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Effect of different packaging materials and storage temperatures on the microbiological quality of sweet corn

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Abstract
Sweet corn (*Zea mays* rugosa) a member of the Gramineae is an annual grass of poece family. The shelf life of a sweet corn is a few days due to high moisture content. Therefore investigation was carried out to study the effect packaging material and storage temperature on the microbial quality of sweet corn in order to determine suitable packaging material and storage temperature. Sweet corn kernels were blanched for various temperatures (75 ˚C, 80 ˚C, 85 ˚C, 90 ˚C, 95 ˚C and 100 ˚C) for various times (3 to 5 minutes) then packed in to LDPE pouches and PP containers and stored at 4 ˚C and -18 ˚C. And packed sweet corn kernels were analysed for microbial growth in order to determine suitable packaging material. And this process was optimized on the basis of microbial load that is total plate count and yeast and mould growth. The sample blanched at 100 ˚C for 5 minutes packed in to LDPE and stored at -18 ˚C have very slow microbial growth up to 90 days.

Keywords: Sweet corn, blanching, low-density polyethylene, polypropylene

Introduction
Maize (*Zea mays*) considered as the queen of cereals, is the major cereal crop of the U.S. and world's third most important crop after wheat and rice. (Arnel R.Hallauer, 2001) It is only grain crop with many types like dent corn, baby corn, flour corn, popcorn, sweet corn, waxy corn, etc. Among the types of corns, sweet corn has gained its importance in urban areas due to its taste and other uses for human consumption Sweet corn is the new age super diet for health conscious people. The main difference between sweet corn and conventional corn is the presence of mutant alleles that block the conversion of sugars into starch Tin the endosperm, giving sweetness. It is one of the most popular vegetables in the western Tand advanced countries of the world. But this sweet corn has less shelf life due to high respiration rate and high moisture content. The separated kernels are quite vulnerable to microbial contamination due to high moisture content and high sugar content (Sanjeev Kumar and Satyendra Gautam) and hence not considered as safe for raw consumption. To address the issue of shelf life of sweet corn some studies have performed. This includes packaging and storage of sweet corn at low temperature. Controlled freezing-point storage kept lower respiration rate and sugar loss than common cold storage for sweet corn. Controlled freezing-point storage carried out at -1°C and common cold storage at 4°C (Xiaolong Shao, 2011) [15]. Dehusked maize packed with 25 µm LDPE at 5°C showed extended shelf life (Florence abolji Bello and adebanjo ayobamidele badejo, 2017) [1]. Sweet corn packed into different packaging materials like low-density polyethylene with and without ventilation, MAP using diffusion channel and silicon membrane, vacuum packaging and shrink package. Among six different packaging systems, better retention for total sugar in corn kernels without conversion into starch, maximum shelf life, and high sensory quality was documented with shrink wrapping packaging (H.P.Geetha, V.Palanimuthu *et al.*, 2017) [2]. If sweet corn stored at controlled freezing-point storage it lowers respiration rate and sugar loss of sweet corn than sweet corn stored at common cold storage. Controlled freezing-point storage carried out at -1°C and common cold storage at 4°C (Xiaolong Shao, 2011) [15].

Materials and Method
Raw material
Fresh sweet corn cobs (*Zea mays* L. var. *rugosa Bonaf.*) were used.

Sample collection and preparation

Fresh sweet corn was procured from the local market. Then sweet corn dehusked and kernels were separated from cob. The sweet corn kernels were water blanched for 3, 4 and 5 minutes at a various temperature from 75˚C to 100˚C. After blanching samples were packed into different packaging materials like low-density polyethylene pouches and polypropylene containers and stored at 4 ˚C and -18 ˚C.

Microbial analysis

Total plate count

Microbial analysis was done to determine total plate count (TPC) of the samples on the nutrient agar media. The four-serial dilution i.e.10^{-1}, 10^{-2}, 10^{-3}, 10^{-4} was prepared and 10^{-3} was poured in Petri plate containing nutrient agar medium when it was solidified. The plates were incubated at 37^{0}C for 48 hr and colonies were counted on colony counter.

Yeast and mold count

Microbial analysis was done to determine total yeast and mold count of the samples on the potato dextrose agar media and the pour plate technique was used for the isolation. The media was sterilized and poured into plates. The dilutions of the sample were made up to 10^{-3} and then the 1 ml of aliquot was used for pouring. Plates were incubated at 37˚C for 48-72 hrs, and results noted in cfu/gm. The yeast and mold count of the product was examined after every five days during storage.

E. coli

The *E. coli* gives red pink colonies on MacConkey agar so it was used for examination. Using the pour-plate technique, appropriately 1 ml aliquots were taken in plates and tempered MacConkey agar was added. Allow agar to solidify. Plates were inverted and incubated at 35 ˚C for 24 hours. Red pink colonies observed if coliform is present in the sample.

Result and Discussion

Following figures present the total plate count, yeast and mold count and coliform count of sweet corn packed into different packaging materials and stored at different storage temperature. Microbial colonies are shown in (cfu/gm x 10^{3}).

Total plate count

Total plate count measures biological activity in a sample. This is a count of all bacteria, fungi, and yeast that will grow in aerobic condition. The packaging material, storage duration, blanching time, blanching temperature and storage temperature affect the sweet corn quality in terms of microbial growth. Total plate count of sweet corn analyzed after 5 days of intervals up to 20 days for sweet corn stored at 4 ˚C and up to 90 days for sweet corn stored at -18˚C. On the 0^{th} day of storage, there is not any microbial growth get detected.

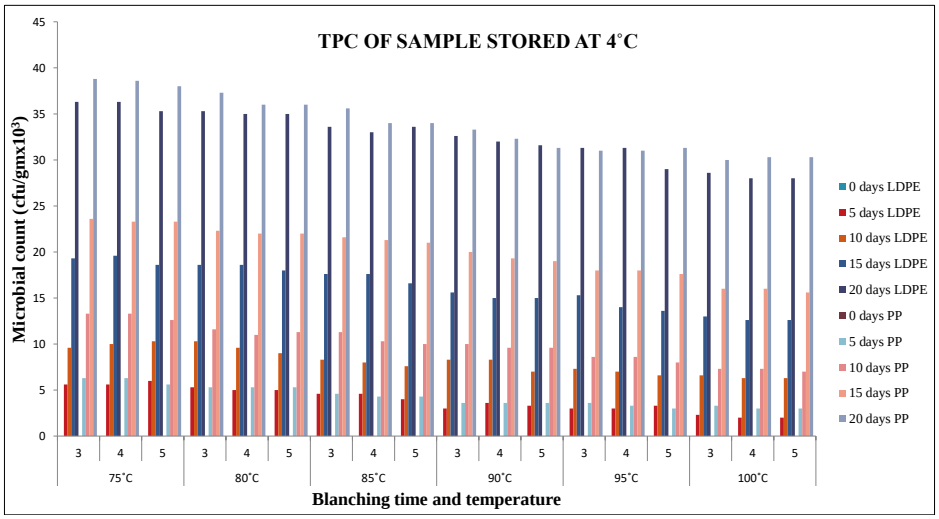

Fig 1: Total plate count of sweet corn stored at 4 ˚C. (LDPE=low density polyethylene, PP= polypropylene.)

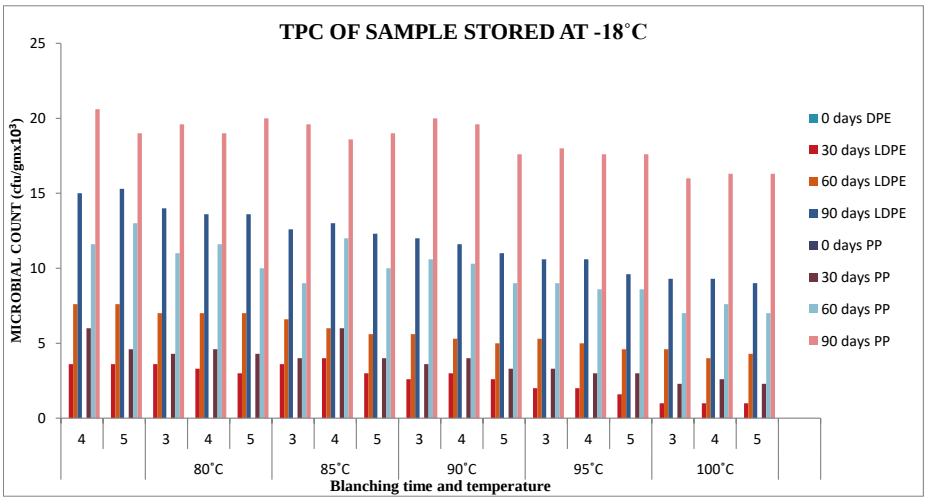

Fig 2: Total plate count of sweet corn stored at -18 ˚C (LDPE=low density polyethylene, PP= polypropylene)

Fig.1. Presents the total plate count of sweet corn stored at 4 ˚C. There were an increase in total plate count in all the samples up to 20 days of storage. But growth is slow as blanching time and temperature increases. The total plate count of sweet corn packed in low-density polyethylene and blanched at 75 ˚C for 3, 4, 5 minutes from the 5th day of storage to 20th day of storage increases from 5.6 x 10^3, 5.6 x 10^3,6 x 10^3 to 36.3 x 10^3, 36.3 x 10^3,35.3x 10^3 respectively. And on 5th days of storage total plate count of sweet corn packed into PP is 6.3 x 10^3, 6.3 x 10^3, and 5.6 x 10^3, which increase to 38.6 x10^3, 38.6 x10^3, and 38 x10^3 on the 20th day of storage.

Fig.2. Presents the total plate count of sweet corn stored at -18˚C and storage period of 90 days. On the 30th day of storage the sweet corn packed into low-density polyethylene and which blanched at 75˚C for a time period of 3, 4, 5 minutes have total plate count 4x10^3, 3.6 x 10^3, 3.6 x 10^3 respectively. On 90th day of storage which increases to 15 x 10^3, 15 x 10^3, 15.3 x 10^3. The sweet corn packed into polypropylene has total plate count 4.6 x 10^3,6 x 10^3, 4.6 x 10^3 on the 30th day of storage which increases to 20 x 10^3, 20.6 x 10^3, 19 x 10^3 on the 90th day of storage.

Fig.1 presents the total plate count of sweet corn stored at 4˚C. On the 5th day of storage, the total plate count of sweet corn packed in LDPE which is blanched at 80˚C for 3, 4, 5 minutes is 5.3 x 10^3, 5 x 10^3, 5 x 10^3 respectively. Which increases to 35.3x10^3, 35 x 10^3, 35 x 10^3 on the 20th day of storage. Total plate count on the 5th day of storage for sample packed into polypropylene have 5.3 x 10^3, 5.3 x 10^3, 5.3 x 10^3 which on the 20th day of storage increases to 37.3 x 10^3, 36x10^3, 36x10^3.

According to fig. 2. total plate count on the 30th day of storage of sweet corn blanched at 80˚C for time period 3, 4, 5 minutes is 3.6x10^3, 3.3x10^3, 3x10^3 respectively. On 90 day of storage which increases to 14x10^3, 13.6x10^3, 13.6x10^3 respectively. These sweet corn kernels were packed into low-density polyethylene and stored at -18 ˚C for 90 days. The sweet corn kernels packed into polypropylene have total plate count on the 5th day of storage is 4.3 x10^3, 4.6x10^3, 4.3x10^3 which increases to 19.6 x 10^3, 19 x 10^3, 20 x 10^3 on the 90th day of storage.

Fig 1 shows that total plate count of the sweet corn stored at 4 ˚C. The sweet corn blanched at 85˚C have total plate count from 4.6x 10^3, 4.6x 10^3, 4x 10^3 for a time period of 3, 4, 5 minutes respectively on the 5th day of storage which increases to 35.3 x 10^3, 35 x 10^3, 35 x 10^3 on the 20th day of storage. Similarly, total plate count for sweet corn packed into polypropylene on the 5th day of storage is 21.6x10^3, 21.3x10^3, 21x10^3 for blanching period of 3, 4, 5 minutes respectively. Total plate count on the 20th day of storage increases to 35.6 x 10^3, 34 x 10^3, 34 x 10^3 for blanching time of 3, 4, 5 minutes respectively.

From fig.2. total plate count of sweet corn stored at -18 ˚C in which sweet corn blanched at 85 ˚C for a time period of 3, 4, 5 minutes have total plate count on the 30th day of storage is 3.6 x 10^3, 4 x 10^3, 3 x 10^3 respectively. Which increases to 12.6 x 10^3, 13 x 10^3, 12.3 x 10^3 on 90th day of storage. Similarly, the sweet corn kernels packed into polypropylene have total plate count 4, 6, 4 on the 30th day of storage which increases to 19.6 x 10^3, 18.6 x 10^3, 19 x 10^3 on the 90th day of storage

Fig 1. Shows that on the 5th day of storage the sweet corn packed into LDPE and blanched at 90˚C for a time period of 3, 4, 5 minutes have total plate count 3 x 10^3, 3.6 x 10^3, 3.3 x 10^3 respectively. Which increase to 32.6 x 10^3, 32 x 10^3, 31.6 x10^3 on 20th day of storage. Similarly on the 5th day of storage for sweet corn packed into PP and blanched at 90˚C for a time period of 3, 4, 5 minutes have total plate count 3.6 x 10^3, 3.6x10^3, 3.6x10^3 respectively and on 20th days of storage is 33.3x10^3, 32.3x10^3, 31.3x10^3.

Fig 2 also shows that the total plate count of sweet corn blanched at 90˚C for a time period of 3, 4, 5 minutes and stored at -18˚ C for 90 days. On the 30th day of storage total plate count for blanching time 3, 4, 5 minutes is 2.6x 10^3, 3x 10^3, 2.6x 10^3 respectively. Total plate count for this sweet corn was increased on the 90th day of storage to the 12x 10^3,11.6x 10^3, 11x 10^3 these sweet corn kernels were packed into low-density polyethylene. Likewise, total plate count for sweet corn packed into polypropylene on the 30th day of storage is 3.6x 10^3, 4x 10^3, 3.3x 10^3 which increases to 20x 10^3, 19.6x 10^3, 17.6x 10^3 on the 90th day of storage.

From fig.1. The sweet corn blanched at 95˚C for a time period of 3, 4, 5 minutes and packed into LDPE have total plate count on the 5th day of storage is 3x10^3, 3 x10^3, 3.3x10^3 respectively. Which increase to 31.3 x 10^3, 31.3 x 10^3, 29 x 10^3 on 20th day of storage. For PP packed sweet corn total plate count on the 5th day of storage for 3, 4, 5 minutes of blanching time is, 3.6x10^3, 3.3x10^3, 3.3 x10^3 respectively and Total plate count on 20th days of storage is 31x 10^3, 31 x 10^3, 31.3 x 10^3 which shows an increase in total plate count.

Fig 2 also presents the total plate count of sweet corn blanched at 95˚C for a time period of 3, 4, 5 minutes and stored at -18˚C for 90 days. Total plate count for sample packed into low-density polyethylene on the 30th day of storage is 2 x 10^3, 2 x 10^3, 1.6 x 10^3 for a time period of 3, 4, 5 minutes respectively which increases to 10.6 x 10^3, 10.6 x 10^3, 9.6 x 10^3. similarly for sweet corn packed into polypropylene total plate count on the 30th day of storage is 3.3 x 10^3, 3 x 10^3, 3 x 10^3 which on the 90th day of storage was 18 x 10^3, 17.6 x 10^3, 17.6 x 10^3.

At 100˚C sweet corn blanched for time period of 3, 4, 5 minutes and packed in to LDPE packets, the total plate count on 5th day of storage is 2.3x10^3, 2x10^3, 2x10^3 respectively and on 20th days of storage which increase to 28.6 x 10^3, 28.6 x 10^3, 28.6 x 10^3.sweet corn packed in to PP have total plate count on 5th day of storage which increases to 3.3x10^3, 3x10^3, 3 x10^3 to 30 x10^3, 30.3x10^3, 30.3x10^3 on 20th day of storage.

From fig.1. on the 30th day of storage the sweet corn packed into LDPE and blanched at 100˚C for a time period of 3, 4, 5 minutes have total plate count 1 x 10^3, 1 x 10^3, 1 x 10^3 respectively. Which increase to 9.3x 10^3, 9.3x 10^3, 9 x10^3 on the 90th day of storage. Similarly on the 30th day of storage for sweet corn packed into PP and blanched at 100˚C for a time period of 3, 4, 5 minutes have total plate count 2.3 x 10^3, 2.6x10^3, 2.3x10^3 respectively and on 90th days of storage is 16x10^3, 16.3x10^3, 16.3x10^3.

Yeast and mold count

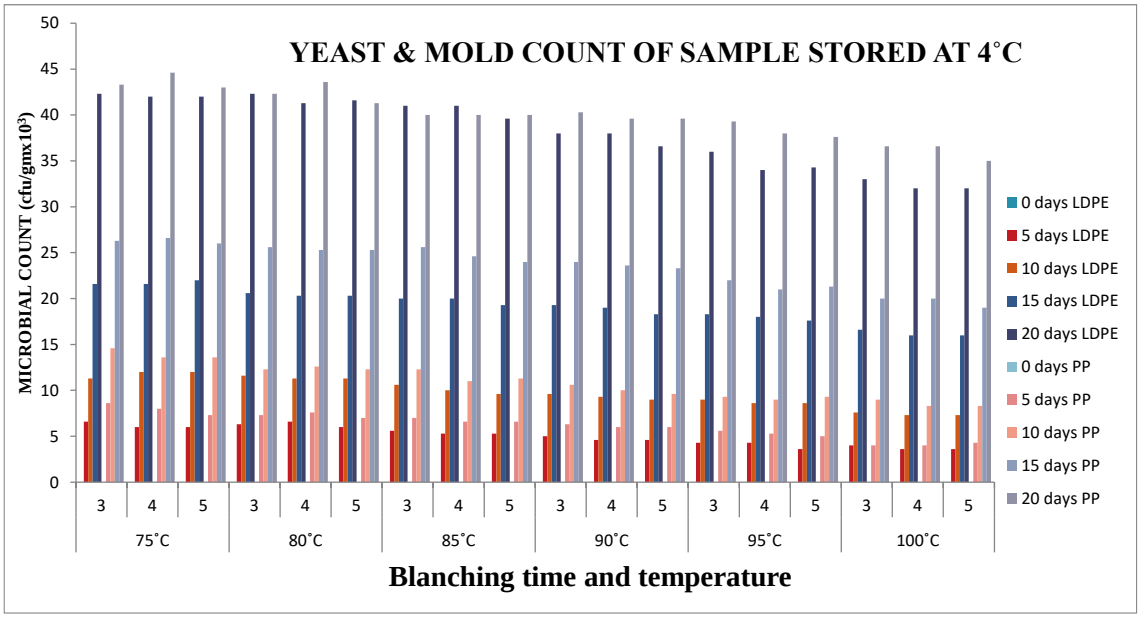

Fig 3: Yeast and Mold count of sweet corn stored at 4 ˚C. (LDPE=low density polyethylene, PP= polypropylene.)

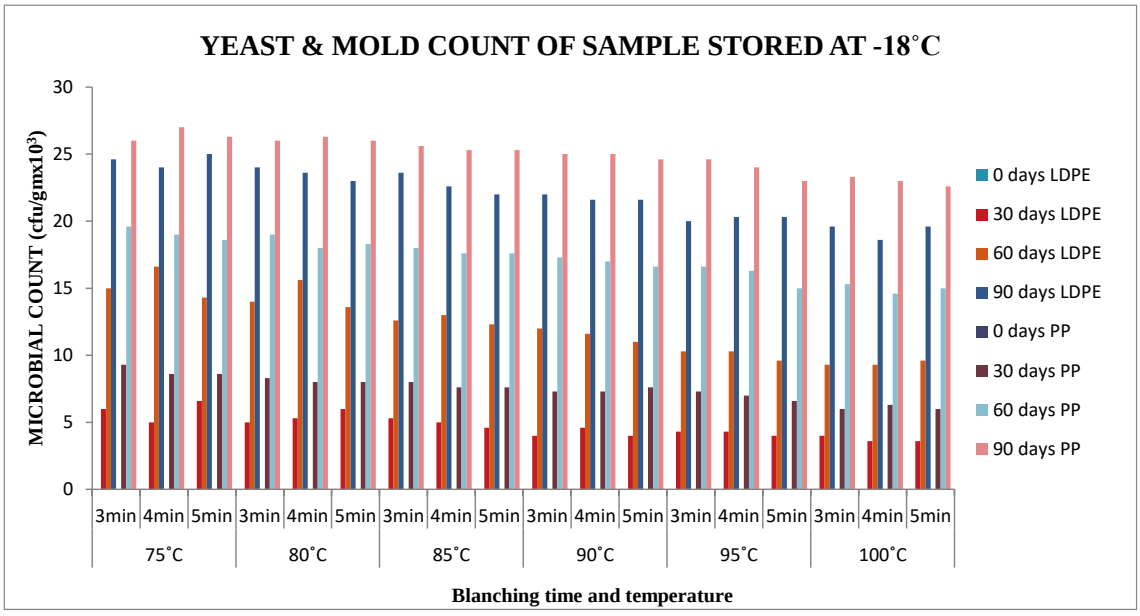

Fig 4: Yeast and Mold count of sweet corn stored at -18 ˚C. (LDPE=low density polyethylene, PP= polypropylene.)

Fig.3.and fig.4. Presents yeast and mold of sweet corn kernels stored at 4 ˚C and at -18 ˚C respectively. The yeast and mold count of sweet corn packed in low-density polyethylene and blanched at 75 ˚C for 3, 4, 5 minutes from the 5th day of storage to 20th day of storage increases from .6 x 10^3, 6 x 10^3,6 x 10^3 respectively to 42.3 x 10^3, 42.3 x 10^3, 42x 10^3. And on 5th days of storage total plate count of sweet corn packed into PP is 8.6 x 10^3, 8 x 10^3, 7.3 x 10^3, which increase to 42.3 x10^3, 42.3 x10^3, 41, 6 x10^3 on the 20th day of storage.

Fig.4. Presents the yeast and mold count of sweet corn stored at -18 ˚C and storage period of 90 days. On the 30th day of storage the sweet corn packed into low-density polyethylene and which blanched at 75˚C for a time period of 3, 4, 5 minutes have yeast and mold count 6x10^3, 5 x 10^3, 6.6 x 10^3 respectively. On 90th day of storage which increases to 24.6 x 10^3, 24 x 10^3, 25 x 10^3. The sweet corn packed into polypropylene have yeast and count 9.3 x 10^3,8.6 x 10^3, 8.6 x 10^3 on the 30th day of storage which increases to 26 x 10^3, 27 x10^3, 26.3 x 10^3 on the 90th day of storage.

Yeast and mold count of sweet corn stored at 4˚C. On the 5th day of storage, the total plate count of sweet corn packed in LDPE which is blanched at 80 ˚C for 3, 4, 5 minutes is 6.3 x 10^3, 6.6x10^3, 6x10^3 respectively. Which increases to 42.3x10^3, 41.3 x 10^3, 41.6 x 10^3 on the 20th day of storage. Total plate count on the 5th day of storage for sample packed into polypropylene have 7.3 x 10^3, 7.6 x 10^3, 7 x 10^3 which on the 20th day of storage increases to 42.3 x 10^3, 43.6x10^3, 41. 3x10^3.

According to fig. 4. Yeast and mold count on the 30th day of storage of sweet corn blanched at 80 ˚C for time period 3, 4, 5 minutes is 5x10^3, 5.3x10^3, 6x10^3 respectively. On 90 day of storage which increases to 24x10^3, 23.6.6x10^3, 23.6x10^3 respectively. These sweet corn kernels were packed into low-density polyethylene and stored at -18 ˚C for 90 days. The sweet corn kernels packed into polypropylene have yeast and mold count on the 30th day of storage is 8.3 x10^3, 8x10^3, 8x10^3 which increases to 26 x 10^3, 26.3 x 10^3, 26 x 10^3 on the 90th day of storage.

Fig. 3. Shows that yeast and mold count of the sweet corn stored at 4 ˚C. The sweet corn blanched at 85˚C has yeast and mold count from 5.6x 10^3, 5.3x 10^3, 5.3x 10^3 for a time period of 3, 4, 5 minutes respectively on the 5th day of storage which increases to 41 x 10^3, 41 x 10^3, 39.6 x 10^3 on the 20th day of storage. Similarly, total plate count for sweet corn packed into polypropylene on the 5th day of storage is 7x10^3, 6.6x10^3, 6.6x10^3 for blanching period of 3, 4, 5 minutes respectively. Yeast and mold count on the 20th day of storage increases to 40 x 10^3, 40 x 10^3, 40 x 10^3 for blanching time of 3, 4, 5 minutes respectively.

From fig.4. yeast and mold count of sweet corn stored at -18 ˚C in which sweet corn blanched at 85˚C for a time period of 3, 4, 5 minutes have yeast and mold count on the 30th day of storage is 5.3 x 10^3, 5 x 10^3, 4.6 x 10^3 respectively. Which increases to 23.6 x 10^3, 22.6 x 10^3, 22x10^3 on 90th day of storage. Similarly, the sweet corn kernels packed into polypropylene have yeast and mold count 8 x 10^3, 7.6 x 10^3, 7.6 x 10^3 on the 30th day of storage which increases to 25.6 x 10^3, 25.3 x 10, 25.3 x 10^3 on the 90th day of storage

Fig 3. Shows on the 5th day of storage the sweet corn packed into LDPE and blanched at 90˚C for a time period of 3, 4, 5 minutes have total plate count 5x 10^3, 4.6 x 10^3, 4.6 x 10^3 respectively. Which increase to 38 x 10^3, 38 x 10^3, 36.6 x10^3 on 20th day of storage. Similarly on the 5th day of storage for sweet corn packed into PP and blanched at 90˚C for a time period of 3, 4, 5 minutes have total plate count 6.3 x 10^3, 6x10^3, 6x10^3 respectively and on 20th days of storage is 40.3x10^3, 39.6x10^3, 39.6x10^3.

Fig 4 also shows that yeast and mold count of sweet corn blanched at 90˚C for a time period of 3, 4, 5 minutes and stored at -18˚ C for 90 days. On the 30th day of storage yeast and mold count for blanching time 3, 4, 5 minutes is, 4x 10^3, 4.6x 10^3, 4x 10^3 respectively. Yeast and mold count for this sweet corn kernels were increased on the 90th day of storage to the 22x 10^3, 21.6x 10^3, 21.6x 10^3 these sweet corn kernels were packed into low-density polyethylene. Likewise, total plate count for sweet corn packed into polypropylene on the 30th day of storage is 7.3x 10^3, 7.3x 10^3, 7.6x 10^3 which increases to 25x 10^3, 25x 10^3, 24.6x 10^3 on the 90th day of storage.

From fig.1. The sweet corn blanched at 95˚C for a time period of 3, 4, 5 minutes and packed into LDPE have yeast and mold count on the 5th day of storage is 4.3x10^3,4.3 x10^3, 3.6x10^3 respectively. Which increase to 36 x 10^3, 34 x 10^3, 34.3x 10^3 on the 20th day of storage. For PP packed sweet corn total plate count on the 5th day of storage for 3, 4, 5 minutes of blanching time is 5.6x103, 5.3x10^3, 5 x10^3 respectively and Total plate count on 20th days of storage is 39.3x 10^3, 38 x 10^3, 37.6 x 10^3 which shows an increase in yeast and mold count.

Fig. 4 also presents the yeast and mold count of sweet corn blanched at 95˚C for a time period of 3, 4, 5 minutes and stored at -18˚C for 90 days. Yeast and mold count for sample packed in too low-density polyethylene on the 30th day of storage is 4.3 x 10^3, 4.3 x 10^3, 4 x 10^3 for a time period of 3, 4, 5 minutes respectively which increases to 20 x 10^3, 20.3 x 10^3, 20.3 x 10^3. Similarly for sweet corn packed into polypropylene yeast and mold count on the 30th day of storage is 7.3 x 10^3, 7 x 10^3, 6.6 x 10^3 which on the 90th day of storage was 24.6 x 10^3, 24 x 10^3, 23 x 10^3.

At 100˚C sweet corn blanched for time period of 3, 4, 5 minutes and packed in to LDPE packets, the yeast and mold count on 5th day of storage is 4x10^3, 3.6x10^3, 3.6x10^3 respectively and on 20th days of storage which increase to 33x10^3, 32x 10^3, 32 x 10^3.sweet corn packed in to PP have yeast and mold count on 5th day of storage which increases to 4x10^3, 4x10^3, 4.3 x10^3 to 36.6x10^3, 36.6x10^3, 35x10^3 on 20th day of storage.

From fig.4. on the 30th day of storage the sweet corn packed into LDPE and blanched at 100˚C for a time period of 3, 4, 5 minutes have yeast and mold count 4x10^3, 3.6x10^3, 3.6x10^3 respectively. Which increase to 19.6x 10^3, 18.6x 10^3, 19.6x10^3 on the 90th day of storage. Similarly on the 30th day of storage for sweet corn packed into PP and blanched at 100˚C fora time period of 3, 4, 5 minutes have yeast and mold count 6 x 10^3, 6.3x10^3, 6x10^3 respectively and on 90th days of storage is 23.3x10^3, 23x10^3, 22.6x10^3.

E. Coli

Throughout the storage period, there is not *E. Coli* was not detected in stored sweet corn packed into different packaging materials.

Conclusion

In this study, the effect of packaging material on shelf life in term of microbial growth of blanched sweet corn which is stored at 4˚C and -the 18˚C temperature was studied Low-density polyethylene pouches show the slow microbial growth than polypropylene containers.

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