Nicolaides, 1997), (Gourama and Bullerman, 1995), (Nout, 1995). Anaerobic conditions should be maintained, insofar as possible, to prevent the growth of microorganisms that might cause spoilage. The sequence of organisms that develop in typical sauerkraut fermentation is as follows: *Leuconostoc mesenteroides* initiates the growth in the shredded cabbage over a wide range of temperatures and salt concentrations. It produces carbon dioxide and lactic and acetic acids, which quickly lower the pH, thereby inhibiting development of undesirable microorganisms that might destroy crispness. The carbon dioxide produced replaces the air and facilitates the anaerobiosis required for the fermentation. The fermentation is completed in sequence by *Lactobacillus brevis* and *Lb. plantarum. Lb. plantarum* is responsible for the high acidity. If the fermentation temperature or salt concentration is high, *Pecicoccus cerevisiae* develops and contributes to acid production. As would be expected, the rate of completion of the fermentation depends on the temperature and salt concentration. At 7.5 ℃ fermentation is very slow: under these

circumstances, *L. mesenteroides* grows slowly, attaining an acidity of 0.4 percent in about 10 days and an acidity of 0.8 to 0.9 percent in a month. Lactobacilli and pediococci cannot grow well at this temperature, and the fermentation may not be completed for 6 months. At 18 ℃ a total acidity (as lactic acid) of 1.7 to 2.3 percent will be reached, with an acetic to lactic acid ratio of 1:4, in about 20 days. At 32 ℃ a similar activity will be reached in 8 to 10 days, with most of the acid being lactic acid produced by the homofermentative bacteria *Lb. plantarum* and *P. cerevesiae*. Increasing the salt concentration to 3.5 percent results in 90 percent inhibition of growth and acid production for both *L. mesenteroides* and *Lb. brevis*. The ratio of non-volatile to volatile acid produced has a marked effect on flavour, *Lb. brevis* producing a harsh, vinegar-like flavour and *L. mesenteroides* a mild, pleasantly aromatic flavour. The homofermenters *Lb. plantarum* and *P. cerevesiae* yield unacceptable products (Vaughn, 1985).

Fermentation is a relatively efficient, low energy preservation process which increases the shelf life and decreases the need for refrigeration or other form of food preservation technology. It is therefore a highly appropriate technique for use in developing countries and remote areas where access to sophisticated equipment is limited. Fermented foods are popular throughout the world and in some regions make a significant contribution to the diet of millions of individuals (Saloheimo, 2005).

Fermenting fruits and vegetables can bring many benefits to people in developing countries. Fermented foods play an important role in providing food security, enhancing livelihoods, and improving the nutrition and social well-being of millions of people around the world, particularly the marginalized and vulnerable (Anon, 1995), (Anon, 1996).

Consumption of Sauerkraut in Southern Africa and in particular Zimbabwe is low though various varieties of cabbage are grown and consumed. A hypothesis is cited that notes that different cabbage varieties produce different qualities of Sauerkraut and lack of knowledge is the major cause of the apparent marked under consumption of Sauerkraut in Zimbabwe and the Southern African region (Collins et al, 2000). There is an apparent need to develop understanding of the processes that take place in the production of Sauerkraut and their adaptation for commercialisation.

8.2 Cabbage Varieties Mainly Grown in Zimbabwe

According to agronomists in the Zimbabwe Ministry of Agriculture, Cabbage varieties (cultivars) are generally classified according to season of maturity, leaf surface (smooth, savaged, or wrinkled), head shape (flattened, round, or pointed), and colour (green or red). Round, smooth-leaved, green heads are commonest. Varieties differ in their resistance to disease and in the tendency for heads to crack or split in the field. The commonly grown cabbage type in Zimbabwe is the green cabbage and the varieties grown are as follows:

8.2.1 Copenhagen Market

The cabbage heads are of fine quality with a solid construction that excels when used fresh or cooked. The interiors of the head are white and are ideal for making sauerkraut. The leaves are tightly wrapped, so this variety will stand for a long time without splitting and stores extremely well.

8.2.2 Drum Head

Late maturing variety, the heads are large, flat, and somewhat loose and drum shaped. Each head weighs 3-5 kg. Outer leaves are light green with prominent mid-rib.

8.2.3 Green Coronet F1 Hybrid

Green Coronet has a very firm flat round shaped head with an average head size (without frame leaves) of between 3-4 kg with an excellent flavor. An adaptable variety suited for the loose head and bagging market. Green Coronet has an excellent dark green colour, has a good holding ability and excellent bolting tolerance and is well adapted for different climates with exceptional cold tolerance.

8.2.4 Star 3311 F1 Hybrid

A large headed hybrid cabbage variety for the fresh market. A medium to large frame that has an upright leaf habit. STAR 3311 has very firm flat-round shaped heads with an average head size (without frame leaves) of between 2, 5 - 3, 0 kg with an excellent flavour. The colour of STAR 3311 is a typical grey-green which is highly sought after by market agents and hawkers.

8.2.5 Star 3316 F1 Hybrid

STAR 3316 has very firm round to semi-globe shaped heads with an average head size (without frame leaves) of between 3 and 5 kg with an excellent flavour.

8.2.6 Marcanta F1 Hybrid

Marcanta has a medium to large upright frame. Marcanta produces firm round uniform heads with excellent internal quality.

8.2.7 Klabish F1 Hybrid

A small to medium sized hybrid savoy cabbage variety for the fresh and prepacked market. Klabish produces firm round heads. Heads are uniform and internal quality of the head is excellent.

8.2.8 Golden Cultivar

This variety resembles Copenhagen Market in type; but the heads though not quite so large are more uniformly round than Copenhagen. There is an entire absence of coarse veins and leaves and it has the quality of hardening the head before it has attained its mature size.

8.2.9 Rotan F1 Hybrid

A small headed hybrid baby cabbage variety for the fresh and pre-pack market. Heads are uniform and internal quality of the head is excellent.

8.2.10 Adelita F1 Hybrid

Adelita produces firm semi-globe shaped heads. Adelita has good uniformity, allows for a uniform cut in the field.

8.2.11 Cape Spitz

Cape Spitz forms a pointed head of exceptional good quality and is certainly one of the most palatable cabbage cultivars. The leaves are dark green, fairly strongly crisped, so that the head sometimes resembles that of Savoy cabbage.

8.3 Spoilage and Defects in the Sauerkraut Process.

The majority of spoilage in sauerkraut is due to aerobic soil micro-organisms which break down the protein and produce undesirable flavour and texture changes. The growth of these aerobes can easily be inhibited by a normal fermentation. Soft kraut can result from many conditions such as large amounts of air, poor salting procedure, and varying temperatures. Whenever the normal sequence of bacterial growth is altered or disturbed, it usually results in a soft product. It is the lactobacilli, which seem to have a greater ability than the cocci to break down cabbage tissues, which are responsible for the softening. High temperatures and a reduced salt content favour the growth of lactobacilli, which are sensitive to higher concentrations of salt. The usual concentration of salt used in sauerkraut production slightly inhibits the lactobacilli, but has no effect on the cocci. If the salt content is too low initially, the lactobacilli grow too rapidly at the beginning and upset the normal sequence of fermentation (Farnworth, 2003). Another problem encountered is the production of dark coloured sauerkraut. This is caused by spoilage organisms during the fermentation process. Several conditions favour the growth of spoilage organisms. For example, an uneven distribution of salt tends to inhibit the desirable organisms while at the same time allowing the undesirable salt tolerant organisms to flourish. An insufficient level of juice to cover the kraut during the fermentation allows undesirable aerobic bacteria and yeasts to grow

on the surface of the kraut, causing off flavours and discoloration. If the fermentation temperature is too high, this also encourages the growth of undesirable micro flora, which results in a darkened colour. Pink kraut is a spoilage problem. It is caused by a group of yeasts which produce an intense red pigment in the juice and on the surface of the cabbage. It is caused by an uneven distribution of or an excessive concentration of salt, both of which allow the yeast to multiply. If conditions are optimal for normal fermentation, these spoilage yeasts are suppressed (Hammes and Tichaczek, 1994).

8.4 Methodology

8.4.1 Sauerkraut Production

Sauerkraut was produced using local varieties of cabbage as follows:

- Cabbage heads were trimmed, outer leaves removed including all bruised and soiled tissue.
- Cabbage heads were trimmed and washed thoroughly with tap water.
- Cabbage heads were cut in half and the hard, central core removed.
- Cabbage was shred using a knife.
- Shredded cabbage was weighed and sprinkled with salt such that a final concentration of 3% was achieved.
- Salt and cabbage were completely and thoroughly mixed.
- Shredded cabbage was packed into the beakers, filling to approximately 75-80% of total volume. The mixture was compressed moderately while

avoiding crushing or bruising the cabbage tissue until the cabbage was covered by juice.

- Beaker was placed in the anaerobic jars.
- The jars were incubated at 21 ℃ for 17 days.

8.4.2 The Experiments

The Table 8.1 below shows the experiments carried out:

Experiment	Cabbage variety
A(792)	Copenhagen market
B(620)	Green coronet
C(985)	Star 3315
D(781)	Golden cultivar

8.4.3 Lactic Acid and pH Determination

Using pH meter, the pH of the undiluted juice sample was determined. 10 ml undiluted juice sample was added to the Erlenmeyer flask followed by 10 ml of distilled water. The contents of the flask were boiled for 1 min to drive off the dissolved carbon dioxide. It was then cooled and 5 drops of phenolphthalein was added. Titration was done with 0.1 M NaOH until a light pink color persisted. The following formula was used to calculate the percent lactic acid (the predominant nonvolatile acid expected in the sauerkraut fermentation):

$$\% \text{ lactic acid} = [(\text{ml of } 0.1 \text{ M NaOH}) \text{ X } (0.9)] / [\text{sample volume}]$$

8.4.4 Sensory Evaluation Tests

Statistical tools were employed to determine if there was a significance difference in the quality of the sauerkraut produced using the different cabbage

varieties. The quantitative descriptive analysis and paired comparison tests were performed.

8.4.5 Quantitative Descriptive Analysis Tests

The analysis of variance technique in one way analysis of variance (ANOVA) was used and took a set of grouped data and determined whether the mean of a variable differed significantly between groups. The data set had measurements of saltiness, sourness, bitterness, consistency, texture, appearance, and aroma on four cabbage varieties. The analysis sought to evaluate if the sensory attributes changed with samples.

Graphical analysis: MATLAB (mathematical software) was used to analyse the data.

A grouped plot matrix of these variables was created using the gplotmatrix function

>>x= [s1 s2 s3 s4 s5 s6 s7];

>>gplotmatrix(x, [], s8, [])

MANOVA was then used to test statistically if the varieties were significantly different from one another with respect to the sensory quality.

Manova1 function

>> [d, p, stats] =manova1(x, s8)

This gives the results

d=0

p=0.2948

=0.8221

=0.9565

8.4.6 Paired Comparison Test

The paired-comparison test was used to determine whether two paired sauerkraut products from two different cabbage varieties differed in a specified attribute.

Two differently coded samples were presented to each panellist simultaneously and the panellist's task was to choose the one that is perceived as higher or more intense in the specified sensory attribute (www.jstor.org).

8.5 Results

8.5.1 pH and Lactic Acid

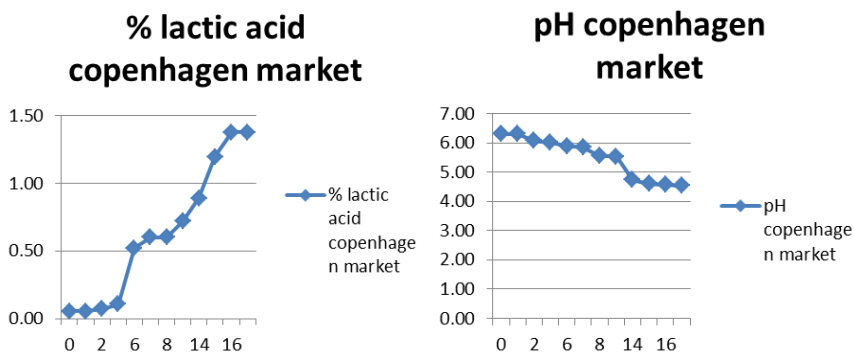

Figure 8.1 *Lactic Acid and pH results for Copenhagen cabbage variety.*

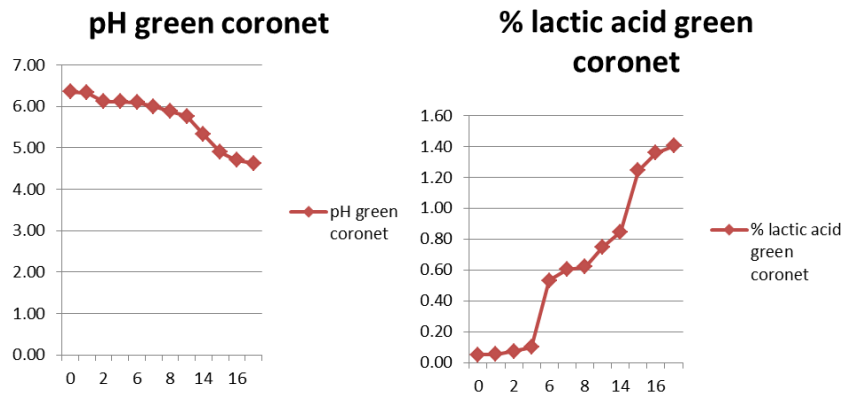

Figure 8.2 *Lactic Acid and pH results for Green coronet cabbage variety.*

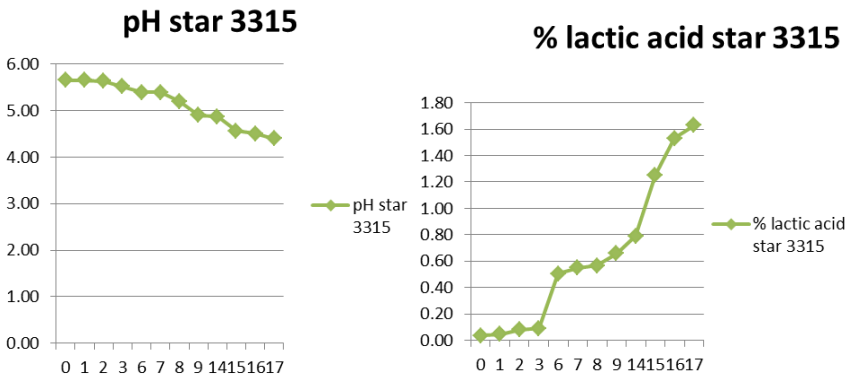

Figure 8.3 *Lactic Acid and pH results for Star 3315 cabbage variety.*

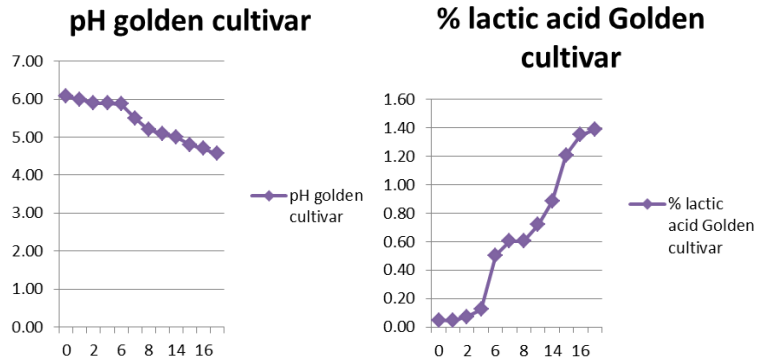

Figure 8.4 *Lactic acid and pH results for golden cultivar cabbage variety.*

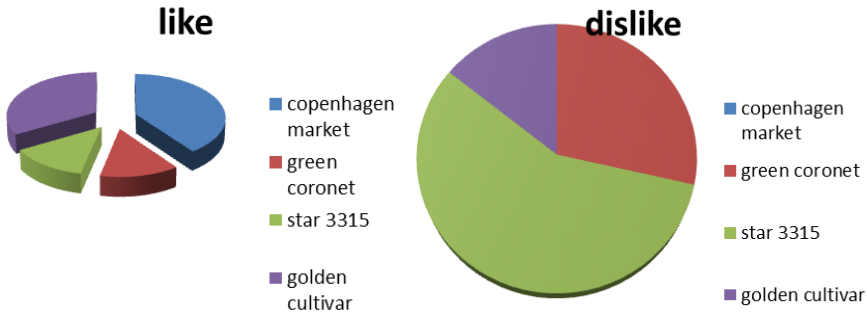

Figure 8.5 *Charts for the like or dislike from consumer preference test using the nine point hedonic scale.*

Table 8.1 *Results for the paired comparison test.*

Sample combinations	**Discussion**
Copenhagen market and Green coronet	Differences were detected by 100% of the panellists and Copenhagen market was preferred to Green coronet
Green Coronet and Star 3315	Difference detected and Star 3315 described to be more salty than Green coronet by 83.3% of the panellists and 16.7% differentiated using colour. Star3315 has a deeper colour than Green coronet
Star 3315 and Golden cultivar	100% of the panellists detected difference and described in terms of saltiness and sourness.
Copenhagen market and Golden cultivar	Differences detected by all the panellists and described in terms of bitterness, colour, odour and saltiness
Copenhagen market and Star3315	Differences detected by all panellists and described in terms of taste, colour, smell and sourness
Green coronet and Golden cultivar	66.6% detected difference and described the difference in terms of bitterness, texture, saltiness, colour and smell and 33.4% did not detect any difference

8.5.2 Qualitative Descriptive Tests Results

Table 8.2 *Qualitative descriptive analysis (QDA) results for the four cabbage varieties investigated.*

Varieties	Saltiness	sourness	Bitterness	Consistency	texture	appearance	Aroma
	6.50	7.30	7.40	5.70	5.40	3.90	7.10
	8.20	7.70	8.00	7.00	7.00	8.40	7.40
A(Copenhagen market)	2.80	6.00	3.10	8.00	8.50	4.00	3.40
	5.90	4.80	2.10	6.30	6.90	7.10	7.00
	9.20	1.20	0.90	5.10	6.30	5.30	2.00
	4.80	5.50	3.80	7.50	6.50	8.00	8.90
	5.50	3.80	3.90	5.50	5.60	3.90	5.30
	4.50	4.70	4.80	5.20	4.10	7.00	6.30
	2.20	8.10	3.10	1.30	8.50	1.50	4.10
B(Green coronet)	3.90	3.30	2.40	2.90	3.60	6.00	5.90
	8.60	1.30	2.20	2.20	7.10	3.70	3.10
	3.50	5.00	4.70	4.40	4.60	4.90	4.10
	9.20	8.20	8.60	6.70	7.00	5.00	3.30
	8.50	8.10	1.20	4.20	3.40	2.40	1.50
C(Star 3315)	9.10	7.50	7.80	1.80	9.10	9.20	2.60
	3.80	2.60	2.30	2.40	2.20	2.10	3.30
	9.00	5.90	5.10	4.90	6.60	6.10	4.40
	6.30	6.20	6.20	7.20	5.00	5.00	3.60
	9.80	7.50	8.00	5.30	3.50	3.60	5.30
	5.00	6.50	4.60	4.50	3.30	2.70	6.20
	1.50	2.80	1.50	1.40	7.40	1.60	3.90
D(Golden cultivar)	5.40	3.10	2.60	6.60	6.00	6.50	5.20
	9.00	7.00	5.00	6.20	6.70	7.20	2.50
	2.70	3.20	3.30	6.90	5.60	5.60	3.80

8.6 Graphical Analysis Results

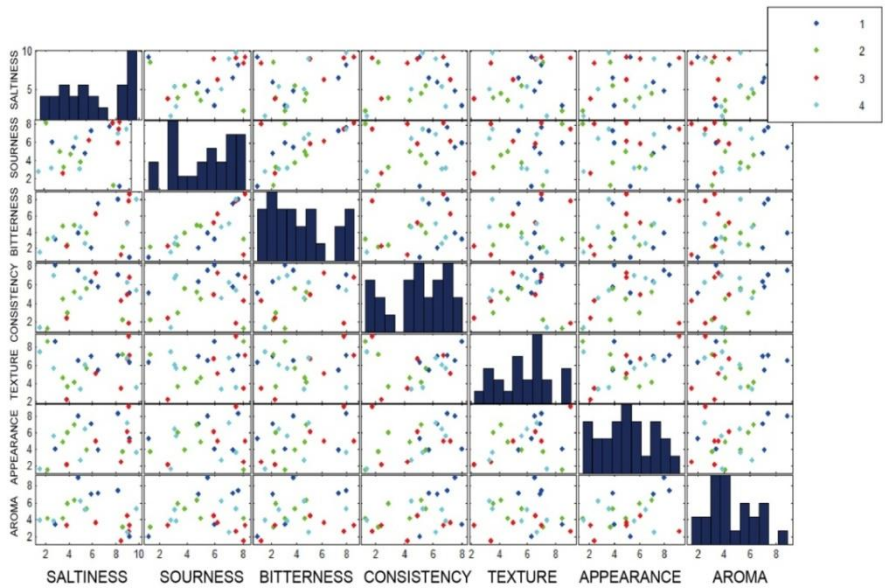

Figure 8.6 *Graphical analysis of the QDA results for the four cabbage varieties investigated.*

8.7 Discussion

Star 3315 had the greatest drop in pH, the final pH was 4.40.pH of Copenhagen market dropped from 6.31 to 4.54, green coronet's pH dropped from 6.35 to 4.63 and golden cultivar had a pH drop from 6.08 to 4.57. The drop in pH in the cabbage varieties is due to the production of lactic acid. Lactic acid was high in Star 3315 variety followed by Green coronet, Golden cultivar and lastly by Copenhagen market. From the hedonic scale results Copenhagen market variety was well liked scoring 40%. Golden cultivar scored 30% and Green coronet and Star 3315 had 13% each. In the range of dislike Star 3315 variety had 57%; Green coronet had 29% and golden cultivar scored 14%.

Copenhagen market was not disliked by any member of the sensory evaluation panel. It can therefore be concluded that Copenhagen market produced sauerkraut that was well liked by panellists.

The manova1 function produced three outputs:

- The first output, d, was an estimate of the dimension of the group means. If the means were all the same, the dimension would be 0, indicating that the means are at the same point. If the means differed but fell along a line, the dimension would be 1. If the dimension is 2, the group means fall in a plane but not along a line.
- The second output, p, was a vector of p-values for a sequence of tests. The first p-value tests whether the dimension, d, is 0, the next whether the dimension is 1 and whether dimension is 2.
- The third output was the stats but in this case it is of no particular importance.

Considering the results obtained the first p-value was small therefore the dimension was 0 and it can be concluded that statistically there was insignificant difference in the quality and sensory characteristics of sauerkraut produced using different cabbage varieties.

8.8 Conclusion

The results for the hedonic test and paired comparison showed that there are differences which can be perceived by consumers. On further analysis with the quantitative descriptive analysis it was found out the differences on the attributes which can be perceived organoleptically are not significant hence

consumption of sauerkraut can be from any cabbage variety. From the research results it was concluded that all the nutritional benefits from sauerkraut can be obtained by increased consumption of sauerkraut made using any cabbage variety that is grown in the country. The revelation of the knowledge of sauerkraut production will make it possible for Zimbabweans to make sauerkraut and draw the nutritional benefits contained therein.

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