



RESEARCH ARTICLE

EFFECT OF DIFFERENT FERMENTATION CONTAINERS ON THE QUALITY OF *GUNDRUK*

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ABSTRACT

Gundruk, a typical indigenous vegetable product of Nepal was prepared from leaves of mustard (*Brassica juncea*) and cabbage (*Brassica oleracea capitata*) in different fermentation containers viz. glass jar, wooden box, earthenware pots and plastic jars which were evaluated sensorially and analyzed chemically. Sensory analysis revealed higher acceptability for *gundruk* prepared in glass jar compared to others. The moisture content, crude fiber, ash, calcium and iron contents on dry basis were found to be 7.92%, 14.65 g/100g, 0.68 g/100g, 2253 mg/100g and 86.4 mg/100g respectively for *gundruk* prepared in glass container. The optimum acidity and pH for *gundruk* prepared in glass was found to be 1.0% (as lactic acid) and 3.9 respectively on 9th day of fermentation.

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INTRODUCTION

In the context of Nepal, fermented food constitute the major nutrient items for rural masses that form the bulk of population in the country. Fermentation of vegetables, dairy products, cereals and beans, as also alcoholic beverages, has been in practice in Nepal since a long time. A significant quantity of fermented foods is produced and consumed throughout the country (Karki, 1984). *Gundruk* is one of the most prized fermented foods of Nepal. Technically it is a traditional, non salted fermented leafy vegetable product indigenous in Nepal. *Gundruk* is primarily valued for its uniquely appetizing taste or flavor. From nutritional standpoint, *gundruk* can be considered as a concentrated source of minerals, vitamins, therapeutically active compounds. Findings suggest that if consumed regularly, there is no denying that *gundruk* solves some of our nutritional problems (Upadhaya, 2002).

Pediococcus and *Lactobacillus* species are the predominant micro-organisms during *gundruk* fermentation. The fermentation is initiated by *L. cellobiosus* and *L. plantarum*, and other homolactics make a vigorous growth from the third day onwards. *Pediococcus pentosaceus* increases in number on the fifth day and thereafter declines (Karki *et al.*, 1983). During fermentation, the pH drops slowly to a final value of 4.0 and the amount of acid (as lactic) increases to about 1% on

the sixth day (Karki *et al.*, 1983). Nepal has a population of about 27,641,000 (UNICEF, 2010) of which 90% is involved in agriculture. A conservative estimate reveals that the annual production of fermented leafy vegetable pickle *gundruk* is 2000 tonnes (Wiki, 2010) and *sinki* (another fermented Rooty vegetable pickle *gundruk*) is 1000 MT (Karki *et al.*, 1984). *Gundruk* is valued for its uniquely appetizing flavor. *Gundruk* is used as an alternative source of green vegetables in the lean season. In Nepal about 2% of the *gundruk* production is industrialized (Rai, 2004). The most common raw material used for the preparation of *gundruk* in the country is mustard leaves. However, depending on the availability of the raw materials, *gundruk* has been prepared in the country using various other leaves, e.g. radish (*Raphanus sativus*), rapeseed (*Brassica campestris* var. *toria*), cauliflower (*Brassica oleracea*), etc (Upadhaya, 2002). Traditionally *gundruk* has been prepared at household levels using different fermentation mediums such as pit, *dhungro*, wood, plastic jars, glass jars and earthenware pots. But no best material for *gundruk* preparation has been known (Personal Communication, 2009).

Nowadays traditional foods are gradually disappearing from the diet. The trend, particularly from many developing nations in Asia, declining towards consumption of foreign food is increasing. Traditional foods contribute to generate employments and income. The change in diet is largely linked to changes in income and wealth, the wider availability of a range of alternate foods, changing perceptions and values of foods, changing demographics and globalization of trade etc (Khadka, 2005). The use of *gundruk* as a food in Nepal is lost in antiquity but the popularity of the product is still very high.

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An estimate reveals that *gundruk* is more consumed in rural areas than in the urban regions. The cheapness of the product and the ease of preparation is the main reason for so. But hygienic quality of product is always under question and hence the product is not commonly eaten in the big cities (Upadhyay, 2002).

Gundruk is good source of nutrient but its tendency among the educated urban class to suspect its hygienic and nutritional quality because of the methodology adopted in the preparation of *gundruk* is prevalent. The present study is therefore a preliminary effort towards finding the possibility of improving the traditional technology to commercialize using best fermentation container for preparation of the best quality of *gundruk*. The study will also focus in value-addition of the surplus and wastage vegetable leaves but the overall emphasis will be on the application of appropriate technology for the commercial production of good quality *gundruk* using different fermentation containers.

If the most potential products could be commercialized, huge numbers of people will have alternate source of income. At present, majority of traditional foods are made in the household level for direct consumption or sale, and with very little in the way of commercialization. With a little technical assistance and attention to hygienic and quality, many of the products could be commercialized.

MATERIALS AND METHODS

Raw materials

Leaves of mustards (*Brassica juncea*), locally called *thulo tori* were brought from *Panmara, Panchakanya V.D.C, Sunsari* district and cabbage (*Brassica oleracea capitata*) was brought from local market of Dharan. Selection was made on the basis of freshness.

Other materials

For the preparation of *gundruk* 8 plastic (HDPE) bottles, 8 glass bottles, 8 earthenware pots (1/2 kg capacity) and 8 small wooden boxes were brought from local market of Dharan. A set of mortar and pestle was also taken for the fragmentation of leaves. All above containers were disinfected with 1.25 % KMS solution.

Method of *gundruk* preparation

The mustard leaves and cabbage leaves were manually cleaned and washed in potable water to remove dirt and other adhered foreign matters. Cabbage was cleaned and shredded to 5 cm length. The cleaned leaves were withered in the sun for a day on the plastic mat at ambient temperature. The leaves were withered in cabinet dryer to moisture content of 40±5% at a temperature of 45±5°C. The withered leaves were cut into 5 cm in length and crushed in a clean mortar. The leaves were tamped gently and uniformly (placing little amount at a time making alternative layer with shredded cabbage) in 32 sterile fermentation jars. All the containers (Glass, wood, plastic and earthenware), withering plastic mat and mortar and pestle were disinfected with 1.25% KMS (Potassium Metabisulfite) solution. 600-700g of leaves was

places in each jar. The mouths of the jars were tightly closed by covering with clean polyethylene bags. The incubator was disinfected with formalin before use. The samples were fermented at room temperature for up to 12 days at 24±1°C temperature. Final drying of the product was done in cabinet drier at temperature 40±5° C to moisture less than 10%. The outline of *gundruk* preparation and testing used in the present study is given in Fig. 1.

Sampling

Samples were taken out from 6th day onward for sensory, pH and acidity analysis. Each container represented a sample and it was not reused for further fermentation or analysis. Samples were taken out between 11 AM to 1 PM to adjust the time period of fermentation.

Chemical analysis

Determination of moisture

The moisture content was determined by hot air oven method as described in AOAC (2005).

Determination of acidity and pH

Acidity was determined by titrimetric method described by Ranganna (2002) and pH by pH meter.

Estimation of total ash

Total ash was estimated following the method described by Ranganna (2002).

Estimation of minerals

Calcium content was estimated by titrimetric method and iron content was estimated by colorimetric method as described by Ranganna (2002).

Estimation of crude fiber

Crude fiber was determined by method as described by AOAC, (2005).

Sensory evaluation

Sensory evaluation was carried out using 9-point hedonic rating as described by Ranganna (2002). The samples were placed in Petri-plates with code numbers and presented to 20-members (teachers, laboratory staffs, library staffs and students who were habituated of eating *gundruk*) sensory panelists in CCT. Sensory evaluation was carried out for the quality attributes *viz.*, color, flavor, taste and overall acceptability to carry out comparative evaluation of *gundruk* prepared in different types of containers *i.e.* plastic, glass, wood and earthenware.

Statistical analysis

The experiment was conducted in triplicates. The data were subjected to ANOVA by GenStat programming (GenStat Discovery version). The means were compared using LSD at

$P \leq 0.05$ and the best treatment was selected.

RESULTS AND DISCUSSION

According to the protocol given in Fig. 1, different samples of gundruk were prepared in different containers viz. glass jar, wooden box, earthenware pot and plastic jar and analyzed. The results obtained with discussion are as follows.

Change in acidity and pH during fermentation

The change in acidity with fermentation days is given in Fig. 2. The statistical analysis shows that there was no significant difference between samples for acidity on zero day of fermentation. All samples had same mean acidity value 0.1. There was no significant difference between samples for acidity on 12th day of fermentation. The mean acidity for sample A, B, C and D were found to be 1.0, 1.05, 1.01 and 1.03 (% in lactic acid). On 6th day of fermentation, the mean acidity value for sample A, B, C and D were found to be 0.8, 0.85, 0.9, and 0.95 (% as lactic acid). The LSD values indicate that sample A was significantly different from sample B, C and D on 6th day of fermentation. The score was highest for sample D. Sample A was significantly different from B, C and D on 9th day of fermentation. The mean acidity value for sample A, B, C and D were found to be 1.0, 1.1, 1.2 and 1.3 (% as lactic acid). Sample D scored highest points for acidity.

The Fig.2 suggests as fermentation days increases, the acidity (as lactic acid) increases but after an optimum value, the acidity becomes constant or slightly decreases. On 6th day of fermentation, the highest acidity is 0.95% which was scored by sample D. On 9th day, the acidity was found to be increased significantly for all samples and the highest acidity is 1.3 which was scored by sample D. On 12th day, however, no significant increase in acidity was found for all samples. The initial stage of fermentation was aerobic. The initiator organism was probably *Leuconostoc mesenteroides* (Karki, 1986). This organism has a good capability of attacking sucrose and fructose producing acidity at the initial stages of fermentation, thus inhibiting non-lactic bacteria. Stocking out oxygen and rising acidity level may be the main reason for the disappearance of *L. mesenteroides*. Immediately, the working place was dominated by heterofermentative *Lactobacillus brevis* and homofermentative *Lactobacillus plantarum*. This two species were responsible for the increase in acidity upto a maximum level. But the termination of fermentation was worked out by *L. plantarum*

Change in pH with fermentation days is shown in Fig. 3. The statistical analysis shows that there was no significant difference between samples for pH on zero day of fermentation. All four samples had same pH values 5.5. There was no significant difference between samples for pH on 12th day of fermentation. The mean pH values for sample A, B, C and D were found to be 3.9, 3.85, 3.85 and 3.83 (% as lactic acid). On 6th day of fermentation, mean pH value for sample A, B, C and D were found to be 4.4, 4.2, 4.1 and 4.0 respectively. The LSD values indicate that the sample A was significantly different from sample B, C and D on 6th day of fermentation. Sample A had highest pH. Sample A was significantly different from B, C and D on 9th day of fermentation. The mean pH values for sample A, B, C and D

were found to be 3.9, 3.8, 3.7 and 3.6 respectively. Sample A had highest pH. The Fig. 3 suggests as fermentation days increases, the pH values decreases in the same manner as acidity increases. But the trend does not remain same after 9th day of fermentation due to stopping of fermentation. On statistical analysis between the 9th and 12th days taking the samples, no significant difference was found between the samples for pH and acidity. It suggests that there was no significant difference in acidity and pH on 9th and 12th day which means *gundruk* had reached its optimum value of acidity and pH on 9th day of fermentation.

Hence, from both the figures, it can be concluded that as fermentation days increases, acidity (as lactic acid) increases while pH decreases till fermentation ceases completely. Also the trend of change remains the same from 6th to 9th days. The above result complies with Karki *et al.*, 1983 who concluded during fermentation the pH drops slowly to final value of 4.0 and the amount of acid (as lactic acid) increase to about 1% which was found in 9th day of fermentation in present study. The significant difference in acidity and pH might be due to different properties of fermentation containers.

Sensory analysis

Sensory evaluation was carried out on the products obtained on 9th day only. The sample of this day was chosen on the basis of fermentation as fermentation was terminated on this day. The mean sensory score is shown graphically in Fig. 4.

Flavor

The mean sensory score given by panelist for flavor for samples A, B, C and D were found to be 6.65, 6.5, 6.5 and 5.6 respectively. The score was highest for sample A. The LSD indicates that the sample A was significantly different from sample D but non significant with samples B and C for flavor at 5% level of significance. Among sensory attributes the flavor is considered to be the most important factor in determining consumer's response. Flavor of all samples on 9th days of fermentation improved because during fermentation the metabolic processes are responsible for the basic flavor changes. In *gundruk* prepared in glass, due to good protection of odor (FAO, 2010) and due to high purity and high homogeneity of glass more flavoring compounds were retained and hence, got highest scores. But most of the panelists liked the flavor of samples A, B and C.

Color

The mean sensory score given by panelist for color for samples A, B, C and D were found to be 6.7, 6.5, 5.5 and 5.65 respectively. The score was highest for sample A. The LSD values indicate that sample A was significantly different from C and D but non significant with B for color at 5 % level of significance. Sample C and D were non significant different but sample B was significantly different from C and D. Although the sample A and B were none significant difference, the mean sensory score is highest for sample A.

Taste

The mean sensory score given by panelist for taste for samples A, B, C and D were found to be 6.4, 5.85, 5.6 and 5.05

Table 1: Chemical composition of *gundruk* (per 100g sample)

Parameters	A	B	C	D
Moisture content (%)(wb)	7.92(0.12) ^a	8.13(0.05) ^a	8.05(0.19) ^a	7.87(0.11) ^a
Crude fiber (g/100g)(db)	14.65(0.31) ^a	14.85(0.16) ^a	14.56(0.18) ^a	14.79(0.30) ^a
Ash (g/100g)(db)	0.68(0.08) ^a	0.64(0.11) ^a	0.66(0.06) ^a	0.69(0.13) ^a
Ca (mg/100g)(db)	2253(2.51) ^a	2247(3.60) ^a	2249(2.08) ^a	2249(2.08) ^a
Iron (mg/100g)(db)	86.4(3.79) ^a	84.3(2.67) ^a	83.0(2.13) ^a	89.6(3.11) ^a

Where, A: *Gundruk* in glass jar, B: *Gundruk* in wooden box, C: *Gundruk* in earthen pot and D: *Gundruk* in plastic jar. wb: wet basis and db: dry basis.

Note: The values are the means of triplicates. The figures in the parenthesis are standard deviations. Values in the row bearing similar superscript did not differ significantly at 5% level of significance.

Outline of *gundruk* preparation

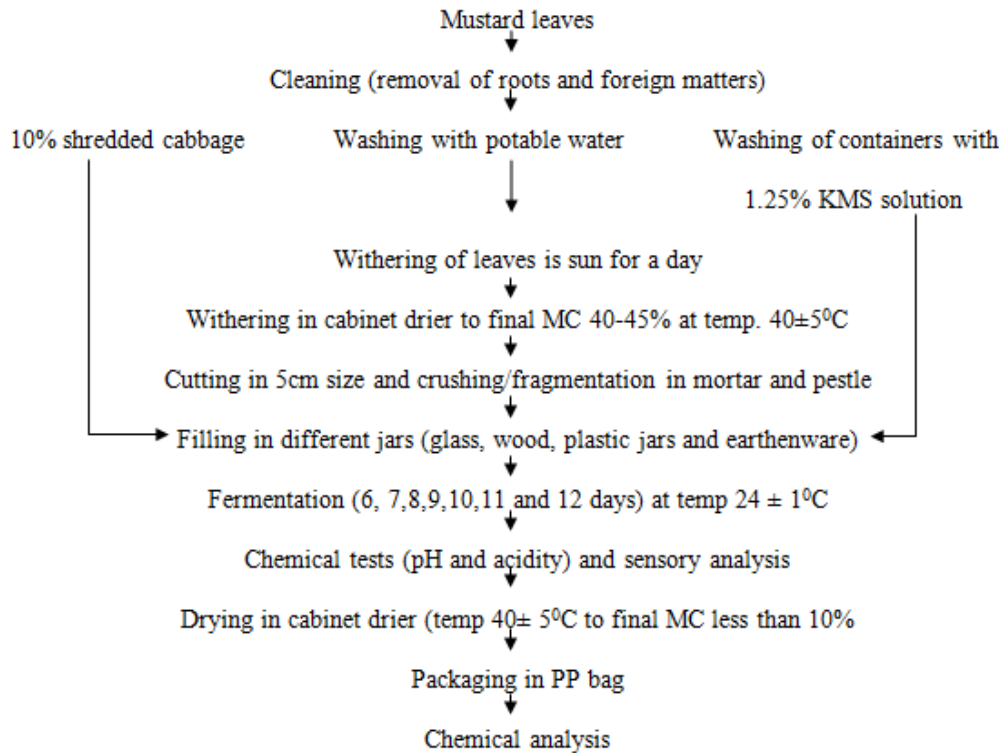


Fig 1. Outline of *Gundruk* preparation

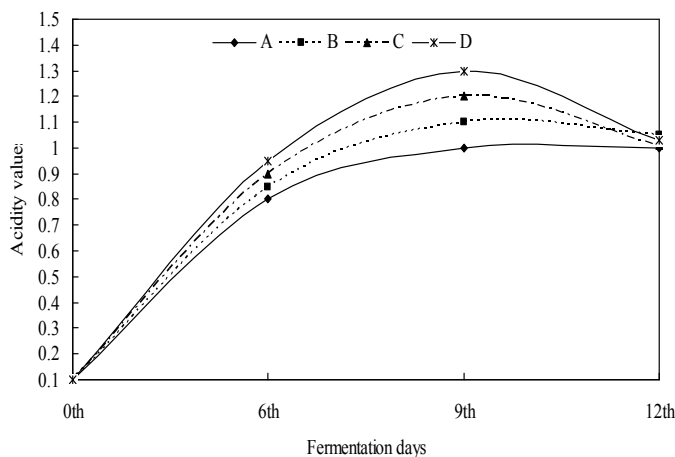


Fig. 2 Change in acidity with fermentation days

where A: *gundruk* in glass jar, B: *gundruk* in wooden box, C: *gundruk* in earthen pot and D: *gundruk* in plastic jar.

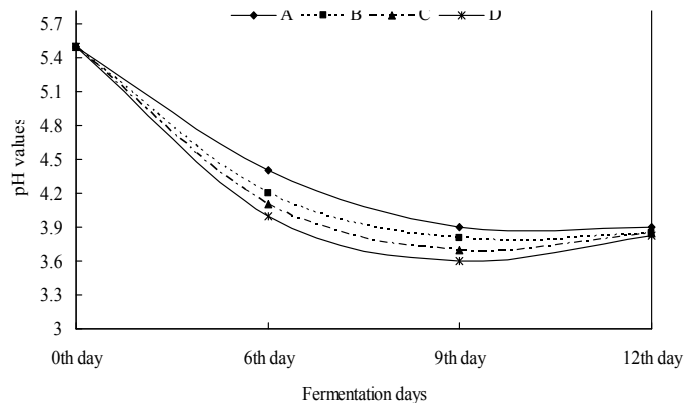


Fig. 3 Change in pH with fermentation days

where A: *gundruk* in glass jar, B: *gundruk* in wooden box, C: *gundruk* in earthen pot and D: *gundruk* in plastic jar.

Sensory scores for *gundruk*

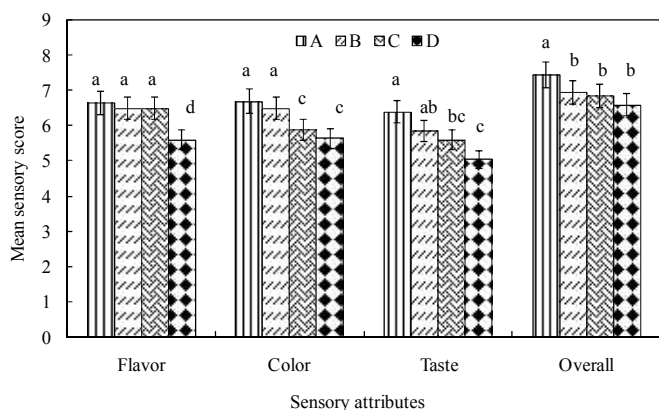


Fig. 4. Mean sensory score for *gundruk*

Note: The values are the means of triplicates. Values in the bars bearing similar superscript are not significantly different at 5% level of significance, Where, A: *gundruk* in glass jar, B: *gundruk* in wooden box, C: *gundruk* in earthen pot and D: *gundruk* in plastic jar.

respectively. The score was highest for sample A. The LSD values indicate that sample A was significantly different from C and D but was non significant with B for taste at 5% level of significance. Similarly sample C is significantly different from A and B but non significant with sample D. Although the sample A and B were non significantly difference, the mean sensory score is highest for sample A.

Overall acceptance

The mean sensory score given by panelist for overall acceptance for samples A, B, C and D were found to be 7.45, 6.95, 6.85 and 6.60 respectively. The score was highest for sample A. The LSD values indicate that sample A was significantly different from samples B, C and D at 5 % level of significance but sample B, C and D were non significant different with each other. Hence sample A can be regarded superior in terms of overall acceptance. In this study, the sample A was significantly different from sample D but non significant with samples B and C for flavor at 5% level of significance. Although the samples A, B and C were non significant different, mean sensory score is highest for sample A. Similarly, the sample A was significantly different from C and D but non significant with B at 5 % level of significance for color. Sample C and D were not significantly different but sample B was significantly different from C and D. although the samples A and B were non significant different, mean sensory score is highest for sample A. so, sample A can be regarded superior in terms of color. Similarly, the sample A was significantly different from C and D but was non significant with B for taste at 5% level of significance. Although the sample A and B were not significant, mean sensory score is highest for sample A. Although the sample A and B were not significantly different ($p \leq 0.05$) on flavor, color and taste but sample A got highest score for all sensory attribute revealed from the above result and discussion, and sample A was statistically superior for overall acceptance. Hence, on this basis sample A i.e. *gundruk* prepared in glass jar was found to be best.

Chemical composition of *gundruk*

The chemical composition of *gundruk* is given in Table 1. The result and discussion about respective parameters are as follows:

Moisture

The moisture content of samples was not found significantly different at 5% level of significance for all samples. The moisture contents for all samples were found to be within general requirements for *gundruk*. Non significant difference in moisture might be due to drying of all samples in cabinet drier to fixed moisture content for fixed time period. The final moisture content for all samples in this study was below 10% which is safe level for dried product like *gundruk*. In similar works by Shrestha, 2002 found 6.6% moisture content for solar dried *gundruk* and 9.6% for sun dried *gundruk*. *Gundruk* is a product with high acid and least sugar content, and hence is an unfavorable environment for the proliferation of most microorganisms. Consequently, it may not be necessary to bring down moisture level below 6% which is the required level for dried fruits and vegetables (Shrestha, 2002).

Ash content

There was no significant difference between the ash content of the different samples prepared in different fermentation containers at 5% level of significance. The ash content was found to be 0.68 g/100g on dry basis for sample A. Non significant difference in ash content for all samples might be due to raw material of same variety and same season having similar composition.

Calcium content

There was no significant different ($p < 0.05$) between all samples for calcium contents. The calcium (mg/100g) on average was found to be 2253 mg/100g for sample A. The above results are quite close to Food Composition Table (Anon, 1994) for Mustard *gundruk*.

Iron content

There was no significant different ($p < 0.05$) between all samples for iron contents. The iron content (mg/100g) on average was found to be 86.4 mg/100g for sample A. The above results are quite close to Food Composition Table (HMG-N, 1994) for Mustard *gundruk*. Green vegetables are good source of mineral and vitamin content. In present study, only minerals were estimated because these are the major minerals known to be absorbed from the vegetables. Thus it can be concluded that *gundruk* contains appreciable amounts of minerals, particularly calcium and iron. Hence, *gundruk* which is consumed only for organoleptic reasons must be now recommended as food to meet minerals requirements of our body.

Crude fiber

There is no significant difference between crude fiber at 5% level of significance for all samples prepared in different fermentation containers. The crude fiber was found to be 14.65 g/100 g on dry basis of *gundruk* for sample A. Non significant difference in crude fiber for all samples might be due to raw material of same variety and same season having similar composition.

Conclusions

The chemical composition of all *gundruk* samples were found to be remain as same irrespective of fermentation containers. Fermentation container has found to have significant effects the sensory quality of prepared *gundruk*. The *gundruk* was

prepared on 9th day of fermentation at temperature 24±1°C. As fermentation days increases, acidity increases while pH decreases till maximum value which is found at 9th day of fermentation. Among all the fermentation containers used, the *gundruk* prepared in glass container was found to be had best quality. *Gundruk* is a good source of minerals esp. calcium and iron.

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