



## The Chemical Composition and Quality Parameters of Biscuits: A Review

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**Abstract:** Biscuits are a popular ready-to-eat food due to their affordable cost and long shelf life. Herein, we review the quality parameters of the biscuits, with a special focus on the changes caused by thermal processing. Particularly, the presence of possible contaminants, including the production of hydroxymethylfurfural is reviewed. In addition, the various microbiological sources of concern during the biscuit-making process, and their effect on the shelf-life and quality of the biscuits are presented. Based on the current state of literature, modern challenges in biscuit-making and a future outlook of the biscuit industry is provided. This review will be useful in understanding the current state of the literature regarding the quality parameters of biscuits and the important critical control points in order to maintain the safety and high quality of biscuits produced.

Keywords: Biscuit, Baking technology, Biscuit quality, Food processing.

## Introduction

Biscuit is a term that comes from the Latin word *Biscoctum* which is often understood as “twice-cooked bread”; Biscuits can be considered one of the cheapest processed food items consumed by a broad range of age groups, from children to the elderly.

Biscuits (European Countries) or cookies (Americas) are one of the most widely consumed bakery products preferred by consumers due to their varied taste, quality,

long shelf-life, availability and low cost (Vitali *et al.*, 2009).

The consumption of biscuits per capita in the United States, United Kingdom, and European countries is above 10 kg, which is comparable with Japan that has a per capita consumption of 7.5 kg. The consumption of Southeast Asian countries such as Indonesia, Hong Kong, Singapore etc. is more than 4.25 kg per capita, whereas comparatively lower

consumption of 2.1 and 1.9 kg per capita is recorded in India and China respectively (Vitali *et al.*, 2009). Global biscuits market was valued at 106 billion USD and is estimated to rise at the rate of 5.35 % per annum, according to the projections for 2021-2026 presented in the Mondor Intelligence Report (Smart Cities Market, 2020). South America is projected to have the highest growth rate in 2021-2026, while Europe held the highest market share in 2021 (Smart Cities Market, 2020). The current major companies in the world include Biscuit International, Britannia Industries, Yıldız Holding Inc., Mondelēz International, Inc., Kellogg Company, ITC Limited.

Biscuits are primarily made of flour, fat, sugar and water, in addition to milk and salt, with other ingredients for taste, nutritional quality or shelf-life extension. An elongated shelf life helps enables large-scale production and distribution of food products throughout a country (Morais *et al.*, 2018), and excellent export potential. Biscuits and biscuit-like products have been made and eaten by humans for centuries. Biscuits contain the necessary nutritional elements, with a possibility of fortification of nutrients according to the needs and ages of consumers (Awobusuyi *et al.*, 2020). Their long shelf-life characteristics were even more appreciated during the lockdown linked to COVID-19 crisis, when the demand for biscuits further increased in several countries due to less frequent food purchases (Pasqualone *et al.*, 2021). Numerous products with low fat, gluten-free, low carbo, organic, and high fibre biscuits were launched by the

biscuit industry to attract consumers further. Consequently, there is a tremendous increase in the consumption of biscuits as a popular snack, both in developed & developing countries, around the world.

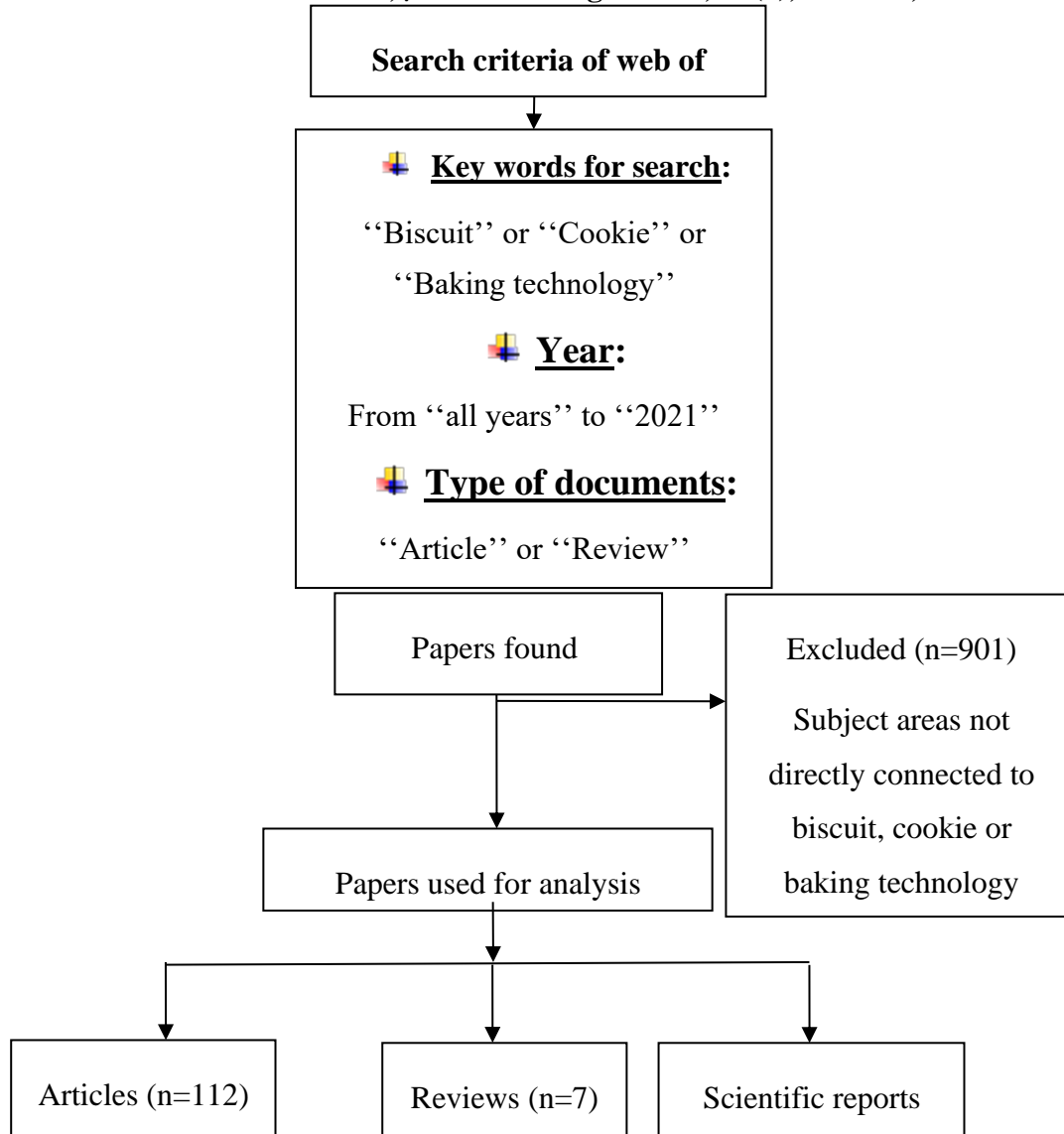
The primary reason for the long-shelf-life of biscuits is attributed to their reduced water activity for most biscuits, which can reach up to 0.5 in confectioners' biscuits or sweet children's biscuit. The critical water activity, beyond which the biscuits start to soften, has been reported to be between 0.51 and 0.59 for cracker bread biscuits (Arimi *et al.*, 2010). Biscuits are in-fact differentiated from other baked products such as bread and cakes due to low moisture content, which slows down microbial spoilage. Despite the low water activity, Al-Timimi *et al.* (2010) studied the level of microbial contamination (bacteria and fungi) in five types of biscuits and reported up to  $21.6 \times 10^3$  cfu.g<sup>-1</sup> bacterial content and  $16.0-5.3 \times 10^3$  cfu.g<sup>-1</sup> fungal content present in the biscuits. It must be mentioned that biscuits tend to absorb humidity in the atmosphere quickly, which necessitates an efficient packaging and storage system.

Thermal processing is widely used as a method of preparing foodstuffs, primarily to ensure food safety, but also to achieve desirable product transformations (Pratap-Singh *et al.*, 2018). Among the most common method is cooking, baking, roasting, extrusion cooking, pasteurization, or sterilization (Singh *et al.*, 2017a; Pratap-Singh *et al.*, 2018). Significant reactions occur during thermal processing, such as the Maillard reaction, caramelization, lipid

oxidation, nutrient leaching and other reactions (Singh *et al.*, 2017 b; Altemimi *et al.*, 2021) that have a positive effect on our senses and our acceptance of these products. However, some chemicals are also produced, which have a harmful effect, both in the short and long term. 5-hydroxymethyl-2-furfural (HMF) is one of these chemicals that are formed during heat treatment (Alkanan *et al.*, 2021). Scientific reports have indicated the presence of this compound in cereal products such as baby food and cereal foods that are eaten at breakfast, pasta and other bakery products (Prata *et al.*, 2021). High levels of HMF showed cytotoxicity, inflammation of the eyes, mucous membranes, upper respiratory tract, and many diseases that are dangerous to human health (Capuano & Fogliano, 2011). In fact, studies in rats and mice have shown that HMF was potentially carcinogenic (Delgado-Andrade *et al.*, 2009; Kowalski *et al.*, 2013a). Besides thermal processing derived contaminants, other chemical contaminants of concern found in biscuits are lead, cadmium, zinc, mercury, magnesium, manganese, and copper (Elham-Alshewey *et al.*, 2015; Iwegbue *et al.*, 2015). Although some of these minerals like zinc, copper, cobalt, manganese etc. are classified as essential elements, when present in high concentrations, they become harmful and

cause various diseases and health symptoms. Dada *et al.* (2017) reported high levels of mineral elements in samples biscuits and donuts, as these two snacks were made from refined wheat flour, which has the potential of acquiring mineral contamination during refining stages.

A substantial rise in research and development related to the bakery industry has been registered in the past decade, particularly related to improving quality characteristics of biscuits through advances in technology and innovation. Therefore, the prime objective of this review article is to review the current state of the literature on the technologies available for baking the biscuits, the biological and nutritional properties of different types of biscuits, and possible contaminants, including both chemical and biological hazards. The database (Web of Science, Clavariate Analytics, United States) of high-quality scientific journals, a systematic search for relevant articles on biscuits was conducted. Fig. (1) depicts the review methodology followed, including the search criteria adopted by the authors. Relevant information on different varieties of biscuits sold in the international markets will aid to establish the most important criteria for producing biscuits of high quality and prolong shelf-life.



**Fig. (1): The literature search in the web of science was conducted by the keywords “Biscuit” or “Cookie” or “Baking technology” and 125 research and review articles had referred for this review**

### Baking technology

Baking is a form of cooking performed in an oven. The semi-solid dough is transformed into a consumable substance by the aid of heat (Arepally *et al.*, 2020). Over the past century, rise in the bakery products inspired by opening of small artisan bakeries in each village, has gradually paved the way for the modern high-tech bakery industry (Dayakar & Bhargavi, 2017). Bakery products are manufactured in the bakery industry using

different types of mechanisms, such as convectional, infrared, microwave, a combination of infrared with microwave, steam baking, and microwaves combined with hot air (Yolacaner *et al.*, 2017; Dessev *et al.*, 2020; Al-Nasser *et al.*, 2021). All three heat transfer modes which are namely conduction, convection, and radiation, play a key role in biscuit processing to contribute to the expansion of dough, moisture removal, and browning index respectively. Although

the convectional heating provides a satisfactory baking system, it produces a gradient of moisture and differential shrinking due to fast surface drying (Arepally *et al.*, 2020). In this regards, microwave baking allows the advantage of inside-out heating, eliminating the problem of surface hardening. Microwave baking was compared with the convectional baking to study the textural changes, and it was found that baking biscuits for 50 s using microwave gave the best textural properties (Arepally *et al.*, 2020). Furthermore, microwave baking was successfully able to reduce the need for checking to 5 % compared to 61 % in convectionally baked biscuits (Ahmad *et al.*, 2001). Keskin *et al.* (2005) studied the effects of halogen lamp–microwave combination baking on the quality of biscuits in terms of spread ratio, colour, and texture. The best baking condition to produce biscuits in a halogen lamp–microwave combination oven was at 70% halogen lamp and 20% microwave power levels for 5.5 min in order to have similar hardness and colour values as convectionally baked ones. Some of the previous studies performed using different techniques are discussed in table (1).

### **Composition and types of biscuit**

The raw materials for biscuit making include wheat flour, water, emulsifiers, sugar, salt. Raw materials can be divided into major and

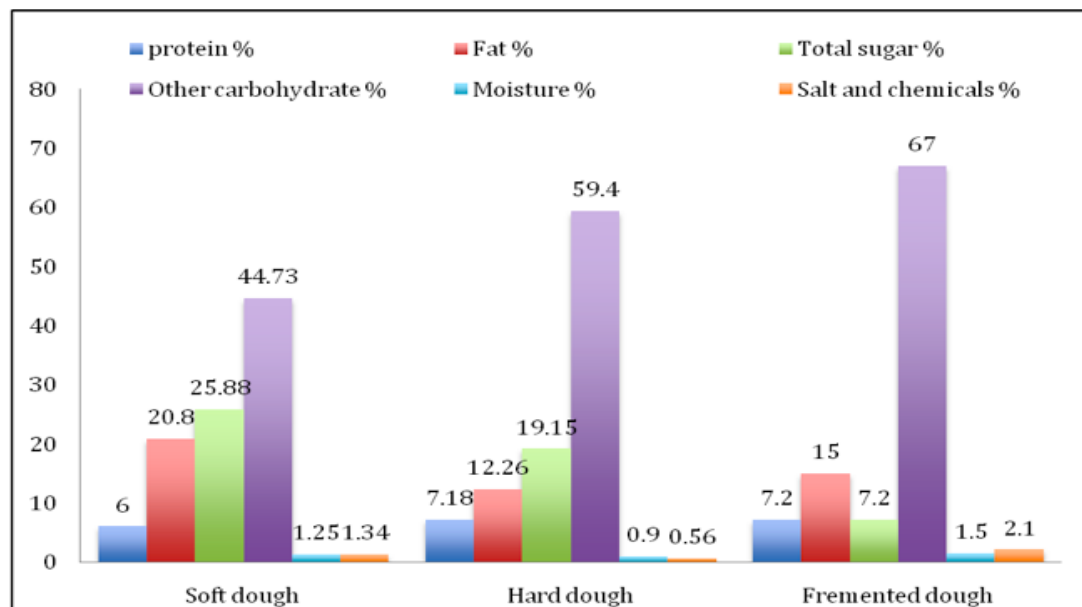
minor ingredients. For example, flour, water, sugar and fat are used in bulk in biscuit making procedure and form the major ingredients (Niroula, 2019). Salt, skim milk powder (SMP), ammonium bi-carbonate, sodium bi-carbonate, colouring agents, flavoring agents, emulsifiers, fortifying agents, improvers etc. are used in small amounts and aren't a must for all types of biscuits cream crackers and soda crackers generally follow a fermented process, in which the dough is first fermented, and then formed into sheets before cutting & baking. Savory crackers are the ones that are generally sprinkled with fat during or after the biscuit making process. Water biscuit are characterized by a crumbly dough that is not completely fermented, whereas puff biscuits are made of puffed dough that generally don't have a flat surface. Sponge biscuits are made of soft fragile dough produced by whipped egg whites, while short dough biscuits are made from cohesive doughs that lack elasticity.

The chemical composition of biscuits varies across different types of biscuits due to differences in the composition of raw materials, the preparation method, the final purpose of manufacturing this type of biscuit, and a range of other factors. The main difference between hard, soft, and fermented biscuits is explained in fig. (2).

Table (1): Some studies on using different types of baking technologies

Method of Baking	Baking conditions	Physico-chemical Properties	Results	References
Convection oven (Convection + Microwave) oven	245 °C, 3.66 min (245 °C, 3 min) + (700 W, 30 s	Checking, mechanical  Strength  Breaking stress	Checking reduced to 5 % in microwaved biscuit (MB) compared to 61 % in conventional biscuit (CB) 997 kPa for MB 610 kPa for CB	Ahmad <i>et al.</i> (2001)
Convection oven Microwave oven	200 C for 12 min 40S, medium power	Moisture content	Higher moisture loss and minimal colour change occurred in the microwave	Sosa- Morales <i>et al.</i> (2004)
Convection oven	220c, 15 ,20 and 25 min	Browning ratio	67.5 %	Gökmen <i>et al.</i> (2008)
Convection oven Convection+radio frequency	205c,11min 205c,9,8 ,27.12MHZ	Acrylamide content	107.3 ng.g <sup>-1</sup> for control biscuits  74.6 ng.g <sup>-1</sup> , 9min, 51.1ng.g <sup>-1</sup> ,8min	KorayPalaz oğlu <i>et al.</i> (2012)
Convection oven	200C, < 20 min	Content of 5- HMF	1.80 ± 0.05 to 34.99 ± 0.22mg.kg <sup>-1</sup>	Cronin & Preis (2000)
Convection oven Microwave oven	190c, 10min 700W, 90 S	Acrylamide content	Acrylamide content was decreased from 355.2 µg.kg <sup>-1</sup> in control samples to 138.6 µg.kg <sup>-1</sup> in conventional-baked biscuits and from 306.9 µg.kg <sup>-1</sup> in control samples to 97.8 µg.kg <sup>-1</sup> in microwave	Waleed <i>et al.</i> (2019)
Convection oven	200c,15min and cooled to room temperature (25c)	Isosteric heat sorption	The maximum isosteric heat of sorption (21.6 kj.mol <sup>-1</sup> ) was attained at 2.5% equilibrium moisture	Sampaio <i>et al.</i> (2009)
Convection oven	180°C, 7, 10 and 13 min	Acrylamide Content	Increased from 72.3 to 861.7 ug.kg <sup>-1</sup>	Žilić <i>et al.</i> (2020)

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**Fig. (2): Compositional differences between hard, soft and fermented biscuits (Niroula, 2019)**

### Foodborne pathogens in biscuits

In recent years, there has been a gradual increase in demand for improved food security. Based on media reports and other outlets, pathogens causing diseases constitute about 40 percent and food-borne diseases have major health effects on the general population and on the economy (Kuhn *et al.*, 2019). Food spoilage is the metabolic process that renders foods unacceptable for human consumption due to changes in their organoleptic properties. Microbial growth in food products can lead to food poisoning, in which symptoms appear shortly after food consumption (Dietrich *et al.*, 2021).

Children under the age of five are more vulnerable to food-borne infections owing to their less developed immune systems and a lack of competition among species with their gut flora. Cereal foods are known to be high in nutrients and contain ingredients from various backgrounds, making them more susceptible to contamination by food-borne pathogens (Kim

*et al.*, 2011). There are several potential sources of microorganism infection of confectionery products, including the first contamination of raw materials that penetrate all types of crops, fruits in fields prior to harvesting, and the subsequent contaminations, machinery, during the manufacturing process, packaging, shipping, and storage

Furthermore, infection can occur on account of insufficient refrigeration, long-term food preparation prior to feeding, poor personal hygiene, and insufficient heat processing, and food storage in plastic devices, both of which promote the growth of bacteria. Thus, food spoilage is a biochemical mechanism that transforms foods into unpalatable for human consumption due to sensory modifications and their ability to be infected by pathogenic food-borne microorganisms (Al-Nasiry, 2020). Kim *et al.* (2011) was investigated the prevalence and degree of pathogenic contamination of various food items consumed by infants, including powdered infant formula, soy milk,

cereal-based follow-up formulas, rice soups, honey, liquid follow-up formulas, biscuits, beverages, nutrient supplements, and noodles. The study results reveal that some of these products, such as cereal-based follow-up formulas and nutrient supplements, had a high aerobic plate count. Therefore carrying a potential risk of exposure to food-borne pathogens. Table (2) illustrates food-borne diseases caused by pathogens in biscuits and biscuits. Many studies have focused on finding a standard or determining the microbial number allowed in the biscuit, studying this specification accurately and knowing the extent of its conformity with all types of biscuits that are made all over the world and with different manufacturing methods and determining the optimal conditions for production (Niroula, 2019). Thus, it is necessary to restrict the microbiological contamination in biscuits to levels below 10000 cfu.g<sup>-1</sup> for mesophilic bacteria, 10 cfu.g<sup>-1</sup> for coliforms, 0 cfu.g<sup>-1</sup> for pathogens like *Escherichia coli*, *Salmonella* sp. and *Staphylococcus* sp., *Enterobacter*

*sakazakii*, 10 cfu.g<sup>-1</sup> *Bacillus cereus*, and 100 cfu.g<sup>-1</sup> for yeast and moulds (Niroula, 2019).

Forsythe & Hayes (2012) indicated that it is possible to assess the sanitary standard of food by analyzing the microorganism index. Besides, there are the main groups of microorganisms that are used alone or together to find out the microbiological characteristics and health status of the food. Biscuits are produced from grains or a grain product and may be affected by microbial contamination due to improper handling, as well as failure to take into account health conditions. The total count of bacteria utilized extensively to obtain an opinion on the health quality and microbiological load of food products. Additionally, Forsythe & Hayes (2012) estimated average values of the total number of mesophyllic aerobic bacteria, coliform bacteria, *Staphylococcus aureus*, coliform fecal bacteria, and *salmonella* bacteria, and the total number of yeasts and molds in 150 samples of biscuits.

**Table (2): Examples of foodborne diseases caused by microorganisms**

Microorganism sources	Products	Symptoms and illnesses	References
<i>Bacillus cereus</i>	Biscuit	The emetic (vomiting) syndrome and the diarrhoeal syndrome	Kim <i>et al.</i> (2011)
<i>Klebsiella</i> spp.	Biscuit	Septicaemia, liver abscesses, and diarrhea	Das <i>et al.</i> (2020)
<i>Bacillus cereus</i>	Biscuit	Toxins produced	Hossain <i>et al.</i> (2013)
<i>Staphylococcus aureus</i>	Biscuit	Bloodstream infections, pneumonia, or bone and joint infections.	Al-Husnian & Alkahtani (2015)
<i>Bacillus megaterium</i>	Biscuits	meningitis, pneumonia	Logan (2012)



Statistical analysis of this study exhibited that there were significant differences between the mean values for each type of microorganism that was detected for all 150 samples. The study results also revealed that there were no significant differences in the values of mesophyllic aerobic bacteria, coliform bacteria and fecal coliform bacteria, with regard to the limit permitted by the World Food Program. Moreover, it is indicated that there were significant differences in the values of the total number of yeasts, molds and salmonella bacteria, according to the limit permitted by the World Food Program. Figure 3 illustrates the comparison between the mean values of the analyzed samples of biscuits with the average values allowed by the World Food Program (Forsythe & Hayes, 2012).

Ferdian *et al.* (2020) collected 30 pieces of bakery products and 10 types of bread were

randomly selected from the city of Yogyakarta, Indonesia, in order to estimate the microbial content of these products.

Three samples were taken from each place and these products had a shelf life from fresh to the age of two days from the time of production. Five types of Gram-positive bacteria have been identified as contaminants in bakery products after the expiration date of the product. The colonies of disease-causing bacteria represented by *S. aureus* were higher than the standard permissible level according to the Indonesian standard and may cause toxicity to the consumer. Although this study outcome has provided information on contaminants of bakery products to the consumers, there is a need for more studies to understand their disease-causing mechanism (Ferdian *et al.*, 2020).

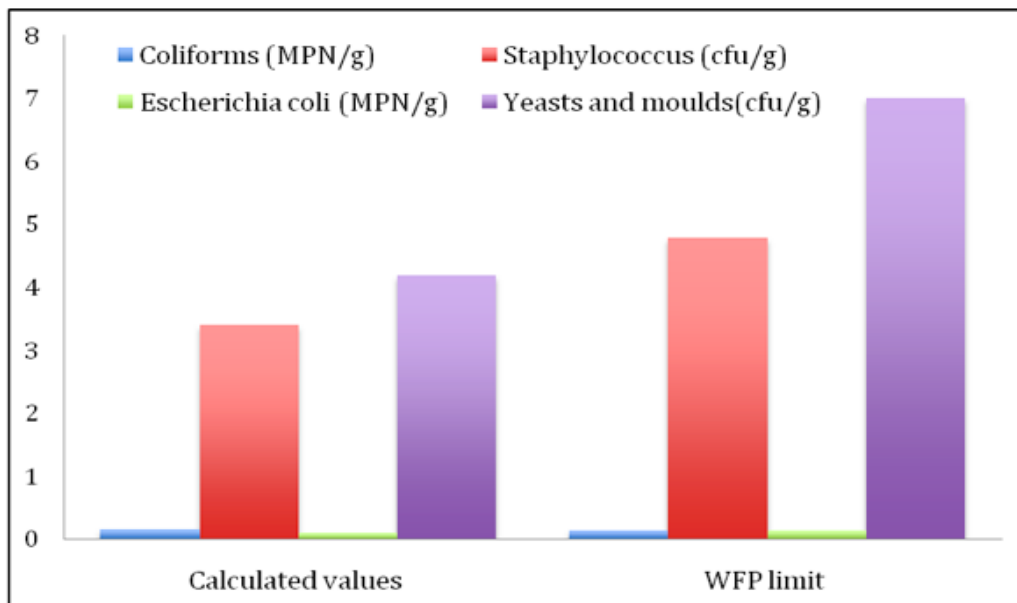


Fig. (3): Comparison of average values for the microbial content of biscuit samples with the limits permitted by the World Food Program (reproduced with permission from Forsythe & Hayes, 2012)

Recent studies have indicated the great role of bakery techniques used in reducing the microbial content and limiting the growth of microorganisms. Table (3) represents the microbiological quality in some types of bakery products produced using different types of baking technologies.

### Quality parameters of biscuits

#### Nutritional analysis

Shuvo & Zahid (2016) conducted a comparative study on the nutritional quality analysis of different types of fortified biscuits that are distributed for school feeding purposes in Bangladesh (Fig. 5). 150 samples of biscuits were collected randomly from

food factories. The results illustrate the approximate composition of fortified high-energy biscuits, while fig. (4) compares the average samples analyzed of high-energy biscuits with the limits permitted by the World Food Program. The moisture content was 2.82 % which, was statistically significant ( $p > 0.001$ ) and below permissible limits according to world food program (WFP, 2010) requirements. Moisture is a critical factor for the biscuit product because it greatly affects the growth of microorganisms, shelf life, and quality (Swanson & Anderson, 2000).

**Table (3): Impact of baking approaches on inactivation of microorganisms**

Type of equipment	Treatment Conditions	Microorganism	Findings	References
Electric oven	170 °C for 15 min	Total bacterial	2.25 log cfu.g <sup>-1</sup>	Aly (2019)
		Spore-forming Total molds or yeasts	1.69 log cfu.g <sup>-1</sup> 2.91 log cfu.g <sup>-1</sup>	
Oven	180 °C for 17 min	APC Fungal count	2.74 log cfu.g <sup>-1</sup> 1.69 log cfu.g <sup>-1</sup>	Adeloa <i>et al.</i> (2020)
Oven	180 °C for 10- 15 min	Total bacterial Spore-forming bacteria total molds and yeasts	2.96 log cfu.g <sup>-1</sup> 2.36 log cfu.g <sup>-1</sup> Not detected	Aly <i>et al.</i> (2021)
Home oven	150 °C for 20 min	APC Yeast/mold	Not detected Not detected	Oladunjoye <i>et al.</i> (2021)
Electrically preheated rotary oven	205 °C for 6.5 min	APC	3.7 log cfu.g <sup>-1</sup>	Sabillón <i>et al.</i> (2021)
		Coliform	3.1 log cfu.g <sup>-1</sup>	
		Yeasts	2.5 log cfu.g <sup>-1</sup>	
		Molds	2.3 log cfu.g <sup>-1</sup>	

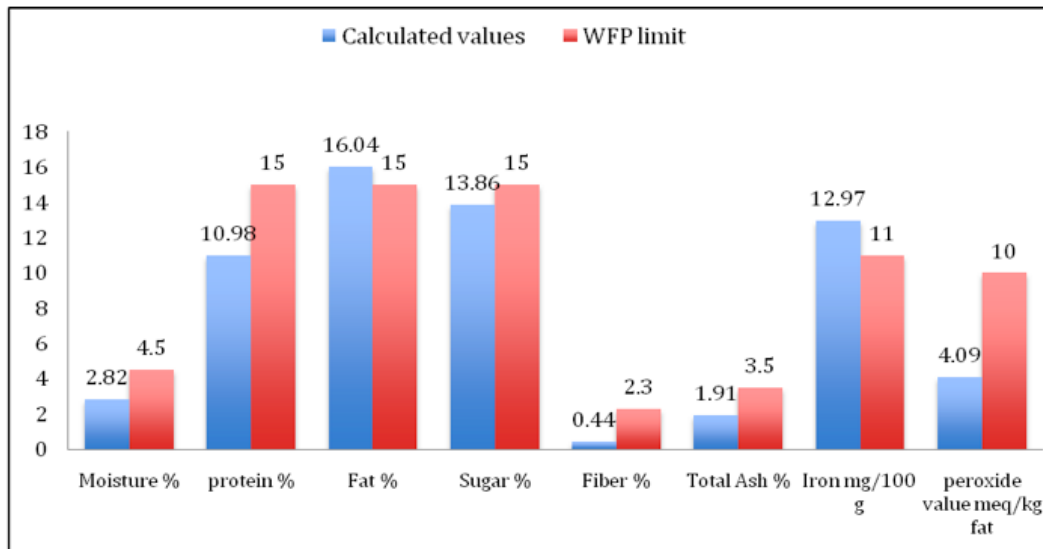
This could be due to an increase in protein content as a result of soya flour and protein has more affinity to moisture than carbohydrate and has the advantage to maintain the shelf life properly as most spoilage organisms may not be able to survive (Agu & Okoli, 2014). This study results were consistent with the study that was conducted on the effect of sesame seed flour on the properties of millet biscuits (Alobo, 2001). The protein content in the biscuit product was 10.983 g and it was statistically significant at the 1% level. Biscuits fortified with soy flour contain significantly higher amounts of total and digestible proteins (Serrem *et al.*, 2011). The obtained results are roughly consistent with the data obtained by Abdel-Aal (2008) who found that the protein content in the biscuit ranges between 11-11.5 g.100g<sup>-1</sup>. The fat content was statistically significant at the level of 1 %. This increase may be due to the addition of vegetable fats and flour, which were a good source of oil. The study also revealed that the content of sugar and crude fibre was 13,687 g and 0.447 g, respectively, and they are considered below the permissible limits according to the requirements of the World Food Program (Dewettinck *et al.*, 2008). The sugar and fibre content may increase due to the addition of wheat and soy flour, which were a good source of fibre content. This is a desirable feature because it helps with bowel movement and ease of digestion. The results also showed that the total ash content was 1.916 g, which is statistically significant at the level of 1 %. The studies indicated that high levels of ash could

be due to the addition of bran in wheat (WFP, 2010). Ash content is a vital part of the biscuit product as it provides essential minerals for the diet system. In contrast, the high ash content causes yeast fermentation (Dewettinck *et al.*, 2008).

The study also indicated that the content of vitamin A was 236.26 µg, which was statistically significant at the level of 5 % and less than the requirements of the World Food Program, while the percentage of iron in the biscuits was about 12.978 mg, which is higher than the requirements of the World Food Program (Fig. 4) (Dewettinck *et al.*, 2008). The energy content of the sample biscuit was 456.54 kcal, which is also higher than the World Food Program requirements (WFP, 2010). The results also showed that the peroxide value was 4.098, which was less than the requirements of the World Food Program (Agu & Okoli., 2014).

### **Metals content**

Heavy metals are one of the most vital contaminants which are the element that has a relatively high density and is toxic or poisonous at low concentrations. Food chain contamination is one of the crucial pathways; heavy metals contribute 90 % compared to other sources and Dada *et al.* (2017) demonstrated the discovery of different concentrations of minerals in snacks manufactured by two various institutions in Nigeria. The results obtained showed variations in the amounts of copper and zinc in snacks manufactured by both institutions.



**Fig. (4): Comparison of average values of biscuit samples with limits permitted by the World Food Program (WFP, 2010)**

In the first institution, the plantain chips meals had an average of zinc and copper concentrations of  $2.15 \pm 0.13 \text{ mg.kg}^{-1}$  and  $0.27 \pm 0.03 \text{ mg.kg}^{-1}$ , respectively (Dada *et al.*, 2017). These results were significantly higher than the corresponding levels of  $1.77 \pm 0.57 \text{ mg.kg}^{-1}$  of zinc and  $0.11 \pm 0.04 \text{ mg/kg}$  of copper in plantain chips obtained from the second institution. Whereas, the average of zinc ( $2.45 \pm 0.52 \text{ mg.kg}^{-1}$ ) in potato chips taken from the second institution was higher than the average level of the same mineral ( $1.79 \pm 0.89 \text{ mg.kg}^{-1}$ ) in potato chips obtained from the first institution (Dada *et al.*, 2017). The donuts and biscuits had higher average zinc levels in the first institution. The average concentration of copper in snacks obtained from the two institutions was about 0.05 to  $1.00 \text{ mg.kg}^{-1}$ , which is within limits permitted by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO), as both health institutions set a standard specification concerned with minerals (Codex Alimentarius Commission,

2015). The study also showed the cadmium and lead concentrations in these snacks obtained from the two institutions (Dada *et al.*, 2017).

The results exhibited that the concentrations of cadmium were lower in general or within the limits permitted by the WHO and the FAO, as it is reached 0.05 to  $0.1 \text{ mg.kg}^{-1}$ . Whereas, the lead concentrations in both potato chips obtained from the first institution and plantain chips obtained from the second institution were 1.19 and  $0.61 \text{ mg.kg}^{-1}$ , respectively. The lead concentrations were inconsistent with the permissible limit of the WHO and the FAO (Codex Alimentarius Commission, 2015).

Iwegbue *et al.* (2015) studied and estimated the levels of iron, copper, lead, cobalt, nickel, zinc, magnesium, and calcium in six different brands of biscuits that were collected from the Nigerian markets. According to the recommended quantities, the six different brands of biscuits were within the permissible standards for daily consumption and for nickel, the concentration was more than the permissible

limit. Mohammadi *et al.* (2018) investigated a health risk assessment of heavy metals (As, Cd, Cu, Ni, Pb, and Sn) in Qom's Sohan, Iran in 2015. Hundred numbers of samples were selected randomly from the most popular brands of Sohan. The results showed that the metals level ( $\text{mg.kg}^{-1}$ ) of As, Cd, Cu, Ni, Pb, and Sn ranged 100-300, 10-50, 500-36,000, 60-550, 30-1750, and 45-1700, respectively. In addition, health risk assessment showed that consuming the traditional Persian saffron brittle toffee poses no potential risks for children and adults.

Shkhaier *et al.* (2018) evaluated the levels of heavy metals such as cadmium (Cd), nickel (Ni), and lead (Pb) in commercial candies and chocolate products that are commonly consumed by children in Iraq. The examined chocolates were Twix (Germany), Mars and Galaxy (Emirates) and the candies were Melody Pops (Iraq), Caretos, and Lip- Top (India).

The research outcomes of this study demonstrate that the amounts of heavy metals (Ni, Pb, and Cd) in the chocolates were higher than candies. Regardless of the source of pollution of these metals, the continued consumption of these contaminated food products can cause harm to health. Therefore, there is a need to exercise caution in consuming these metals because nickel can aggravate dermatitis while lead may decrease IQ in humans (Shkhaier *et al.*, 2018).

Oyekunle *et al.* (2021) examined and evaluated the levels of potentially toxic metals in six biscuit samples commonly consumed by Nigerians. Potentially toxic metal levels were ranged from 0.050 to 2.525  $\mu\text{g.g}^{-1}$ . Health risk indices evaluated for toxic metals indicated that consumption of the biscuit products as

occasional in-between meals and snacks might not constitute serious health problems. Salazar-Flores *et al.* (2019) evaluated the dietary intake and risk assessment of heavy metals from selected biscuit brands in Nigeria. The observed mean concentrations of trace metals detected in the samples were, 0-46.4  $\text{mg.kg}^{-1}$  Cr, 3.11-92.0  $\text{mg.kg}^{-1}$  Pb, respectively. Cu and Cd were not detected in all the biscuit samples.

### **Hydroxymethylfurfural (HMF) Content**

The hydroxymethylfurfural (HMF) content in food is currently undergoing careful evaluation due to its toxic association with human health Delgado Andrade *et al.* (2009). A mechanism of the harmful effect of this carcinogenic compound is enabled by its metabolic activity by sulfotransferases, which convert it to sulfoxymethylfurfural (Pasqualone *et al.*, 2021). This reaction may occur in the liver. The exceptionally high percentage of this compound in humans, the presence of this compound in many diets, and its cause in cases of poisoning inside the living body, as proven by scientific studies, called for the need to conduct extensive studies and update information on its toxicity in a wide range of foods.

Delgado Andrade *et al.* (2009) studied sixty-one types of biscuits manufactured by different companies to estimate the HMF compound and these biscuits were sold in the Spanish market. Study samples containing chocolate, dried fruits and cream were excluded. The amount of HMF was estimated and calculated for Spanish consumers from the biscuit at a rate of 2.3  $\mu\text{g.kg}^{-1}$  of body weight per day with an average weight of 70 kg. The results showed that the amount of HMF was ranged between 3.1 to 182.5  $\text{mg.kg}^{-1}$ , with an average of 14.4  $\text{mg.kg}^{-1}$ . The large

variation in the amount of this compound cannot be directly related to any specific ingredient but may be closely associated with the type of heat treatment used in the manufacturing process, as well as the significant change in the composition of the dough that is not authorized by the manufacturers, which is highly relevant in affecting high or low amount of HMF (Delgado Andrade *et al.*, 2009)

Svecova & Mojmir (2017) estimated the HMF content in 13 samples of biscuits sold in the Slovak markets. The biscuit samples were divided into three groups, the first group is four samples of biscuits intended for children over the age of six. The second group is also four samples of biscuits intended for children over one year of age. The third group represents five samples of biscuits that are not specified for a specific age. High-performance liquid chromatography was used to quantify the HMF.

The amount of HMF in the first group ranged from 0.34 to 1.73 mg.kg<sup>-1</sup>. The second group ranged between 0.57 to 1.78 mg.kg<sup>-1</sup>, while in the third group, the amount of HMF ranged between 1.8 to 34.99 mg.kg<sup>-1</sup>. The statistical analysis of this study indicate a decrease in the amount of HMF in the biscuits intended for children over the age of six months, and the biscuits intended for children over one year of age (Svecova & Mojmir, 2017). Biscuit-making industries, greatly interested in effective and simple ways for limiting acrylamide formation, are modifying their processing conditions to reduce the thermal load while keeping good levels of sensorial satisfaction. Table (4) represents the HMF in some types of bakery products produced using different types of baking technologies.

### Acrylamide content

Cereal products are one of the main contributors to acrylamide exposure and therefore are included among the foodstuffs regulated by the European Commission (EFSA, 2015). Recently, acrylamide is gained a considerable attention and it was found to be formed as a result of heat processing in foods. Acrylamide is regarded as a Maillard reaction product that is synthesised from amino acids and reducing sugars (Mottram *et al.*, 2002). Acrylamide was classified and listed as 'probably carcinogenic to humans' under the Group 2A by the International Agency for Research on Cancer (IARC) (Ölmez *et al.*, 2008). The indicative values set by the European Commission for acrylamide in biscuits have been reduced from 500 to a benchmark value of 350 µg.kg<sup>-1</sup> (EU, 2017).

Mesías *et al.* (2019) determined the acrylamide content in 80 commercial biscuits marketed in Spain using LC-ESI-MS/MS. The acrylamide levels in biscuits marketed in Spain showed a great variability, ranging from lower than 20 µg.kg<sup>-1</sup> to 2144 µg.kg<sup>-1</sup>. 70 % of the samples were below the benchmark level established by the EU Regulation 2017/2158. In contrast, 30 % of the samples exceed the reference level. Ölmez *et al.* (2008) estimated the acrylamide content in 40 samples of biscuits sold in the Turkish market using GC-MS.

Significant differences were observed in the acrylamide contents of different brands of the baby biscuits. No significant change in the acrylamide contents of the baby biscuits were observed during the six months of storage time after their production dates.

**Table (4): Effect different types of baking technologies on HMF**

Products	Heating condition	Heating parameters	HMF	Findings	References
Biscuits	Conventional oven	200°C, less than 20 min	1.80 to 34.99 mg.kg <sup>-1</sup>	The content of 5-HMF in biscuits without age group determination was significantly high	Svecova & Mojmir (2017)
Biscuits	Laboratory oven	200, 215, 230 and 245 °C for 5 to 18 min	2.99+0.02 mg.kg <sup>-1</sup> 13.48+0.47 mg.kg <sup>-1</sup> 21.20+6.24 mg.kg <sup>-1</sup> 31.16+0.52 mg.kg <sup>-1</sup>	An increase in HMF amount with temperature rising during baking	Kowalski <i>et al.</i> (2013b)
Biscuit	Hot air oven	180,190 and 200 °C	2.7 mg.kg <sup>-1</sup> 17.5 mg.kg <sup>-1</sup> 295 mg.kg <sup>-1</sup>	high amount of HMF at all the tested temperatures	Van Der Fels- Klerx <i>et al.</i> (2014)
Biscuit ammonia	Oven	180 °C,200 °C for 10 min	2581.5 ug.kg <sup>-1</sup> 4567.1 ug.kg <sup>-1</sup>	A decrease in the 5-HMF amount at all the temperatures	Mousa (2019)
Biscuit	Oven	200 °C for 20 min	14.4 mg.kg <sup>-1</sup>	High levels of HMF	Delgado-Andrade <i>et al.</i> (2009)

Mencin *et al.* (2020) estimated the amount of acrylamide in food products on the Slovenian market. The current study also evaluated risk assessment for the average dietary exposure to acrylamide of Slovenian population. The mean acrylamide levels for the seven samples of biscuits that were obtained randomly from Slovenian supermarkets ranged from  $20.5 \mu\text{g}\cdot\text{kg}^{-1}$  to  $3439.4 \mu\text{g}\cdot\text{kg}^{-1}$ . None of the samples showed acrylamide levels below the LOD and the LOQ. In total, 49 % of the samples analysed exceeded the benchmark levels for acrylamide as recommended by European Commission Regulation (EU, 2017). The levels of acrylamide in biscuits found in the range of  $52.3 \pm 0.70$  to  $507.5 \pm 1.5 \mu\text{g}\cdot\text{kg}^{-1}$ . The acrylamide level is reported first time in Pakistani food products. Acrylamide formation in baked and fried products is still of concern, as the formation of acrylamide in food products of developing country is still unknown for consumers and industries. Therefore, it is an urgent need to reduce the acrylamide level produced during food processing.

### Conclusion and Future Trends

The biscuit-making industry has constantly evolved over the last three decades with rapid developments and innovation with the aid of the biscuit-making technology. Converting convectional, infrared, microwave, and combination of infrared with microwave, steam baking, and microwave heating methods presents additional options for biscuit manufacturers. In the upcoming days, it could be expected that new, updated, and

better technologies will reduce the baking process's processing time while maintaining high standard nutritional quality and minimizing any environmental or toxicological impact of biscuits and biscuits will be rapidly investigated. Increasingly aware consumers are constantly demanding innovations in the types of biscuits and their nutritive compositions. As a result, a large variety of healthy biscuits with functional ingredients continually appear on the global market. The future outlook also involves greater research on fat-replacers and sugar-replacers and making biscuits more nutritive and palatable. Both the fat and sugar replacers are beneficial for consumer health, and they play a crucial role in low-fat bakery food items.

The microbiological safety of the biscuits is primarily achieved by the low water activity and moisture content. Thus, it is truly essential to streamline the packaging and storage considerations of the biscuits to extend the shelf-life and maintain the quality parameters. Therefore, the minimum acceptable safety levels for different microorganisms are presented in this review, highlighting the other microorganisms of concern found in biscuits.

In terms of chemical contaminants, heavy metals were revealed to be the most significant contaminants that find their way in biscuits due to the contamination along the production and supply chain. In addition, the generation of hydroxymethyl furfural with contents up to  $180 \text{ mg/kg}$  has been reported in the literature. This requires further investigation into applicable



technologies that minimize the generation of HMF, while still maintaining high product quality.

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## Conflict of interest

The authors declared that they have no conflict of interest.

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## التركيب الكيميائي ومعايير الجودة للبسكويت: مراجعة بحثية

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5 **المستخلص:** البسكويت هو غذاء مشهور وجاهز للاكل بسبب تكلفته المعقوله وفترة صلاحيته الطويله. سيتم استعراض معايير  
6 الجوده للبسكويت مع التركيز بشكل خاص على التغيرات التي تسببها المعاملات الحراريه. سيتم على وجه الخصوص بالتحري على  
7 وجود الملوثات المحتمله بما في ذلك مركب هيدروكسي مثيل فورفرال. بالاضافه الى ذلك، سيتم عرض المصادر الميكروبيولوجيه  
8 المختلفه التي تثير القلق اثناء عمليه صنع البسكويت وتأثيرها على العمر الافتراضي وجوده البسكويت. وبناء آ على الدراسات السابقه ،  
9 سيتم التركيز على اهم التحديات الحديثه في صناعه البسكويت والنظره المستقبليه لصناعه البسكويت. ستكون هذه مقاله مفيده في  
10 فهم الحاله الحاليه للدراسات المتعلقه بمعايير جوده البسكويت ونقاط التحكم الحرجه المهمه من اجل الحفاظ على سلامه وجوده  
11 منتجات البسكويت

12 **الكلمات المفتاحيه:** بسكويت، تكنولوجيا التخبيز، جوده البسكويت، تصنيع اغذيه.