QUALITY CHANGES OF CEREAL MUESLI WITH SEEDS DURING STORAGE

Santa Senhofa, Evita Straumite, Dace Klava

Department of Food Technology, Faculty of Food Technology, Latvia University of Agriculture, Liela Street 2, Jelgava, Latvia, e-mail: shenhofa@inbox.lv

Abstract

Cereals play a vital role in diet because they not only provide humans with essential macronutrients such as protein, fat and carbohydrate for growth and maintenance but also supply with vitamins, minerals, and micronutrients for optimal health. In recent years the activities of human consumption "clean" products, with no extra added sugars, food additives and preservatives increases. The aim of this study was to evaluate cereal muesli with seeds quality changes during storage. Samples of muesli with seeds (linseeds, pumpkins seeds, almond slices) were packaged in 3 different packages –paper bag, paper tubes and *Doypack* (standup pouches) and stored for 6 months (at 20±2 °C temperature and air humidity – 50±5%). During the storage moisture content, water activity, and microbiological safety were evaluated.

After 6 months storage of muesli with seeds, the moisture content in samples packaged in the paper tube decreases by 14.3%, in *Doypack*–20.5% and in paper bag by 34.9%. The lowest moisture content was determined for muesli samples storage in the paper package – 6.00%.Water activity compared to the fresh prepared muesli (a_w=0.56) decreased, in paper tube it was 0.33, in paper bag – 0.16 and in *Doypack* – 0.47. As more unusable for cereal muesli with seeds packaging paper bags was detected, because of essential quality changes of samples during storage. After 6 months storage total count of microorganisms and moulds increase, but remained within the normal range. Therefore, the shelf-life of cereal muesli with seeds packaged in paper tube or *Doypack* for 6 months could be recommendable.

Keywords: cereals, muesli, packaging, storage time.

Introduction

Muesli is a mixture of grain flakes and dried fruits, where can be also added seeds and nuts. Thanks to its easy and quick preparation with milk, yogurt or hot water, muesli is often called as a breakfast flakes. Cereals play a vital role in diet because they are not only providing humans with essential macronutrients such as protein, fat and carbohydrate for growth and maintenance but also supply other important vitamins, minerals, and micronutrients for optimal health (Collins et al., 2010). The breakfast cereals are generally high in carbohydrate are low in fat; some have high bran contents, and many contain appreciable amounts of certain vitamins and minerals, partially satisfying the mineral and vitamin requirements (Albertson et al., 2008; Bertais et al., 2000). Eating cereal at breakfast was associated with increased consumption of fibre and carbohydrates and decreased consumption of fats throughout the day (Gibson, Gunn, 2011; Albertson et al. 2008; Williams, 2007; Wilson et al., 2006), and improved mental and greater physical performance (Albertson et al. 2008; Rampersaud et al., 2005). This may be because they are a good source of whole grains and commonly eaten with milk. Whole grains are rich in dietary fibre and both grains and milk will improve micronutrient intake (Coudray, 2011; Drewnowski, 2011; Vissers et al., 2011; Williamson, 2010). Breakfast cereals are often now also fortified with vitamins such as folate and thiamine (Loui et al., 2012; Hannon et al., 2007; Berner et al., 2001). Cereal consumption as part of a healthy lifestyle may play a role in maintaining adequate nutrient intake and physical activity (Albertson et al., 2008).

The earliest breakfast cereal manufacture was based on boiling then drying, extrusion has become a well-established industrial technology with beneficial effects on the nutritional properties and texture of the raw material. The pleasant flavours and colours of breakfast cereals are produced in the drying and toasting steps (Delgado-Andrade et al., 2007; Rufian-Henares et al., 2006; Rada-Mendoza et al., 2004).

The majority of cereal-associated bacteria are located in the outer layers of the kernel and are thus concentrated in bran (ICMFS (International Commission on Microbiological Specifications for Foods), 2005; Laca et al., 2006). Contamination of the grains during storage, transport, and processing further affects the microflora.

Texture in ready-to-eat cereals is fundamental for product acceptance by consumers. Textural properties of food are used by consumers as key quality indicators that contribute to product acceptability. Crispness is one such key indicator and is considered a primary textural attribute of breakfast cereal. Cereal hardness is another force claimed that crispness is the most important attribute affecting consumer acceptability (Pathare et al., 2012; Burrington, 2001). Moisture content for breakfast cereal is as the critical quality parameter and relative humidity as the most influential environmental factor (Macedo et al., 2011).

The use of packaging in the food supply chain is very important and is an essential part of food processing. It can be used for various purposes such as the assurance of protection of food from external infections (microorganisms), surrounding conditions (like atmosphere gases, water activity, etc.), and the appropriate labelling of foods (La Storia et al., 2008). Flexible pouch used to package breakfast cereal in air is not integral to the product. The cereal could be removed from the package and poured into a plastic dispenser and not suffer any loss in shelf life. Cereal products are usually packaged in paper/polyethylene

packaging (Galic et al., 2009), but there is an interest in replacing its packaging and potentially use different and more environmentally friendly packaging materials. Paper can be combined with layers of LDPE (low density polyethylene) and aluminium to make sealed bags and pouches that provide a better barrier to moisture and oxygen for the food product (Krochta, 2006). Similar products such as granola muesli, the recommended period of validity is 270 days (Macedo et al., 2013).

The aim of this study was to evaluate cereal muesli with seeds quality changes during storage.

Materials and Methods

Characterisation of muesli with seeds

Muesli with seeds contains:

- 40% roasted whole grain triticale flakes (200 °C for 10 min),
- 25% roasted whole grain rye flakes (200 °C for 10 min),
- 15% linseeds,
- 10% almond pieces,
- 10% pumpkin seeds.

Characterisation of packaging materials

Samples of muesli with seeds (linseeds, pumpkins seeds, almond slices) were packaged in 3 different packaging materials:

- paper tubes – tubes with aluminium layer inside and LDPE (low density polyethylene) black cover ;
- paper bag –brown kraft paper 90–100 g m^{-2} with PP (polypropylene) window;
- *Doypack* (standup pouches) – Pap50g/Alu7/Pe60.

Amount of sample in package – 250 g, storage time 6 months at 20±2 °C temperature and air humidity – 50±5%.

Moisture content

Moisture content of muesli with seeds was determined using heating oven Memmert (GmbH) Memmert, Germany) – 5.00±0.03 g sample for 1 hour was dried at 110±1 °C temperature (LVS EN ISO 712:2010A). In the analysis on moisture content was run in duplicate and averaged.

Water activity (a_w)

Water activity (a_w) was determined using LabSwift-aw (AG Novasina, Switzerland) equipment. In the analysis on water activity analysis was run in triplicate and averaged.

Microbiological parameters

Total plate count of mesophylic aerobic and facultative anaerobic microorganisms (MAFAm) were determined in conformity with the standard LVS EN 4833:2003;yeasts and moulds – with the standard ISO 21527-2:2008.

Statistical analysis

The mean and standard deviation were processed by mathematical and statistical methods.

Results and Discussion

Moisture content

During 6 months of storage, muesli moisture content in paper tube decreased by 14.3%, in paper bag with window – by 34.9% and in *Doypack* by 20.5% (Figure 1.). Muesli moisture varied from 9.2% at first to 6.0% at the end.

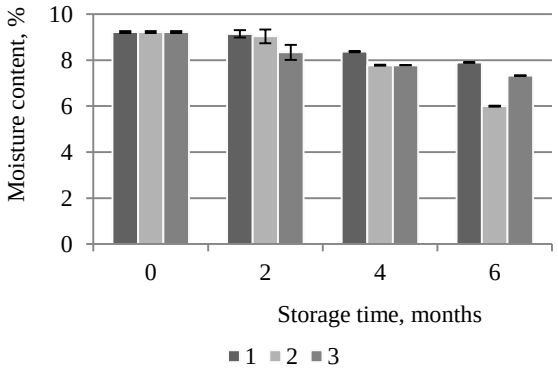

Figure 1. Changes in moisture content of muesli with seeds during storage
1 – paper tube, 2– paper bag, 3– *Doypack*

The lowest moisture content was determined in the paper bag with PP window after 6 month storage – 6.00%. Legislation lay down that moisture content for flakes has to be in the range between 10–14% (Prasības..., 2008). Comparing obtained results with other researches, results shows, that oat flakes moisture content is between 6.0–8.7% (Gates et. al., 2007).

In the paper bag with PP window it has decreased more than in the paper tube and *Doypack*. This difference can be due to the quality of the packaging material. High moisture content may be caused to the additives and their interaction with each other by connecting a number of components. Each additive moisture content is variable and storing the environment constitute the final product which resulted on the product quality. During storage, the product has seen a steady, slow decline of moisture, which can be related to the raw materials used in the product, which has the ability to bind moisture from one to another by connecting to creating a favourable environment for microbial growth.

Water activity (a_w)

Water activity was used to determine stable shelf-life for foods. During storage of the muesli a decrease in water activity was observed (Fig. 2.).

Water activity for muesli with seeds ranged between 0.56 at first to 0.16 at the end. These differences affected packaging materials – the lowest water activity was determined in the paper bag – 0.16. In the paper tube water activity (a_w) decreased for 41.1% and in *Doypack* – for 16.1%. Water activity for muesli products is not defined in legislation, but there are some researches, where water activity for dried foods is

defined like no microbial proliferation below 0.6 (Beuchat, 1981).

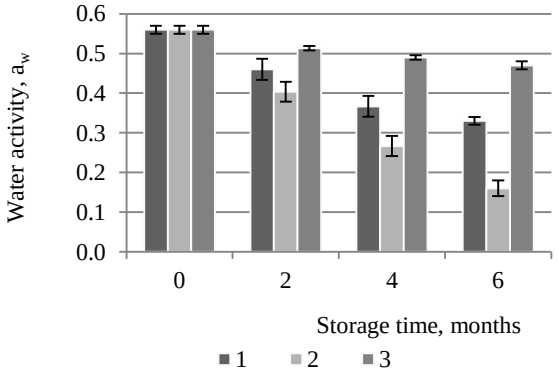

Figure 2. Changes in water activity *(a_w)* of muesli with seeds during storage

1 – paper tube, 2 – paper bag, 3 – *Doypack*

Reduced water activity does not provide a complete inactivation of microorganisms, but partially restrict their activities in the product, which helps to ensure a longer shelf-life. Having a water activity below 0.6 products are stable against microbial growth, but chemical and enzymatic reactions can occur which results in deterioration. Comparing data with other research, it can be concluded that the muesli stored up to 12 months, the water activity is 0.22 (Labuza, 1980).

Microbiological parameters

Taking into account that the grain seed mixture contains more different components that are re-cooked as they are received from a supplier, the product is increased microbial risk.

Table 1

Changes of microbiological parameters during muesli storage

Parame-ters / Samples	Storage time, months			
	0	**2**	**4**	**6**
MAFAm CFU g^{-1}				
paper tube	1.8×10^3	2.3×10^4	3.4×10^4	5.6×10^4
paper bag	1.8×10^3	2.9×10^4	4.2×10^4	1.3×10^5
Doypack	1.8×10^3	2.4×10^4	3.8×10^4	5.2×10^4
Yeasts CFU g^{-1}				
paper tube	1.3×10^2	2.3×10^3	2.8×10^3	3.3×10^3
paper bag	1.3×10^2	3.4×10^3	4.2×10^3	5.6×10^3
Doypack	1.3×10^2	2.1×10^3	3.1×10^3	3.7×10^3
Moulds CFU g^{-1}				
paper tube	1.1×10^2	1.7×10^3	2.9×10^3	4.8×10^3
paper bag	1.1×10^2	2.8×10^3	3.6×10^3	5.3×10^3
Doypack	1.1×10^2	2.2×10^3	2.7×10^3	4.2×10^3

Known to increase the risk of storing the product packaging that is air, moisture, aroma and light permeable. It is important to judge the preparation to avoid pollution in the early stages of some raw materials.

Microbiological parameters (mesophylic aerobic and facultative anaerobic microorganisms (MAFAm), yeasts and moulds) were analysed during 6 months storage (Table 1). The total count of mesophylic aerobic and facultative anaerobic microorganisms (MAFAm), increased during storage. The lowest total mesophylic aerobic and facultative anaerobic microorganisms'count during storage is 5.2×10^4 CFU g^{-1} in *Doypack*, after 6 months. These parameters are included in within acceptable limits for total plate count of mesophylic aerobic and facultative anaerobic microorganisms are from 10^4 to 10^5 CFU g^{-1} (Nerbrink, 2007). The most rapid growth was observed for yeasts in the paper bag with windows – from 1.3×10^2 to 5.6×10^5 CFU g^{-1} after 6 months storage. Comparing the count of moulds during storage, they are from 1.1×10^2 to 5.3×10^3 CFU g^{-1}, an acceptable range is from 10^2 to 10^4 CFU g^{-1} ICMFS (International Commission on Microbiological Specifications for Foods, 2005). Microorganism increase can be attributed with possible flakes environmental pollution. Flakes, which are made from the outside of the grain layer, there has been an increased moulds contamination products. Flaking process cannot be observed all HACCP (Hazard Analyses and Critical Control Points) conditions as a result of a dry product with a reduced water activity can develop pollution and increase microorganisms.

To minimize the risk of microorganisms' multiplication, the product must be stored in containers able to maintain an inert environment for the entire storage period. Evaluating product packaging materials, the most appropriate of these is *Doypack* packaging, which is able to keep the product during storage of a positive effect on the safety of the product. The products are suitable for the storage of selected packages specified period of time, but extending the shelf-life should be evaluated in addition to the quality indicators.

Conclusions

The shelf-life of cereal muesli with seeds packaged in paper tube with aluminium layer inside and LDPE black cover or *Doypack* (stand-up pouches) Pap50g/Alu7/Pe60 for 6 months could be recommendable.

The shelf-life of cereal muesli with seeds packaged in paper bag with PP window for 4 months could be recommendable.

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