Journal of Food Science and Technology (Iran)

Homepage:www.fsct.modares.ir

Scientific Research

Studying the effect of enzymatic improver on the physicochemical and sensory properties of Zabol traditional cookie based on bug-damaged wheat flour with different extraction rates

Narges Mir[1], Bahareh Sahraiyan [2*]

1- M.S, Department of Food Science and Technology, Faculty of Agriculture, University of Zabol, Zabol, Iran.

2- Department of Food Quality and Safety, Food Science and Technology Research Institute, ACECR Khorasan Razavi Branch, Mashhad, Iran.

ARTICLE INFO

Article History:

Received:2025/2/18

Accepted:2025/4/15

Keywords:

Wholemeal flour,
Bug-damaged,
Extruded bran,
Traditional cookies,
Texture.

DOI: **10.22034/FSCT.22.166.230.**

*Corresponding Author E-

Baharehsahraiyan@yahoo.com

ABSTRACT

This study aimed to produce Zabol traditional cookies from bug-damaged wheat flour with an extraction rate of 78, 88 and 96% and to design a specific improver for this product using ascorbic acid (0.003%), xylanase enzyme (0.04%), sodium stearoyl 2-lactylate (SSL) and tartaric acid mono- and diglyceride esters (DATEM) (0.5%) emulsifiers and sorbitol sugar alcohol (1%), and then to evaluate the quantity and quality of the final product. The results showed that the samples with bran and containing the improver had a higher moisture content during one month of storage. With increasing the extraction rates of bug-damaged wheat flour, the texture firmness increased and the specific volume of the cookies decreased. This was while the presence of the improver in the formulation of the produced samples played an effective role in improving the textural properties. By increasing the flour extraction rates, the amount of L* and b* values decreased and the amount of a* increased, and the presence of an improved in the formulation led to a decrease in the darkness of the surface of the cookies. Finally, based on the findings, it was determined that without the desire to use improvers, the sample prepared from bug-damaged wheat flour with an extraction rate of 78 percent had the best quantitative and qualitative properties. This was while using the designed improver made it possible to use 10 percent bran in the formulation of Zabol traditional cookies (using bug-damaged wheat flour with an extraction rate of 88 percent), and this sample with the highest score in form and shape, porosity, chewiness, and firmness and softness of texture is introduced as the superior sample in this study.

1. Introduction

Cookies represent a widely consumed baked confection, typically composed of wheat flour, oil, sugar, and eggs as primary ingredients [1]. The wheat flour utilized in cookie production is generally weaker and exhibits a lower protein content compared to bread flour [2]. Consequently, sunn pest-damaged wheat, characterized by a reduced gluten content, can be incorporated at appropriate levels in combination with intact (non-insect-damaged) wheat flour for cookie manufacturing [3]. However, it is crucial to acknowledge that the protease enzyme originating from the sunn pest (Eurygaster integriceps) weakens the gluten network, resulting in a fragile and sticky dough with diminished handling and shaping properties. Due to impaired water retention, consistency, and a low tolerance factor, this dough yields a final product with an inferior internal texture and undesirable sensory attributes (texture, chewability, form and shape, color, aroma, and taste) [4]. Ascorbic acid is commonly employed to strengthen weak wheat flour and partially mitigate the detrimental effects of sunn pest damage. This additive enhances the kneading and baking processes, reduces dough stickiness, increases volume and porosity, and imparts more desirable sensory characteristics, including aroma, taste, color, appearance, and form, to the resultant product [5]. The utilization of whole wheat flour in baked goods, including cookies, is limited due to the presence of 4.5-4.8% phytic acid in wheat bran. Moreover, the high ratio of insoluble to soluble fibers, insoluble arabinoxylans, and glutathione can create technological challenges in bran-enriched bakery products [6 and 7]. Extrusion cooking emerges as an effective strategy to mitigate certain drawbacks associated with bran. During extrusion, materials are subjected to a combination of moisture, pressure, temperature, and mechanical shear. This process offers advantages such as reduced microbial content, inactivation of specific enzymes and anti-nutritional factors (phytate reduction in bran), and increased soluble fiber content [8]. In addition to mitigating the detrimental effects of wheat bran on protein and starch structures, common baking industry additives such as enzymes, emulsifiers, and sugar alcohols can be employed. Xylanase, a crucial hemicellulase enzyme, hydrolyzes non-starch polysaccharides into xylose and oligosaccharides [9]. By cleaving glycosidic bonds within the xylan backbone of arabinoxylans, xylanase reduces the degree of polymerization and releases smaller components [10]. Consequently, the conversion of insoluble arabinoxylans into soluble forms enhances dough extensibility and diminishes their negative impacts [11]. Xylanase is utilized in the baking industry to stabilize dough structure, improve its flexibility, enhance gluten strength, and reduce retrogradation [12]. Sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM) are common emulsifiers in the baking industry. Emulsifiers, being surface-active compounds, function as additives in baking to soften the internal texture and produce products with extended shelf life. This effect can be attributed to their ability to bind with gluten proteins and starch [13]. Polyols, owing to their inherent hygroscopic properties, contribute to reducing water activity and improving the internal texture of baked goods [14]. Sugar alcohols, such as sorbitol, are commonly employed in food applications to enhance quality by modifying starch gelatinization and retrogradation [15]. Therefore, considering the positive impact of ascorbic acid on improving the quality of sunn pest-damaged wheat flour and the performance of xylanase enzyme, in conjunction with the beneficial effects of sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM) emulsifiers, and the sugar alcohol sorbitol on enhancing the quantity and quality of baked products containing whole wheat flour or bran-rich flours, the objective of this research was to formulate an improver containing a mixture of ascorbic acid, xylanase enzyme, emulsifiers, and sorbitol, and to investigate its influence on the physicochemical and sensory characteristics of Zabol traditional cookies made with sunn pest-damaged whole wheat flour.

2- Materials and Methods

2.1. Materials

Wheat kernels exhibiting approximately 10% sunn pest damage were cleaned (processed in a grain cleaner) and milled into flour using a hammer mill, passing the resulting flour through a 60-mesh sieve. Three flour samples were then stored in a cool, dry storage facility under controlled conditions until the commencement of experimental analyses. Ascorbic acid, the emulsifiers sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM), the enzyme xylanase, the sugar alcohol sorbitol, and other chemical reagents were procured from reputable commercial suppliers. Granulated sugar, salt, hydrogenated vegetable oil, and *Saccharomyces cerevisiae* yeast (in the form of active dry yeast powder, vacuum-packed) were purchased from a confectionery supply store in Mashhad, Iran.

2.2. Preparation of Extruded Bran

Wheat bran was extruded under optimized conditions [8], specifically at a moisture content of 21%, an extrusion temperature of 120$^{\circ C}$, a screw speed of 300 rpm, a feed rate of 40 kg/h, and using a 4 mm diameter die. Notably, the sunn pest-damaged wheat (initial sample) was milled to produce flour with an extraction rate of 78%. To prepare flour with higher extraction rates of 96% (whole wheat flour) and 88%, 18% and 10% extruded bran was added to the flour with an extraction rate of 78%, respectively.

2.3. preparation of cookie

The preparation and baking of Zabol traditional cookie dough (simple type) were conducted using the following raw materials: 100% sunn pest-damaged wheat flour (with three extraction rates of 78%, 88%, and 96%), 25% semi-solid oil, 2% powdered sugar, 0.5% yeast, 0.3% salt, and 20% water. To prepare the dough, powdered sugar, yeast, and lukewarm water (35$^{\circ C}$) were mixed in a 250 mL beaker and allowed to stand for 5 minutes (until a foamy appearance, indicating yeast activation, was observed). Subsequently, the flour, salt, and oil were mixed in a laboratory mixer (BJY-BM5N, Bik Sanat Co., Iran) until a homogeneous and uniform dough was achieved. The activated yeast was then added, and kneading was performed manually for 5 minutes. The dough was then covered with polyethylene film and allowed to rest for 1 hour and 30 minutes at room temperature (25$^{\circ C}$). Next, the prepared dough was rolled out on a silicone sheet using a rolling pin and prepared for molding with a round cutter with a diameter of 2 cm and a height of 0.5 cm. Finally, the cookie dough pieces were placed on a tray and baked in a laboratory oven (XFT135, Italy) at 180°C for 25 minutes. After baking, the samples were stored in polyethylene packages at room temperature (25$^{\circ C}$) for subsequent testing. It is important to note that this research included 6 treatments, in which ascorbic acid, xylanase enzyme, and sorbitol were added to the flour, and emulsifiers were added to the semi-solid oil before being thoroughly mixed and incorporated into the formulation.

Treatment 1: Sample containing sunn pest-damaged wheat flour with a 78% extraction rate and without additives.

Treatment 2: Sample containing sunn pest-damaged wheat flour with a 78% extraction rate, supplemented with 0.003% ascorbic acid, 0.04% xylanase enzyme, 0.5% emulsifiers (DATEM and Sodium Stearoyl-2-Lactylate), and 1% sorbitol.

Treatment 3: Sample containing sunn pest-damaged wheat flour with an 88% extraction rate and without additives.

Treatment 4: Sample containing sunn pest-damaged wheat flour with an 88% extraction rate, supplemented with 0.003% ascorbic acid, 0.04% xylanase enzyme, 0.5% emulsifiers (DATEM and Sodium Stearoyl-2-Lactylate), and 1% sorbitol.

Treatment 5: Sample containing sunn pest-damaged wheat flour with a 96% extraction rate and without additives.

Treatment 6: Sample containing sunn pest-damaged wheat flour with a 96% extraction rate, supplemented with 0.003% ascorbic acid, 0.04% xylanase enzyme, 0.5% emulsifiers (DATEM and Sodium Stearoyl-2-Lactylate), and 1% sorbitol."

2.4. Moisture Content:

Moisture content analysis was conducted according to the AACC Method 44-16 (2000) [16]. Samples were analyzed at designated time intervals of 2 hours, 2 weeks, and 1-month post-baking. For this purpose, samples were placed in an oven (Jeto Tech, Model OF-O2G, South Korea) maintained at a temperature range of 100-105$^{\circ C}$.

2.5. Specific Volume:

Specific volume was determined using the rapeseed displacement method, following AACC Method 72-10 (2000) [16]. The weight and volume of individual cookie samples were measured. Specific volume was then calculated by dividing the volume by the weight of the sample, expressed in milliliters per gram (mL/g).

2.6. Texture Analysis

Texture analysis, specifically firmness, of the cookie samples was performed using a texture analyzer (TA plus, UK) at the aforementioned time intervals: 2 hours, 2 weeks, and 1-month post-baking. A cylindrical probe with a diameter of 5 mm was employed. The pre-test speed was set at 1 mm/s, the test speed at 0.5 mm/s, the penetration depth at 2 mm, and the load cell capacity at 50 kg. The firmness of the cookie samples was ultimately reported in Newtons (N) [17].

2.7. Color Analysis ($L^*a^*b^*$)

The color components of the cookie surface were quantified using ImageJ software (version 1.43r) at 2-hour intervals post-baking [18]. The $L^*a^*b^*$ color space was utilized to provide a comprehensive assessment of color changes.

2.8. Sensory Evaluation

A panel of 10 trained assessors was selected using the triangle test methodology. Sensory attributes of the cookies, including form and shape, top surface characteristics, bottom surface characteristics, texture (hardness and softness), chewability, odor, and taste, were evaluated. Assessors rated each attribute using a five-point hedonic scale, ranging from very poor (1) to very good (5) [19 and 20]. Acknowledging that not all sensory attributes contribute equally to overall quality, ranking coefficients were assigned to each attribute based on a review of relevant literature. Specifically, coefficients of 4, 2, 1, 2, 3, and 3 were assigned to form/shape, surface characteristics (top and bottom), texture, chewability, odor, and taste, respectively. The overall quality score (Q) of the cookies was then calculated using Equation 1:

Equation 1: $Q = (\Sigma (P * G)) / \Sigma P$

Where:

Q = Overall Quality Score (cookie quality number)

P = Ranking Coefficient of the attribute

G = Evaluation Score of the attribute

2.9. Statistical Analysis

A completely randomized design was employed for the experiment. Statistical analysis was performed using Minitab 17 software. Mean comparisons were conducted using the Tukey's Honestly

Significant Difference (HSD) test at a 95% confidence level ($p< 0.05$). All tests, with the exception of sensory evaluation, were performed in triplicate. For sensory evaluation, 30 replicates were used (3 baking replicates * 10 assessors). Graphing was performed using Microsoft Excel software.

3. Results and Discussion

3.1. Moisture Content

Table 1 presents the findings from the moisture content assessment of the produced cookie samples over a one-month storage period (measured at 2 hours, two weeks, and one-month post-baking). The data reflects the influence of wheat flour extraction rate from sunn pest-damaged wheat and the incorporation of an improved. The results clearly demonstrate that increasing the extraction rate of sunn pest-damaged wheat flour, coupled with the addition of an improver containing ascorbic acid, xylanase enzyme, emulsifiers (sodium stearoyl-2-lactylate [SSL] and diacetyl tartaric acid esters of mono- and diglycerides [DATEM]), and the sugar alcohol sorbitol, was effective in preserving the moisture content of the produced samples during baking and storage. Specifically, the lowest moisture content was observed in the sample containing sunn pest-damaged wheat flour with a 78% extraction rate and without the improver. Conversely, the highest moisture content was found in the sample containing sunn pest-damaged wheat flour with a 96% extraction rate and the improver. Ascorbic acid, as a baking industry additive, strengthens the gluten network in doughs made from sunn pest-damaged wheat. Research indicates that the primary effect of ascorbic acid is to oxidize thiol groups (-SH) present in gluten, preventing their substitution reactions with disulfide bonds (S-S), which are detrimental to the dough. This process improves the gluten network, ultimately leading to better moisture retention during the baking process and improved shelf life [21]. Shokraie et al. (2018) investigated the rheological and qualitative properties of pasta made from sunn pest-damaged wheat flour and ascorbic acid. The results indicated that increasing the proportion of sunn pest-damaged wheat in the formulation had no effect on the moisture content of the produced samples. However, the presence of ascorbic acid contributed to moisture retention during the storage period [22]. Tebben et al. (2020), examining the effect of xylanase enzyme on the moisture content of whole wheat bread, reported that samples containing the enzyme were more successful in retaining moisture during the baking process compared to samples without the enzyme. The inclusion of this enzyme in whole grain bread also led to a reduction in weight loss during the storage period [23]. Ding et al. (2019) corroborate the significance of sugar alcohols, including sorbitol, as integral components in formulations designed to maintain moisture content in baked goods. The amphiphilic nature of emulsifiers, characterized by both hydrophilic and hydrophobic moieties within their molecular structure, endows them with desirable functional properties. This dual affinity implies a simultaneous attraction towards lipid components, facilitated by the nonpolar head, and an aptitude for binding with water molecules, attributed to the polar head. Consequently, the incorporation of emulsifiers into food matrices promotes their localization at the oil-water interface within the composite structure. The hydrophilic groups of the emulsifier chain interact with free water, thereby augmenting water-holding capacity and, in turn, exhibiting an inhibitory effect on moisture reduction during and after the baking process (shelf life) [24]. Supporting this, Pourfarzad et al. (2014) observed that emulsifiers, due to their hydrophilic characteristics, demonstrate a greater propensity for forming stronger bonds with water molecules compared to other bread components, thus impeding moisture migration from the crumb to the crust [25].

Table 1- The effect of treatments on the moisture of cookies during one month.

Treatments	Moisture (%)		
	2 hours	2 weeks	1 month
1	13.27±0.50e	11.20±0.70f	9.81±0.14d
2	14.83±0.26c	13.99±0.36c	13.01±0.49b
3	14.09±0.44d	12.87±0.04e	11.76±0.25c
4	15.31±0.46b	14.59±0.22b	14.21±0.07a
5	14.87±0.20c	13.21±0.75d	11.82±0.90c
6	15.70±0.25a	15.03±0.82a	14.35±0.67a

Different letters in each column represent significant differences from one another ($p<0.05$).

3.2. Specific Volume

Figure 1 presents the findings from the evaluation of the specific volume of cookie samples produced, influenced by both the extraction rate of sunn pest-damaged wheat flour and the addition of an improved. The results demonstrate that an increase in the flour extraction rate (corresponding to a higher bran content in the formulation) resulted in a decrease in the specific volume of the samples. Furthermore, the data clearly indicate that the incorporation of an improved, containing ascorbic acid, enzymes, emulsifiers, and a sugar alcohol, into the cookie formulation led to an increase in sample volume. The positive effect of the improver was most pronounced in the sample containing flour with an 88% extraction rate compared to the other samples. Consequently, the cookie prepared from flour with an 88% extraction rate, supplemented with 0.003% ascorbic acid, 0.04% xylanase enzyme, 0.5% DATEM and sodium stearoyl-2-lactylate emulsifiers, and 1% sorbitol, exhibited the highest specific volume. Conversely, the sample containing flour with a 96% extraction rate and lacking the improver displayed the lowest specific volume compared to the other produced samples. The attenuating effect of wheat bran on volume can be attributed to its inhibition of optimal gas cell expansion. This effect manifests through the creation of a physical barrier by the fiber particles present in the bran around the gas cells [26]. Kiyashko and Slideltsev (2022) reported that the application of ascorbic acid as an improver with oxidizing functionality on the rheological, technological, and sensory properties of bread dough and bread led to improved dough rheology and increased volume and porosity of the produced samples. The ultimate effect of ascorbic acid is to enhance the dough's gas retention capacity, improve dough expansion, increase dough resistance, and ultimately increase volume and produce a product with a fine and uniform cell structure [5]. Several studies (Both et al., 2020; Ghoshal et al., 2017; Sheikholeslami et al., 2021; Tebben et al., 2020) have identified the presence of xylanase enzyme in baked good formulations containing whole wheat or bran flour as a significant factor in increasing volume [27, 28, 29 and 23]. Multiple mechanisms contribute to the ability of xylanase to enhance the volume of baked goods made from whole wheat flour. Xylanase converts water-unextractable arabinoxylans into a water-extractable form, which improves gas retention capacity in whole wheat flour dough, consequently leading to increased volume [12]. Furthermore, xylanase breaks down non-starch polysaccharides into short-chain saccharides, which interfere less with gluten network formation compared to polysaccharides [30]. On another note, the role of emulsifiers like SSL and DATEM, and the sugar alcohol sorbitol, in increasing the specific volume of cake samples should not be overlooked. The volume increase attributed to the presence of emulsifiers in baked good formulations can be linked to the provision of ample water by these additives in the flour matrix, facilitating cross-linking between protein and starch and forming a stronger gluten network. This stronger network exhibits a higher gas retention capacity during the baking process [31]. Zhou et al. (2016) observed an increase in specific volume when adding the sugar alcohol sorbitol to bread formulations in amounts less than 8% [35]. However, excessive addition of sugar alcohols to baked good formulations can reduce gluten network hydration and cohesion, ultimately diminishing gas retention capacity in the dough and the specific volume of the final product [33].

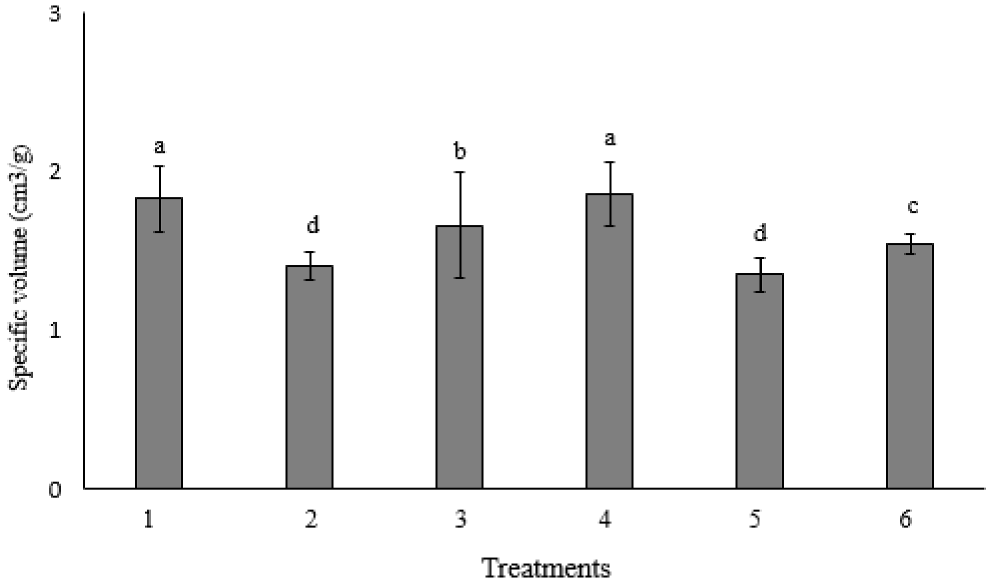

Fig 1- The effect of treatments on the specific volume of cookies.
Different letters represent significant differences from one another ($p<0.05$).

3.3. Texture Analysis

Table 2 presents the results of texture evaluation for cookie samples produced with varying wheat flour extraction rates and the addition of an improved, assessed over a one-month storage period (2 hours, two weeks, and one-month post-baking). The findings clearly indicate that increasing the flour extraction rate led to an increase in the firmness of the produced samples. Conversely, the presence of an improver containing ascorbic acid, enzymes, emulsifiers, and sugar alcohol significantly contributed to maintaining the softness of the texture by inhibiting premature staling and preventing an increase in firmness during both baking and storage. Wheat bran disrupts the cross-links between starch and gluten, thereby reducing elasticity and increasing the firmness of the internal texture of baked goods [34]. Furthermore, dietary fibers present in bran, especially insoluble types, generally weaken the texture of baked products due to their competition for water absorption with the gluten network [35]. Sheikholeslami et al. (2018) investigated the effect of a mixture of ascorbic acid and guar gum on improving the technological properties of bread containing weakened wheat flour (a mixture of wheat and hull-less barley flour). This research utilized levels of 0, 10, and 20 percent hull-less barley flour, levels of 0, 1, 1.5, and 2 percent guar gum, and a level of 200 ppm ascorbic acid. The results demonstrated that the inclusion of 2 percent hull-less barley flour, 1 percent guar gum, and 200 ppm ascorbic acid improved the textural properties of bread, including reducing texture firmness and maintaining volume during storage [21]. Both et al. (2020) reported that xylanase enzyme reduces bread crumb firmness by increasing soluble fiber content and improving water absorption within the gluten-starch network [27]. Conversely, emulsifiers in baked goods function as dough strengtheners, forming a layered structure at the gluten-starch interface and promoting the development of the gluten network. Furthermore, through the improvement of dough rheological properties, including increased stability and extensibility, they contribute to reducing crumb firmness in baked goods containing whole wheat flour or those enriched with bran [36]. Sorbitol also enhances crumb softness in bakery products by improving water-holding capacity within the gluten network. In essence, the combination of fibers and sugar alcohols can improve textural characteristics, including crumb softness. This effect can be attributed to the increased water-holding capacity resulting from the addition of fibers and the water-absorbing properties of polyols [32]. Sheikholeslami et al. (2021) identified the simultaneous use of emulsifiers and xylanase enzyme as an effective method for improving the texture of bread containing flour with varying extraction rates (88 and 96%) [29].

Table 2- The effect of treatments on the firmness of cookies during one month.

Treatments	Firmness (N)		
	2 hours	2 weeks	1 month
1	9.24±0.68d	12.88±0.32c	19.72±0.69a
2	10.45±0.71c	11.92±0.78d	12.49±0.32d
3	12.37±0.04a	14.59±0.41b	17.32±0.80b
4	9.11±0.34d	10.70±0.65e	12.60±0.35d
5	12.44±0.25a	15.81±0.39a	17.50±0.77b
6	11.14±0.19b	12.04±0.57d	13.83±0.22c

Different letters in each column represent significant differences from one another ($p<0.05$).

4.3. Color Values

Table 3 presents the results of color evaluation ($L^*a^*b^*$ Values) of cookie samples, examining the influence of wheat flour extraction rate, insect (Sunn Pest) damage, and improvers. Increasing the flour extraction rate resulted in a decrease in lightness (L^*) and yellowness (b^*), while redness (a^*) increased. Conversely, the inclusion of a blend of ascorbic acid, xylanase enzyme, emulsifiers sodium stearoyl-2-lactylate (SSL) and tartaric acid esters of mono- and diglycerides (DATEM), and the sugar alcohol sorbitol as an improved led to an increase in lightness (L^*) and a decrease in both yellowness (b^*) and redness (a^*) of the cookie surface. The development of a yellowish-brown color in the crust of baked goods is considered an indicator of product quality. However, the addition of high quantities of wheat bran can reduce crust lightness, as reducing sugars in wheat bran play a significant role in non-enzymatic browning reactions, consequently reducing the L^* color component [36 and 28]. Furthermore, ascorbic acid contributes to color lightening by oxidizing pigments present in the flour. The smoother and more uniform surface of dough and baked products containing ascorbic acid should also be considered a contributing factor to increased lightness [37]. Kiyashko and Slideltsey (2022) studied the application of ascorbic acid as an improved with oxidizing function in bread. Their results indicated that adding 0.03% ascorbic acid (based on flour weight) resulted in lighter and more vitreous colored samples [5]. Pourhaji and Sahraiyan (2018) reported an increase in the L^* color component, indicating increased lightness of the final product, due to the presence of ascorbic acid in donut formulations [38]. Mirzaei (2013), formulating and evaluating the impact of several types of improvers (a combination of ascorbic acid, xylanase enzyme, and emulsifier sodium stearoyl-2-lactylate) on the quality of Sangak bread, stated that the bread sample containing the improver was lighter (reduction in redness and yellowness components) than the control sample [39]. Ghoshal et al. (2017) observed that the enrichment of bread with wheat bran particles resulted in a reduction of the yellow color and the development of a reddish-gray hue in the crust. These researchers also reported that xylanase enzyme application increased the lightness of bread containing whole wheat flour [28]. The increase in the L^* color component in baked goods containing xylanase may be attributed to the enzyme's ability to convert arabinoxylans from an insoluble to a soluble form, and the subsequent absorption of water released from pentosans by the gluten network. This suggests that baked products with higher water absorption exhibit a higher lightness parameter [40]. Matsushita et al. (2017) found that the addition of xylanase to bread containing whole wheat flour led to a decrease in the redness (a^*) value of the bread crust compared to the control without the enzyme [30]. Ghoshal et al. (2017) attributed the presence of xylanase in bread made from whole wheat flour to an increase in yellowness (b^*) [28]. Emulsifiers, due to their high-water absorption capacity and increased water absorption in the dough, also contribute to increasing the lightness parameters of the crust of baked products by diluting amino acids and sugars [41]. Ahmad (2016) and Bhise and Kaur (2014) reported that sugar alcohols, including sorbitol, led to an increase in lightness and a decrease in yellowness in the bread crust, which they attributed to the non-participation of sugar alcohols in the Maillard reaction and their interaction with amino acids [42 and 33].

Table 3- The effect of treatments on the crust color of cookies during one month.

Treatments	Crust color values		
	L*	a*	b*
1	59.67±0.93b	0.72±0.06e	22.30±1.28a
2	62.44±0.29a	0.37±0.02f	21.29±1.04b
3	54.59±0.77d	1.79±0.13b	20.06±1.15c
4	57.31±0.84c	1.12±0.09d	18.57±0.92d
5	48.90±0.07e	1.95±0.03a	17.04±1.40e
6	54.32±0.25d	1.57±0.04c	18.61±0.48d

Different letters in each column represent significant differences from one another ($p<0.05$).

3.5. Sensory Properties

Table 4 and Figure 3 present the sensory attribute scores and overall acceptability of cookie samples produced using varying extraction rates of sunn pest-damaged wheat flour, both with and without an improved blend. The results indicate that, among samples without the improver, the cookie made with sunn pest-damaged wheat flour at the lowest bran content (78% extraction rate) received the highest sensory scores, particularly in texture-related attributes such as crumb structure (porosity and cell size), crumb firmness, and chewability. This suggests that whole-wheat cookies (samples produced with sunn pest-damaged wheat flour at 88% and 96% extraction rates) may not achieve adequate market appeal in the absence of baking industry additives like the improver designed in this study, comprising ascorbic acid, xylanase enzyme, emulsifiers sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM), and the sugar alcohol sorbitol. However, the highest sensory attribute scores and, consequently, the highest overall acceptability score, were attributed to the sample containing flour at an 88% extraction rate with the improver (0.003% ascorbic acid, 0.04% xylanase enzyme, 0.5% DATEM and sodium stearoyl-2-lactylate emulsifiers, and 1% sorbitol).

Dizlek and Ozar (2023) reported that the use of sunn pest-damaged wheat flour without oxidants in baked product formulations resulted in undesirable texture, chewability, form, shape, color, aroma, and taste, leading to a reduction in overall quality [4]. Ekramian et al. (2023) utilized 100% sunn pest-damaged wheat flour in waffle production. Their findings indicated that the highest overall acceptance score in sensory evaluation was observed in the sample containing 0.5% sunn pest-damaged wheat flour (derived from 100% bug-damaged wheat). This study reported that the application of sunn pest-damaged wheat flour in waffle formulation not only did not reduce quality but also played a role in improving sensory characteristics [3]. Furthermore, reports suggest that the presence of ascorbic acid in the formulation of baked products containing weak flour or sunn pest-damaged wheat flour can improve sensory properties. Findings from these studies indicate that bread containing ascorbic acid exhibited improved aroma and taste. Kiyashko and Slideltsey (2022) investigated the application of ascorbic acid as an improved with oxidizing function on the sensory characteristics of bread. The results of this research showed that adding 0.03% ascorbic acid (based on flour weight) to the formulation improved the bread's aroma and taste, resulting in a softer texture and a desirable mouthfeel [5]. Zeidvand et al. (2023) examined the effects of varying levels (0, 0.25, and 0.50%) of lactic acid, ascorbic acid, and azodicarbonamide on the qualitative characteristics of Sangak bread. Based on their findings, the presence of the additives used in the bread formulation improved sensory properties (taste, aroma, color, and texture) and reduced staling [43]. Ghoshal et al. (2017) investigated the impact of xylanase enzyme on the quality of whole wheat flour bread and reported a significant improvement in sensory characteristics. Their findings indicated that bread containing xylanase exhibited a softer texture, more uniform cellular structure (increased porosity), and improved aroma and flavor compared to control samples lacking the enzyme [28]. Similarly, Kumar and Satyanaana (2014) documented that the addition of xylanase to whole wheat flour bread resulted in higher sensory attribute scores and increased consumer acceptance [44]. Furthermore, Sheikholeslami et al. (2021) demonstrated that the highest sensory scores in bran-containing breads were achieved with those incorporating a blend of xylanase enzyme and emulsifiers, specifically sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM). A hypothesis suggests that the combination of emulsifiers and xylanase creates a homogenous and uniform structure in baked product textures, characterized by a close association between starch granules and gluten proteins [29]. Ding and Yang (2021) proposed that the addition of the sugar alcohol sorbitol to bakery products effectively enhances sensory attributes, particularly firmness, texture softness, and chewability, by increasing the water-binding capacity of flour components [45].

Table 4- The effect of treatments on the sensory properties of cookies

Treatments	Sensory properties					
	Form and Shape	Surface	Subsurface	Firmness and Softness	Chewiness	Odor&Taste
1	3.3±0.2b	4.5±0.2a	4.0±0.5a	4.2±0.4a	3.8±0.2a	4.4±0.5a
2	3.5±0.4b	3.2±0.1c	2.0±0.3c	3.3±0.2b	3.0±0.2b	3.0±0.2c
3	3.0±0.2b	3.0±0.2c	2.2±0.2c	4.0±0.2a	3.0±0.2b	3.6±0.2b
4	4.3±0.2a	4.8±0.2a	4.2±0.2a	4.0±0.4a	4.0±0.1a	4.2±0.4a
5	3.3±0.3b	2.0±0.4d	2.0±0.5c	2.4±0.5c	2.1±0.4c	3.0±0.2cb
6	4.0±0.1a	3.7±0.2b	3.4±0.2b	4.1±0.2a	3.8±0.2a	4.0±0.5a

Different letters in each column represent significant differences from one another ($p<0.05$).

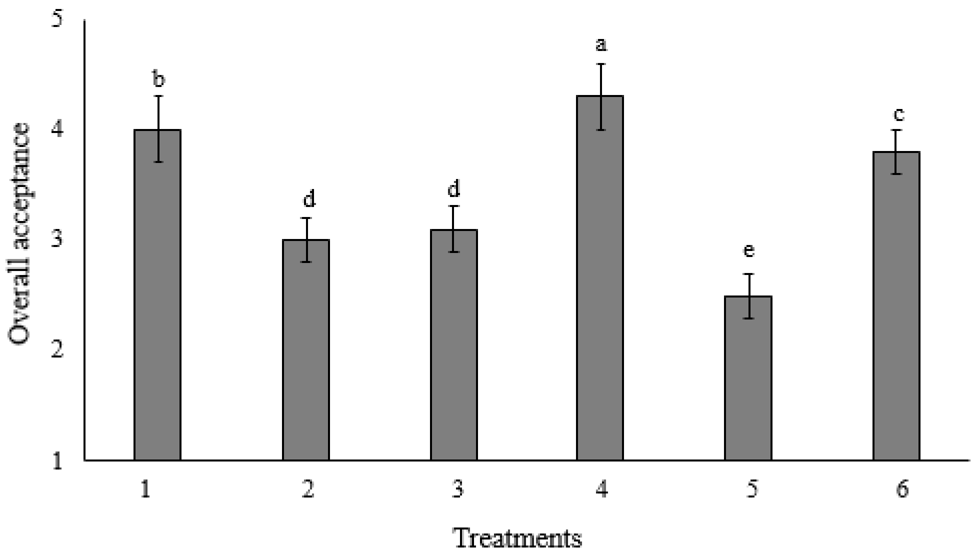

Fig 2- The effect of treatments on the overall acceptance of cookies.
Different letters represent significant differences from one another (p<0.05).

4. Conclusion

This study demonstrates the potential for value creation in the baking industry through the utilization of sunn pest-damaged wheat flour, a byproduct of agricultural processes. Furthermore, the incorporation of wheat bran into product formulations not only enhances nutritional value but also offers the opportunity to reduce production costs by partially substituting flour with bran. Consequently, this research investigated the use of sunn pest-damaged wheat flour with varying extraction rates in the formulation of Zabol traditional cookies. To mitigate the detrimental effects of sprouting and the inclusion of wheat bran, an improved containing ascorbic acid, xylanase enzyme, emulsifiers sodium stearoyl-2-lactylate (SSL) and diacetyl tartaric acid esters of mono- and diglycerides (DATEM), and sorbitol was developed. The findings revealed that, in the absence of improvers, a sample prepared from sunn pest-damaged wheat flour with the lowest bran content (78% extraction rate) exhibited the most favorable quantitative and qualitative characteristics. However, the utilization of the designed improver facilitated the incorporation of 10% extruded bran into the Zabol cookie formulation (using sunn pest-damaged wheat flour with an 88% extraction rate). Notably, this sample outperformed even the formulation containing flour with a 78% extraction rate in terms of shape, porosity, chewability, texture firmness, and softness, thus establishing it as the superior sample within this research.

5-References

[1] AleemZaker, M. D., Genitha, T. R. and Hashmi, S. I. 2012. Effects of defatted soy flour incorporation on physical, sensorial and nutritional properties of biscuits. *Journal of Food Process & Technology*, 3: 1-4.

[2] Aziah, A. A., Noor, A. Y. and Ho, L. H. 2012. Physicochemical and organoleptic properties of cookies incorporated with legume flour. *International Food Research Journal*, 19(4). 1539-1543.

[3] Ekramian, H., Saeedi Asl, M. R. Karimi, M. Sheikholeslami, Z. and Pedram Niya, A. 2023. Comparison the Effect of Sunn Pest Flour wheat and Microbial Protease on Waffle Production. *Journal of Innovation in Food Science and Technology*, 15(2): 151-162.

[4] Dizlek, H. and Ozar, M. S. 2023. Comparison of transglutaminase and L-ascorbic acid additives in improving the quality of bread made from sunn pest (*Eurygast*e *integriceps*) damaged wheat. *International Journal of Food Science and Technology*, 58(3): 1275-1283.

[5] Kiyashko, N. and Slideltsey, O. 2022. The use of ascorbic acid as an improver of oxidative action in production of wheat bread. *International Scientific Conference on Agricultural Machinery Industry "INTERAGROMASH 2022"*, 574: 2544-2549.

[6] Ferng, L., Liou, C., Yeh, R. and Hsin, S. 2015. Food Hydrocolloids physicochemical property and glycemic response of chiffon cakes with different rice flours. Food Hydrocolloids, 53: 172–179.

[7] Javed, M. M., Zahoor, S., Shafaat, S., Mehmooda, I., Gul, A., Rasheed, H. and Aftab, M. N. 2012. Wheat bran as a brown gold: Nutritious value and its biotechnological applications. 6: 724–733.

[8] Goli Movahed, G., Millani, E. and Jafari, M. (2018). Utilization of extruded wheat bran in Barbary bread: Evaluation of sensory, color and texture properties of bread and rheological properties of dough. Journal of Food Science and Technology, 82(15): 129-137.

[9] Jiang, Y., Zhao, Y., Zhu, Y., Qin, S., Deng, Y. and Zhao, Y. 2019. Effect of dietary fiber-rich fractions on texture, thermal, water distribution, and gluten properties of frozen dough during storage. Food Chemistry, 297: 124902.

[10] Tebben, L., Shen, Y. and Li, Y. 2018. Improvers and functional ingredients in whole wheat bread: A review of their effects on dough properties and bread quality. Trends in Food Science and Technology, 81: 10–24.

[11] Liu, W., Brennan, M. A., Serventi, L. and Brennan, C. S. 2017. Effect of cellulase, xylanase and α-amylase combinations on the rheological properties of Chinese steamed bread dough enriched in wheat bran. Food Chemistry, 234: 93–102.

[12] Altınel, B. and Ünal, S. S. 2017b. The effects of certain enzymes on the rheology of dough and the quality characteristics of bread prepared from wheat meal. Journal of Food Science and Technology, 54: 1628–1637.

[13] Colakoglu, A. S. and Ozkaya, H. (2012). Potential use of exogenous lipases for DATEM replacement to modify the rheological and thermal properties of wheat flour dough. Journal of Cereal Science, 55: 397–404.

[14] Suhendro, E. L., Waniska, R. D., Rooney, L. W. and Gomez, M. H. 1995. Effects of polyols on the processing and qualities of wheat tortillas. Cereal Chemistry, 72: 122–127.

[15] Tian, Y., Xu, X., Li, Y., Jin, Z., Chen, H. and Wang, H. 2009. Effect of β-cyclodextrin on the long-term retrogradation of rice starch. European Food Research and Technology, 228: 743–748.

[16] AACC. 2000. Approved Methods of the American Association of Cereal Chemists, 10th Ed., Vol. 2. American Association of Cereal Chemists, St. Paul, MN.

[17] Bassinello, P. Z., Freitasb, D. D. G. C., Ascherib, J. L. R., Takeitib, C. Y., Carvalhoa, R. N., Koakuzua, S. N. and Carvalhoc, A. V. 2011. Characterization of cookies formulated with rice and black bean extruded flours. *Procedia Food Science*, 1: 1645 – 1652.

[18] Naji-Tabasi, S. and Mohebbi, M. 2014. Evaluation of cress seed gum and xanthan gum effect on macrostructure properties of gluten-free bread by image processing. *Journal of Food Measurement and Characterization*, 9(1): 100-110.

[19] Yaseen, A.A., Shouk, A.H. and Ramadan, M.T. 2010. Corn-wheat pan bread quality as affected by hydrocolloids. *Journal of American Science*, 6(10): 684-690.

[20] Jalali, M., Sheikholeslami, Z., Elhamirad, A. H., Haddad Khodaparast, M. H. and Karimi, M. 2019. The effect of Balangu Shirazi (Lallemantia Royleana) gum on the quality of gluten-free pan bread containing pre-gelatinization simple corn flour with microeave. *Carpathain Journal of Food Science and Technology*, 11(2): 68-83.

[21] Sheikholeslami, Z., Karimi, m., Komeili, H. R. and Mahfouzi, M. 2018. A new mixed bread formula with improved physicochemical properties by using hull-less barley flour at the presence of guar gum and ascorbic acid. *LWT*, 93: 628-633.

[22] Shokraie, M., Salehifar, M. and Afshin Pazhooh, R. 2018. Rheological and quality characteristics of pasta produced from sunn pest damaged wheat flour and ascorbic Acid. *Journal of Agricultural Science and Technology*, 20: 935-963.

[23] Tebben, L., Chen, G., Tilley, M. and Li, Y. 2020. Individual effects of enzymes and vital wheat gluten on whole wheat dough and bread properties. Journal of Food Science, 85: 4201–4208.

[24] Ding, S., Peng, B., Li, Y. and Yang, J. 2019. Evaluation of specific volume, texture, thermal features, water mobility, and inhibitory effect of

staling in wheat bread affected by maltitol. Food Chemistry, 283: 123–130.

[25] Pourfarzad, A., Hossein, M. and Khodaparast, H. 2014. Optimization of a novel improver gel formulation for Barbari flat bread using response surface methodology. Journal of Food Science and Technology, 51: 2344–2356.

[26] Hemdane, S., Langenaeken, N. A., Jacobs, P. J., Verspreet, J., Delcour, J. A. and Courtin, C. M. 2018. Study of the role of bran water binding and the steric hindrance by bran in straight dough bread making. Food Chemistry, 253: 262–268.

[27] Both, J., Biduski, B., Gómez, M., Bertolin, T. E., Friedrich, M. T. and Gutkoski, L. C. 2020. Micronized whole wheat flour and xylanase application: dough properties and bread quality. Journal of Food Science and Technology, 56: 3902–3912.

[28] Ghoshal, G., Shivhare, U. S. and Banerjee, U. C. 2017. Rheological properties and microstructure of xylanase containing whole wheat bread dough. Journal of Food Science and Technology, 54: 1928–1937.

[29] Sheikholeslami, Z., Mahfouzi, M., Karimi, M. and Ghiafehdavoodi, M. 2021. Modification of dough characteristics and baking quality based on whole wheat flour by enzymes and emulsifiers supplementation. LWT – Food Science and Technology, 139: 110794.

[30] Matsushita, K., Santiago, D. M., Noda, T., Tsuboi, K., Kawakami, S. and Yamauchi, H. 2017. The bread making qualities of bread dough supplemented with whole wheat flour and treated with enzymes. Food Science and Technology Research, 23: 403–410.

[31] Kurek, M. A., Wyrwisz, J., Piwińska, M. Wierzbicka, A. 2015. Influence of the wheat flour extraction degree in the quality of bread made with high proportions of β-glucan. Food Science and Technology, 35: 273–278.

[32] Zhou, C. F., Qian, P., Meng, J., Gao, S. M. and Lu, R. R. 2016. Effect of glycerol and sorbitol on the properties of dough and white bread. Cereal Chemistry, 93, 196–200.

[33] Bhise, S. and Kaur, A. 2014. Baking quality, sensory properties and shelf life of bread with polyols. Journal of Food Science and Technology, 51: 2054–2061.

[34] Penella, J. M. S., Collar, C. and Haros, M. 2008. Effect of wheat bran and enzyme addition on dough functional performance and phytic acid levels in bread. Journal of Cereal Science, 48: 715–721.

[35] Rosell, C. M. 2019. Trends in Science of Doughs and Bread Quality. In Flour and Breads and their Fortification in Health and Disease Prevention (2nd ed.). Elsevier Inc.

[36] Atalay, M. H., Bilgiçli, N., Elgün, A. and Demir, M. K. 2013. Effects of buckwheat (fagopyrum esculentum moench) milling products, transglutaminase and sodium stearoyl-2-lactylate on bread properties. Journal of Food Processing and Preservation, 37: 1–9.

[37] Zeng, Q., Wei, T., Song, Y., Guo, X., Jiang, H. and Zhang, G. 2022. Comparative study on composite buckwheat dough and steamed bread modified by transglutaminase and ascorbic acid. *International Journal of Food Science and Technology*, 57(2): 1273-1282.

[38] Pourhaji, F. and Sahraiyan, B. 2018. Evaluating the Oxidative Stability of Doughnut Containing Ascorbic Acid and Green Tea Extract During Storage Using Principal Component Analysis (PCA). *Food Engineering Research*, 41-56.

[39] Mirzaei, M. 2012. Formulating and evaluating the effect of several types of improvers on the quality of Sangak bread. Master thesis of Food Science and Industry, Faculty of Agriculture, Isfahan University of Technology.

[40] Niu, M., Hou, G. G., Kindelspire, J., Krishnan, P. Zhao, S. 2017. Microstructural, textural, and sensory properties of whole-wheat noodle modified by enzymes and emulsifiers. Food Chemistry, 223: 16–24.

[41] Bilgiçli, N., Demir, M. K. and Yilmaz, C. 2014. Influence of some additives on dough and bread properties of a wheat-lupin flour blend. Quality Assurance and Safety of Crops and Foods, 6: 167–173.

[42] Ahmad, A. 2016. Optimization of Gluten Free Bread Formulation by Adding Xanthan Gum , Potato Starch and Sorbitol Using Response Surface Methodology. The National Conference for Postgraduate Research, 607–615.

[43] Zeidvand, S., Movahhed, S. and Rajaei, P. 2023. Effect of lactic acid, acid ascorbic and azodicarbonamid on microstructure and organoleptic properties of Sangak bread. *Journal of Food Biosciences and Technology*, 13(2): 61-69.

[44] Kumar, V. and Satyanaana, T. 2014. Production of thermo-alkali-stable xylanase by a novel polyextremophilic Bacillus halodurans TSEV1 in cane molasses medium and its applicability in making whole wheat bread. Bioprocess and Biosystems Engineering, 37: 1043–1053.

[45] Ding, S. and Yang, J. 2021. The effects of sugar alcohols on rheological properties, functionalities, and texture in baked products – A review. Trends in Food Science and Technology, 111: 670–679.

مجله علوم و صنایع غذایی ایران

سایت مجله: www.fsct.modares.ac.ir

مقاله علمی_پژوهشی

بررسی تاثیر بهبود دهنده آنزیمی بر کمیت و کیفیت کلوچه سنتی زابلی بر پایه آرد گندم سن‌زده با درجه استخراج متفاوت

نرگس میر[1]، بهاره صحرائیان[2]*

۱- کارشناسی ارشد علوم و صنایع غذایی، دانشکده کشاورزی، دانشگاه زابل، زابل، ایران.

۲- استادیار گروه پژوهشی کیفیت و ایمنی مواد غذایی، پژوهشکده علوم و فناوری مواد غذایی، جهاددانشگاهی خراسان رضوی، مشهد، ایران.

اطلاعات مقاله

تاریخ های مقاله :

تاریخ دریافت: ۱٤۰۳/۱۱/۳۰

/تاریخ پذیرش: ۱٤۰٤/۱/۲٦

کلمات کلیدی:

آرد کامل،

بافت،

سبوس اکسترود شده،

سن‌زدگی،

کلوچه سنتی.

DO: 10.22034/FSCT.22.166.230.

* مسئول مکاتبات:

Baharehsahraiyan@yahoo.com

چکیده

هدف از انجام این پژوهش تولید کلوچه سنتی زابلی از آرد گندم سن‌زده با درجه استخراج ۷۸، ۸۸ و ۹٦ درصد و طراحی یک بهبوددهنده اختصاصی برای این فراورده با استفاده از اسید آسکوربیک (۰/۰۰۳ درصد)، آنزیم زایلاناز (۰/۰٤ درصد)، امولسیفایرهای سدیم استئاروئیل ۲-لاکتیلات (SSL) و استرهای مونو و دی گلیسرید تارتاریک اسید (داتم) (۰/۵ درصد) و قند الکلی سوربیتول (۱ درصد) و در ادامه ارزیابی کمیت و کیفیت فراورده نهایی بود. نتایج نشان داد نمونه‌های سبوس‌دار و حاوی بهبوددهنده از میزان رطوبت بیشتری طی یک ماه نگهداری برخوردار بودند. با افزایش درجه استخراج آرد گندم سن‌زده سفتی بافت افزایش و حجم کلوچه‌ها کاهش یافت. این در حالی بود که حضور بهبوددهنده در فرمولاسیون نمونه‌های تولیدی در بهبود ویژگی‌های بافتی نقش موثری داشت. با افزایش درجه استخراج آرد از میزان مولفه‌های رنگی L^* و b^* کاسته و بر میزان a^* افزوده و حضور بهبوددهنده در فرمولاسیون منجر به کاهش تیرگی سطح کلوچه‌ها شد. در نهایت براساس یافته‌ها مشخص شد در صورت عدم تمایل به استفاده از بهبوددهنده‌ها، نمونه تهیه شده از آرد گندم سن‌زده با درجه استخراج ۷۸ درصد از بهترین ویژگی‌های کمی و کیفی برخوردار بود. این در حالی بود که با استفاده از بهبوددهنده طراحی شده امکان استفاده از ۱۰ درصد سبوس در فرمولاسیون کلوچه سنتی زابلی (استفاده از آرد گندم سن‌زده با درجه استخراج ۸۸ درصد) مهیا گردید و این نمونه با بیشترین امتیاز فرم و شکل، پوکی و تخلخل، قابلیت جویدن و سفتی و نرمی بافت به عنوان نمونه برتر در این پژوهش معرفی می‌گردد.