Effect of Harvesting Stages of Maize on Quality and Consumption Preferences of *Tengma*

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ABSTRACT

Local cornflake or beaten maize known in the eastern Bhutan as Tengma is one of the most popular processed maize products in Bhutan. The colour, taste and texture are important quality attributes of Tengma, which are influenced by harvesting stage of maize. This study on colour, taste, texture and the general quality acceptability of Tengma was conducted to identify optimal harvesting stage of maize for processing Tengma. The study was conducted at Thridangbi Chewog under Saling geog, Mongar Dzongkhag. Maize harvested at milk, dough, dent and physiologically matured as well as maize from previous season were collected from Agriculture Research sub-center, Lingmethang and were processed using farmer's cornflake machine following local processing method. Colour, taste, texture and overall acceptability were done by 30 panelists representing various sectors while total soluble solids (TSS), moisture content (MC) and weight were recorded using refractometer, moisture meter and weighing scale, respectively. The results indicate MC and TSS were significantly higher ($p \leq 0.05$) in Tengma processed from maize grains harvested at milk stage (MS). Tengma processed with maize grains harvested at dent stage scored the highest "extremely like" of 47% in terms of color. In terms of taste and texture, Tengma processed using maize grains harvested at milk and dough stage scored the highest "extremely like" and "like" rating of 90% to 97% each. In overall acceptability category, Tengma processed using maize grains harvested at MS and from the previous season had the highest "extremely like" or "like" score of 100% and "extremely dislike" score of 25%, respectively.

Keywords: *Colour, Moisture content, Physiologically matured, Taste, Texture and total soluble solid*

1. Introduction

Maize (*Zea mays*) is the most widely cultivated cereal crop globally. The average yields of traditional varieties grown by small-scale farmers is around 0.8 tha^{-1}, compared with 2 to 5 tha^{-1} for improved varieties (Hoopen & Abdou, 2012). The Total area under maize cultivation in Bhutan in 2010 was 61,676 acres with a total production of 57,666 t with a national average yield of 2.38 t ha-1 (DOA, 2013).

Maize in several countries is both a staple food and a cash crop for small holder farmers. As a food it can be prepared in many different ways (fried, grilled, salad or soup). Processing maize

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can also produce a wide range of products such as corn flour, corn flakes and corn meal. In Bhutan, maize products are consumed in different forms, such as *Tengma* (roasted and pounded maize), *Kharang* (maize grit), popcorn, roasted and flour. It is also used for brewing beverages such as *Bangchhang* (local ale) and *Ara* (local alcohol). Maize is also used as a feed for livestock.

In Bhutan maize is grown all over the country, but is more popular in the eastern region. About 45% of the total maize production comes from the six eastern districts of Trashigang, Samdrup Jongkhar, Pemagatshel, Trashiyangtse, Monggar and Lhuntse (FAO, 2014). Over 70% of the households cultivate maize mainly for subsistence (NBC, 2008) and therefore, it plays a crucial role in achieving household food security. Maize constituted 43.7% of the national food composition in 2011. The area under maize cultivation is 70,171 acres (constituting 44.2% of the cultivated area) with a total production of 79,667 t (DoA, 2013). The national average yield is 1.135 t ha^{-1}, while the average yield of maize in eastern region is 1.310 t ha^{-1}(DoA, 2013).There are 81 varieties or landraces of maize cultivated in Bhutan (NBC, 2008) covering an altitudinal range of 300 masl to 2,800 masl (Katwal et al., 2013).

The rural households sell about 6% of the total maize production (Katwal, 2013). Maize is either sold to the Food Corporation of Bhutan or to feed companies or to dealers across the borders. *Kharang* and *Tengma* are the most popular processed maize products in the country, and sold mostly in the local markets. Katwal et al. (2007) reported that there were about 73 effective *Tengma* processors in the country with most of them concentrated in the eastern region.

To process *Tengma* maize has tobe roasted in a pan and pounded either in a machine or in a traditional wooden pound. The maize at milk, dough, dent, and physiologically matured can be used for processing *Tengma* immediately after harvesting whereas maize grains harvested in previous season have to be boiled and soaked in hot water overnight before processing. In absence of scientifically recommended harvesting maturity index for maize meant for processing *Tengma*, farmers depend on visual and other clues to judge whether maize are good for processing. Too matured or immature maize grain meant for processing *Tengma* could compromise eating and other quality attributes such as texture, sugar content and keeping quality of the processed *Tengma*.

Therefore this study is designed to determine the optimal harvesting stage(s) of maize meant for processing good quality *Tengma*in terms of colour, taste and texture and overall acceptability.

2. Materials and Methods

The experiment was conducted in Thridangbe Chewog under Saling Geog, Monggar dzongkhag. Maize is one of the major cereals grown in this geog and it is cultivated twice a year.The 347 households in the geog cultivate maize. The total area under maize cultivation is 504 acres with production of 617 t and an average yield of 1,224kg Ac^{-1} (DoA, 2013).

The study had five treatments corresponding to five different development stages of maize grain (T 1 – dough, T 2- milk, T3- dent, T4- physiologically matured and T5-previous season maize). Each treatment was replicated five times and each replication weighed 4 kg of maize grains.

Maize (Yangtsepa[1] variety) was harvested from field of ARDC sub-center, Lingmethang at five different stages (milk, dough, dent and physiologically matured), and the cobs were de-husked and shelled. The maize harvested in previous season was collected from the store of the ARDC sub-center based in Lingmethang. Maize cobs harvested at milk stage were blanched in boiling water for about five minutes and kept overnight before shelling to ease shelling. After shelling the grains were spread on bamboo mat and plastic sheets to dry the surface water.

For each replication the shelled maize grains were weighed using an electrical weighing balance (Model # DS-252). The maize grains were then roasted for 20 to 30 minutes in traditional roasting pan at a temperature of 110^0C – 120 ^{0}C. A laser gun thermometer was pointed at the grains to take the temperature reading of the grains. For each replication three readings were taken and averaged.

The grains were kept overnight in room temperature and roasted again for a second time before pounding into tengma. The temperature for second roasting ranged from 130 ^{0}C – 140 ^{0}C. For the maize from previous season the grains were first boiled for 30 minutes and soaked overnight as traditionally practiced by the farmers in the locality before roasting and pounding into *Tengma*,

Moisture content (MC) of maize grains was measured before and after roasting using a moisture meter (G-7, Grain Moisture meter, DELMHORST INSTRUMENT Co.). About 10-14 grains were randomly selected for each replication and were placed on the measuring plate of moisture meter to read the moisture content.

The final processed product *Tengma* was tested for qualities such as colour, taste, texture, overall acceptability and TSS content (sugar content). For determining TSS, the processed *Tengma* was first powdered using a mixture grinder and 5 g of this powder from each replication stirred in 45 ml of distilled water in a breaker and heated for five minutes. The solution was filtered and a few drops of filtered solution were placed on the lens of a refractometer to obtain the reading for a particular sample *Tengma*.

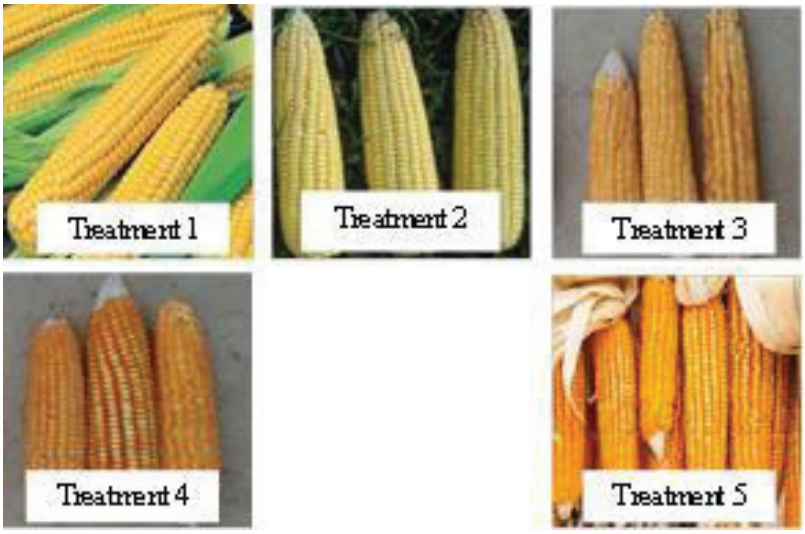

Figure1.Different stages of maize used for *Tengma* processing

The weight of fresh grains and the final processed *Tengma* for each replication was measured using electric digital weighing balance.

Sensory evaluation of colour, taste, texture and overall acceptability was done using a 5-point hedonic scale with 5 being extremely like and 1 being extremely dislike. A 30-member panelist comprising farmers and agricultural officers evaluated the above qualities. The panelist tasted as well made visual and sensory observation of individual samples and their individual observations were recorded in the evaluation form.

The data generated from experiment were analyzed using the Statistical Package for Social Science (SPSS) 16.0. Quantitative data such as weight, sugar content and MC were analyzed using One Way ANOVA and Microsoft Excel 2008. *P* values ≤ 0.05 were considered significant in all the analyses. For the qualitative data on sensory evaluation, the results were interpreted in proportions/percentages because statistical analysis of such data is still mired in controversies.

3. Results and Discussion

3.1. Moisture content of maize grains before and after roasting and processing

Moisture content (MC) of maize grains before roasting was significantly different between all the stages of harvest (Table 1). The highest MC was observed in maize grains harvested at milk stage (35 ±.13%) followed by those grains harvested at dough stage (29.06 ± .08%). The lowest MC (12.50± .05%) was in maize grains of previous season harvest.

The MC (25.18 ± .40%) after roasting was significantly higher in maize grains harvested at dough stage compared to maize grains harvested at all other stages. While the MC after roasting

was not significantly different between the maize grains harvested in milk stage and physiologically matured ones, the former had significantly higher than maize grains harvested at dent stage and from the previous season maize. The latter and dent stage maize grains had significantly higher MC than the maize grains harvested at previous season. The MC of *Tengma* was significantly higher in maize grains harvested at milk stage (13.14± 1) compared with the maize grains harvested at all other stages except the dough stage. There was no significant difference in MC of maize grains harvested in other stages.

According to Reyneri and Mairano (2010) developing maize kernels accumulate more water than reserves early on the development stage, reaching a 90% or higher moisture content. The kernel moisture content then declines progressively as kernel continuous to mature. During early grain filling stage, moisture declines from around 70% to around 18% at harvest. As per the Indian standard, moisture content of corn flakes should be more than 7.5% and all brands of corn flakes in the Indian markets are found within the required limit (Consumer voice, 2012). Lhendup (2009) pointed out that while roasting maize in open flame, the moisture from maize dries up, thereby reducing the MC in *Tengma*.

Table 1.MC of maize grain before and after roasting and processing, TSS and weight of *Tengma* (Mean ± Standard Deviation)

Treatments	MC before roasting (%)	MC after roasting (%)	MC of tengma (%)	TSS(^{0}B)	Weight (Kg)
Dough stage	29.06 ± 0.08^{b}	25.18 ± 0.40^{a}	12.00 ± 1.40^{ab}	10.00 ± 1.22^{ab}	1.81 ± 0.02^{a}
Milk stage	35 ± 0.13^{a}	20.22 ± 1.10^{b}	13.14 ± 1.00^{b}	12.04 ± 0.08^{b}	2.83 ± 0.14^{b}
Dent stage	27.32 ± 1.26^{c}	18.82 ± 0.64^{c}	10.58 ± 1.04^{a}	9.00 ± 2.44^{ac}	2.94 ± 0.09^{bc}
Physiological maturity stage	24.76 ± 0.43^{d}	19.35 ± 0.15^{bc}	10.92 ± 1.21^{a}	6.20 ± 2.28^{d}	3.07 ± 0.10^{c}
Previous season maize	12.50 ± 0.05^{e}	14.36 ± 0.59^{d}	10.82 ± 0.61^{a}	5.60 ± 2.60^{d}	2.91 ± 0.10^{bc}

Means within a column with different superscripts differ significantly ($p \leq 0.05$)

3.2. Total Soluble Solids

The total soluble solids (TSS) in *Tengma* processed from maize grains harvested at milk stage was significantly higher compared to *Tengma* processed from maize grains harvested at all other stages except the *Tengma* processed from maize grains harvested at dough stage (Table 1). The TSS in the latter and *Tengma* processed from maize grains harvested at dent stages were similar, but they were significantly higher from the TSS of *Tengma* processed from maize grains harvested at physiologically matured and in previous season. The TSS of the latter two stages

was not significantly different from each other. The findings of this study are in line with the study of Pajic et al. (2004), which states that maize when consumed at milk stage is sweeter because it contains around 15-35% sugar and 20-30% starch. However, Sygenta® (2011) reports that maize variety Winter Sweet contains about 15-20% sugar and variety Sugar 75 about 16% sugar, which is higher than sugar content found in *Tengma.*

Huang (2013) stated that MC at the time of harvesting affects the composition and nutritive value of the maize. Similarly the high sugar content in milk stage of the corn could be due to proper nutrient management practices, which results in higher protein and sugar content (Shinde, Patange & Dhage, 2014).

According to Office of the Gene Technology Regulator (2008), sugar content in maize kernels will be high at the milk and early dough stage of the grain development.

Plessis (2003) reported that at soft dough stage maize grain mass increases and the sugar get converted into starch and in the hard dough stage sugar in the maize grains decreases rapidly, while starch accumulation increases.

A black layer cell formation at the base of kernels indicates the stoppage of flow of sugars from leaves to the kernels (Brewbaker, 2003). A black or brown layer cell formation on the kernel indicates the physiological maturity of corn (Lee, 2011**)**.

3.3. Weight of *Tengma*

Tengma recovery was significantly influenced by the stage at which maize was harvested ($p \leq 0.05$). Tengma made from maize grains harvested at physiological maturity had the highest weight at 3.07 kg. This was followed by *Tengma* processed from maize grains harvested at milk stage and dough stage at 2.83 kg and 1.8 kg, respectively (Table 1). It was however, not significantly different from weight of *Tengma* processed from maize harvested at dent stage and previous season. The latter two were not significantly different from each other, but differed significantly with the weight of *Tengma* processed from maize grains harvested at dough stage.

The highest recovery (or final weight) obtained in *Tengma* processed from maize grains harvested at physiologically matured could be because of lower MC and high starch accumulation in the grains compared to *Tengma* processed from maize grains harvested at milk and dough stages.

3.4. Sensory Evaluation

3.4.1. Colour of Tengma

Visual appearance such as color is an important quality aspect that could, to some extent, influence consumer's decision to purchase. The color of *Tengma* processed using grains harvested at different stages was varied. *Tengma* processed using maize grains harvested at dent stage scored the highest "extremely like" rating at 47% followed by *Tengma* processed using maize grains harvested at physiologically matured at 27% (Figure 2). The least color rating was for *Tengma* processed using maize grains harvested at dough and milk stage at 10% each. This

could be because dough and milk stage maize grains contain more moisture and sugar than protein, which is responsible for golden yellow color. Milk sugar being whitish does not give attractive coloration in physiologically advanced maize grains.

The color of *Tengma* processed using maize grains harvested at dough, milk, dent and physiologically matured did not have "extremely dislike" rating, while at least 3% of the respondents "extremely disliked" the color of *Tengma* processed using maize grains harvested at previous season.

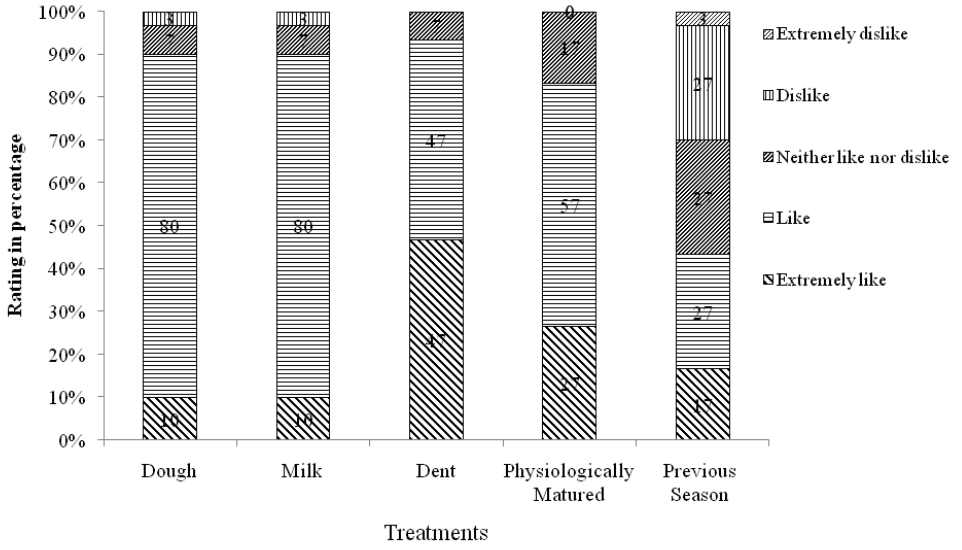

Figure 2.Analysis of colour of *Tengma* processed from maize harvested at different stages

3.4.2. Taste of Tengma

The taste of *Tengma* processed using maize grains harvested at different stages showed different ratings with *Tengma* processed using maize grains harvested at milk and dough stage scoring the highest "extremely like" or" like" ratings of 90% followed by *Tengma* processed using maize grains harvested at dent stage at 80% (Figure 3). The least "extremely like" or "like" taste rating was for *Tengma* processed using maize grains harvested from the previous season at 26%. This could be because *Tengma* harvested at dough and milk stages contain higher level of sugar unlike maize harvested at other stages.

While no respondents extremely disliked the taste of *Tengma* processed using maize grains harvested at dough, milk, dent and physiologically matured, at least 10% of the respondents extremely disliked *Tengma* processed using maize grains harvested from previous season.

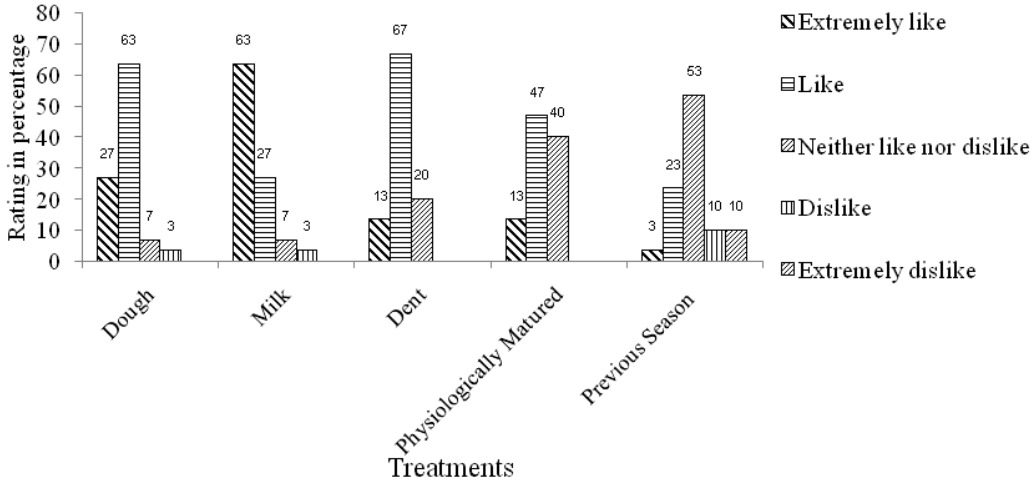

Figure 3.Analysis of taste of *Tengma* processed from maize harvested at different stages

3.4.3. Texture of Tengma

Tengma can be hard, mushy or crunchy and such texture can define the quality and likeability of *Tengma*. The texture of *Tengma* can be influenced by moisture content as well as the way of processing, including roasting method. Between 90% to 97% "liked" or "extremely liked" the texture of *Tengma* processed using maize harvested at milk and dough stage, respectively compared with only about 47% and 70% for *Tengma* processed using maize grains harvested from previous season and at physiologically matured, respectively (Figure 4).

While no respondents "extremely disliked" the texture of *Tengma* processed using maize grains harvested at dough, milk, dent and physiologically matured, at least 3% of the respondents "extremely disliked" the texture of *Tengma* processed using maize grains harvested from previous season. This could be because of low moisture and sugar content in maize grains harvested in previous season compared to maize grains harvested in other stages, especially dough and milk stage

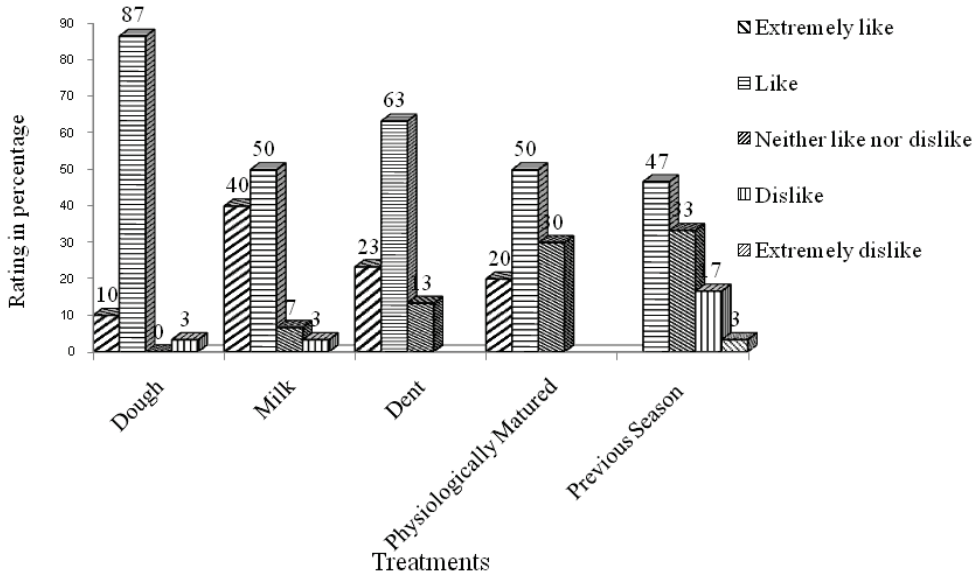

Figure 4.Analysis of texture of Tengma processed from maize harvested at different stages

3.5. Overall acceptability

In the overall acceptability rating, *Tengma* processed using maize grains harvested at milk stage and dough stage had the highest "extremely like" and "like" scores of 100% and 94%, respectively, while those processed using maize grains harvested at dent stage and previous season had the least at 67% and 0%, respectively (Figure 5). This could be presumably because *Tengma* processed from maize grains harvested at milk and dough stages contain relatively higher sugar which could have influenced both sweetness and attractive golden yellow coloration.

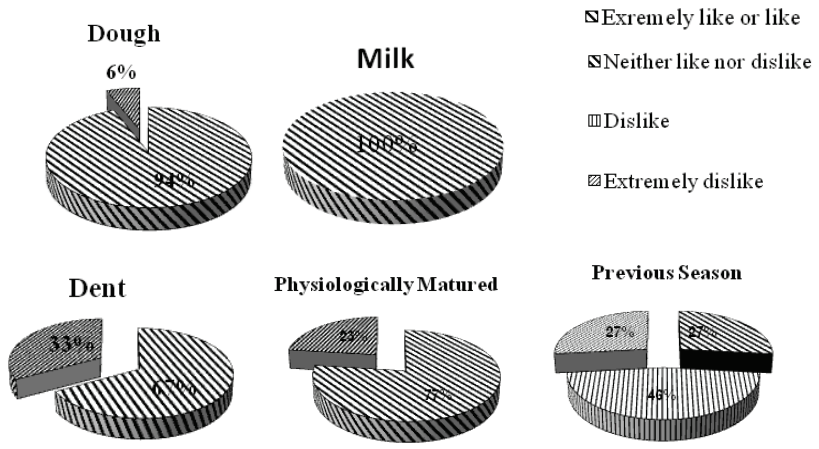

Figure 5.Analysis of overall acceptability of *Tengma* processed from maize harvested at different stages

4. Conclusion

Maize is cultivated in all part of the country either as sole or intercrop. To add value as well as extend shelf life, maize is processed into various products, including *Tengma*, the roasted and pounded maize, which is gaining popularity in the country. *Tengma* processing method is still very traditional because of which its quality is often compromised. This study assessed the quality of *Tengma*, particularly colour, taste and texture by processing *Tengma* using maize grains harvested at different stages namely milk, dough, dent and physiologically matured. In addition, maize grains harvested from previous season was also processed.

So *Tengma* processed using grains harvested at dough and milk stages may have good taste and better acceptability in terms of taste, but the final weight (or recovery) would be low, which could impact returns. Therefore, to make up for low return prices for *Tengma* processed using grains harvested at dough and milk stage will have to be increased, particularly because these *Tengma* taste good.

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