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Determination of technological, sensory and nutritional properties of instant porridge based on composite flour almond oil cake- oatmeal and grape syrup powder

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ABSTRACT

The production of instant weaning food porridge is one of the most popular research topics. Granulation is the preferred method for producing instant foods. The advantages of granulation include easy storage, dissolution and shelf life. Whole-grain flour and high-fiber materials, in addition to replacing sugar with natural sweeteners, are a viable solution to reduce the adverse effects of a high-calorie diet. In this study, the effect of the granule content of almond oil cake oatmeal (65-70%), grape juice powder (25-30%) and sugar (0-5%) on the physicochemical properties, color brightness, emulsifying activity, stability and sensory parameters of the final porridge was investigated based on the statistical mixing design. According to the optimization results, the recipe of the instant porridge contains 69.9% almond oatmeal granules, 9.26% grape juice powder and 3.89% sugar to achieve emulsifying ability, emulsion stability, color brightness and overall acceptability of 65.82, 64.16, 3.75 and 89.89, respectively. According to the optimization results, for emulsifying ability, emulsion stability, color brightness and total acceptance 65.82, 64.16, 3.75 and 89.89, respectively, the instant porridge formulation was found to contain 69.9% almond oatmeal granules, 9.26% grape juice powder and 3.13% sugar. The fluctuations in blood sugar after 120 minutes of consumption of the optimal sample were significantly lower than in consumers with glucose sugar. Generally speaking, the combination of extrusion, foam mat and granulation technologies for the production of instant weaning food is considered an innovative idea for the development of healthy food technology.

1-Introduction`

Instant food products are usually referred to as powdered compounds that are ready to use when mixed with liquids. Another form of serving this product is the use of granulation process. In this process, materials are granulated into small and uniform particles [1]. Easy storage, dissolution, and longer shelf life are considered advantages of granules. A high-calorie diet along with a sedentary lifestyle is a crucial factor for diseases such as obesity, hypertension, diabetes, and cardiovascular diseases [2]. The use of whole grain flour and fiber-rich ingredients alongside sugar replacement with natural sweeteners are practical solutions to reduce adverse effects. Increased blood glucose levels, the type of carbohydrates, and the presence of fibers in food items are important factors for diabetic patients, obesity control, and insulin resistance. Therefore, the World Health Organization (WHO) recommends the use of the glycemic index (the rate of increase in blood sugar after consuming a food item) as an appropriate indicator of nutritional quality [3]. Currently, many foods in the global market demonstrate the glycemic index on the nutritional information label. Whole Grain Oat Flour is rich in carbohydrates and proteins, especially beta-glucan, vitamins, minerals, and antioxidants that play an effective role in regulating intestinal function, reducing cholesterol and blood glucose levels, and controlling body weight [4]. Sweet almonds contain various micronutrients, essential fatty acids, phytochemicals, and antioxidants. The high fat content in almonds reduces its shelf life; therefore, the use of defatted almonds as a by-product in oil extraction factories with reduced cost leads to prolong the shelf life of product [5]. Instant grape juice powder produced by foam mat drying is a by-product of grape juice factory and rich in micronutrients, antioxidants, and natural sugars such as fructose and glucose. Physiologically, fructose does not require insulin absorption in the body and is suitable for diabetic patients [6]. Extrusion cooking technology provides a unique platform for producing instant powders and processed products that are gelatinized and porous with high water absorption capacity [7]. Additionally, increased yield and nutritional value in instant powders produced by extrusion compared to other methods have made this production method a practical technology conversion. In the study by Okhrovi et al. (2022), the effect of variables such as moisture, temperature, and the ratio of Oat meal flour to rice flour on the physicochemical properties of instant powder was investigated with the aim of producing instant porridge [8]. The observations indicated a desirable potential for instant porridge for enrichment programs. Seymourina et al. (2018) compared the physicochemical, textural, and thermal properties of instant porridge based on wheat and barley flours [9]. The results showed that the resistant starch content in barley porridge was higher than German wheat porridge, and wheat porridge had a slightly firmer texture and better hydration properties. Neeraj Gandhi and Baljeet Singh (2015) studied the properties of extruded porridge based on wheat bran and guava pulp [10]. Increasing the feed moisture content along with the level of guava pulp led to a decrease in expansion ratio and an increase in the density of extruded materials. With an increase in feed moisture content, water absorption index increased, and water solubility index decreased. In the study by Milani et al. (2018), instant powder made from almond oil cake-corn flour was fabricated and then the effects of different levels of 65-70% granulated flour, 25-30% sugar, and 0-5% stevia on the physicochemical properties of the powder were investigated using a statistical mixture design [11]. Based on results, the optimal formulation of the powder with high solubility, flowability, and appropriate cohesiveness was determined at 9.69%

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powder, 9.29% sugar, and 0.2% stevia. The innovation of current project is based on the simultaneous use of extrusion, foam mat, and granulation technologies for producing instant baby food. For this purpose, in this study, the formulation of instant granola powder from almond oil cake, whole barley flour, and grape juice powder as natural color and sweetener substitutes was modified to improve technological properties, nutritional value, sensory characteristics, and low glycemic index properties.

2- Material and methods

2-1- Materials

In this study, instant powder based on extruded whole barley-almond oil cake under feed moisture of 13%, screw speed of 150 rpm, and almond oil cake: whole barley 23:77% was processed (Milani et al., 2018). Grape juice powder was prepared by foam mat drying method using coating agents including 3% glycerol monostearate (GMS) and 5% arabic gum (AG) according to the method of Milani et al. (2024). [7]. Subsequently, the powder was fed into the granulator machine of the School of Pharmacy, Mashhad Glatt, and homogenized by mixer, then a binding solution contains water at a ratio of 1:1.5 was sprayed onto the powder and thoroughly mixed. After that, the materials were dried and granulated in a controlled manner using indirect heat in wall ovens at 40°C. In the present research, for the production of instant baby food porridge , the optimal formulation of instant granulated powder was determined using a statistical mixture design to investigate the effects of formulation variables including the ratio of extruded whole barley-almond oil cake powder, grape juice powder, and sugar on technological properties, moisture content, color, zeta potential, sensory characteristics, and nutritional properties (fiber content and blood sugar increase).

2-2- The moisture content and physicochemical properties of the raw materials

The moisture content of the raw materials was measured using standard method number 14-15, fat content was determined by Soxhlet method, protein was measured using Kjeldahl automatic model 20VAP by Gerhardt company, and Ash content was determined according to 2000 AACC. The carbohydrate content was calculated from the difference in the sum of fat, protein, ash, and moisture percentages from 100%. The measurement of dietary fiber content in soluble, insoluble, and total forms was performed enzymatically based on AOAC [12].

2-3- Emulsifying properties

Emulsification and emulsion stability were determined based on the Yasumatsu et al. (1972) method. For this purpose, 5.0 grams of sample were mixed with 3 milliliters of distilled water and 3 milliliters of purified oil in a graduated centrifuge tube. The contents of the centrifuge tube were vigorously mixed (5 minutes) and centrifuged at g2000 for 30 minutes. The emulsification activity was calculated from the following equation [13].

2-4- Emulsion stability

To determine the emulsion stability, a mixture of water, oil, and the sample was heated at 80 °C for 30 minutes before centrifugation at g2000 for 30 minutes. The emulsion stability was calculated from the following equation. Finally, the emulsifying activity and emulsion stability are reported as milliliters of emulsion per 100 milliliters of the mixture [13].

2-5- The particle size distribution of the ingredient

The particle size distribution was measured using a dynamic light scattering instrument (Nano-ZS model, Malvern, UK) with visible light radiation at a wavelength of 633 nanometers applied to the sample suspension. To prevent particle scattering,

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samples were diluted with distilled water at a ratio of 1:10 and assessed at a constant volume of one milliliter at pH 7. The zeta potential was measured at 25 °C and a power of 149 watts to prevent particle dispersion.

2-6- Changes in Blood Glucose of Instant Granule Powder

Ten healthy individuals with an average age of 30±5, a body mass index (BMI) range of 21-22 kg/m^2, and a fasting blood glucose range of 88-89 milligrams per deciliter participated in the present study. In addition to the above information, the selection criteria for individuals included not smoking, not being pregnant or breastfeeding, not using medications affecting blood glucose and serum metabolism, not having metabolic diseases, no digestive disorders, and following a specific diet and intense exercise regimen. Glucose was used as the reference food. Volunteers were asked to refrain from intense physical activity the night before the test and on the day of sampling, and to consume a similar dinner the night before each test. Individuals participated in the experiment on four different days at one-week intervals. On each test day, individuals visited the laboratory after a 10-hour fast and a fasting blood sample was taken from them. The blood sample was obtained from the individual's fingertip using a home glucometer (On Call Plus). Then, a glucose solution (50 grams dissolved in 200 milliliters of cold water), instant almond-jujube powder containing grape syrup-sugar heated in 200 milliliters of water, was randomly given to individuals. Volunteers were asked to consume either almond-jujube powder or glucose solution within 10 to 15 minutes. Blood glucose was measured at 0, 15, 30, 45, 60, 90, and 120 minutes after ingestion. During these two hours, individuals were not allowed to eat or drink anything except water, and their activity level was moderate. The area under the glucose curve divided by the area under the fasting values was calculated using the trapezoidal formula. The glycemic index was calculated using the following formula [3].

GI x the amount of carbohydrates (in grams, in a serving of food) ÷ 100

2-7- Color Assessment

The color of the samples was measured by HunterLab instrument according to the method described by Hashemi et al. (2017). For this purpose, the powder samples were first poured into a special cup to completely cover its surface. In this test, the L, a, and b values were determined. The L* values, which range from zero (black) to 100 (white), indicate brightness. Positive a* values indicate redness, while negative values indicate greenness of the product. Additionally, positive b* values indicate yellowness, and negative values indicate blueness of the product.

2-8- Sensory analysis

To evaluate the sensory properties of instant porridge , ten trained persons were selected. A five-point hedonic test was used for scoring, ranging from one (undesirable) to five (desirable). The powder samples, prepared according to specific pre-treatments, were mixed with warm water in a 4:1 ratio. Assessors were asked to evaluate the samples based on taste, mouthfeel (texture), and overall acceptance.

Table 1- Treatments and amounts of variables of instant granule formulation

Grape Syrup Powder (%)	Sugar (%)	Extrudate powder (%)	Treatment
27.9	4.17	67.92	1
27.5	2.5	70	2
30	2.5	67.5	3

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30	0	70	4
27.5	2.5	70	5
27.5	5	67.5	6
27.9	2.92	69.17	7
30	5	65	8
27.9	4.17	69.17	9
28.3	3.33	68.33	10
29.2	4.17	66.67	11
29.2	1.67	69.17	12
29.2	2.92	67.92	13

3- Result and discussion

The chemical compositions of raw materials used in the formulation of instant porridge based on dry weight are given in table (2).

Table 2: Physicochemical composition of ingredients

Seasome oil cake	Whole oat meal	
1± 38.69	0.21± 10.9	Protein
0.5± 2.74	0.3± 0.87	Ash
0.25± 9.25	0.59± 1.05	Fat
0.31± 4.05	0.14± 12.97	Total fiber
0.44± 0.65	1.2± 7.25	Soluble fiber
0.26± 1.62	0.36± 5.72	Insoluble fiber
0.11± 7.94	0.68± 7.41	Moisture

* Data are reported in two replications in terms of (Mean ± SD value).

3-1-Moisture Content

The moisture content of food products not only affects microbial stability, enzymatic browning, enzymatic reactions, lipid oxidation, and shelf life, but also influences the physical quality of the powder, leading to clumping [14,15]. According to the results of a two-way statistical model for fitting moisture changes, it was suggested. Results showed that the interaction effect of the amount of sugar and grape syrup powder on the moisture content of porridge instant powder was significant ($P<0.05$). The moisture content of porridge instant powder was calculated between 4.23% to 4.98%. According to the findings of Goula et al (2010), the desirable moisture range for food powders is less than 5%, as higher moisture levels in food powders can lead to undesirable physical changes [16]. Increasing moisture content leads to an increase in density as well as a decrease in flowability and solubility of the powders [17]. Therefore, the moisture content of our produced powder is within an acceptable range. As shown in Figure 1, with an increase in grape syrup powder, the instant powder moisture increased. This phenomenon can be justified due to its high moisture absorption capacity. Sugar and grape syrup powder act as preservatives in the food industry due to their moisture-absorbing properties; however, grape syrup powder creates a sticky and clumpy state in the powder by affecting the glass transition temperature and forming liquid bridges between solid particles [16, 18, 19]. Increasing moisture content leads to softening or plasticization of water-soluble components, which changes the particle shape and increases the contact surface area of the powder particles. Food powders

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exhibit different sensitivities to relative humidity, and the critical relative humidity at which clumping occurs varies for different powders. Moisture content significantly affects powder flowability. Negative effects of high moisture content and high fat content on flowability have also been reported by other researchers [16, 18, 19]. The type of raw materials used in the final moisture content of the powder, as well as an increase in porosity and a decrease in stickiness with decreasing moisture in instant green banana flour by Rayo et al. (2015) tamarind and pineapple powders by Taufiq et al. (2015) have also been reported [17, 20].

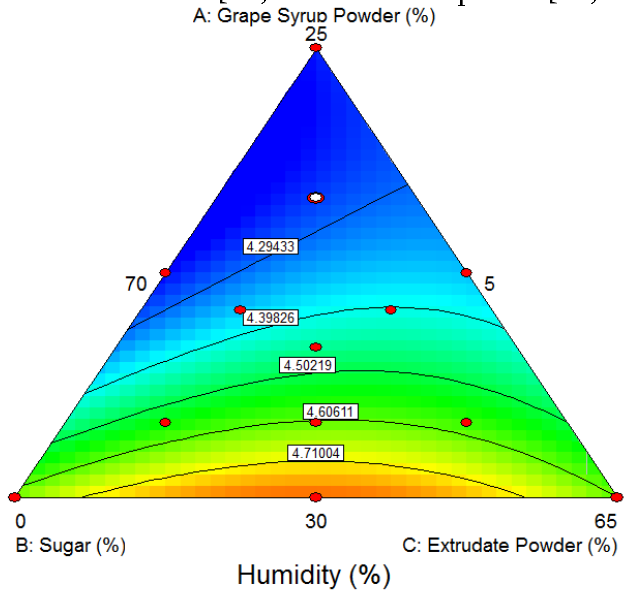

Fig 1 Contour plot for moisture content as a function of formulation variables.

3-2-Brighness index

Color is one of the characteristics that is prioritized when selecting a product. The reasons for color changes in food materials are not only influenced by the type and intensity of heat processes but also affected by changes in the physical characteristics of the food material. In the present study, color changes are related to differences in the amount and type of raw materials used in the formulation. According to the results of the analysis of variance table, a two-way statistical model was suggested for fitting the brightness index of porridge instant powder, and the interaction effect of the amount of almond-oat extrudate powder and almond-oat extrudate powder on the brightness index capacity of the powder was significant. The brightness index range was calculated between 78.1 to 89.97. As shown in Figure 2, with an increase in almond-oat extrudate powder and an increase in sugar content, the brightness intensity increased. The highest brightness level was observed in the sample containing 70% almond-oat extrudate powder. Since the color of food materials is due to the amount of light passing, absorbing, and reflecting by food particles, and considering that powders are mixtures of particles with different structures and sizes, as well as non-homogeneous, the distance and voids between particles, as well as their porosity, are different. Furthermore, all physical changes in powder structure such as flocculation and clumping that lead to changes in particle size, dimensions, and particle adhesion affect the brightness index. Therefore, their brightness index is influenced by porosity and density, essentially the particle size. With increased porosity, a brighter is created in the product. Dense textures have less light reflection and shine. Charunuch et al. (2008) produced a type of plant-based beverage powder based on corn bran, whole soy flour, and white mulberry using extrusion. Increasing the amount of white mulberry powder led to an increase in bulk

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density, reduced water absorption, decreased color brightness, and increased antioxidant activity [23]. In the study of Trombini et al (2016), the brightness index and solubility of extruded cassava leaf powder showed similar results to the current study [1]. Jeske, et al. (2017) reported brightness indices ranging from 68.36 to 75.95 for various plant-based beverages made from almond milk [24].

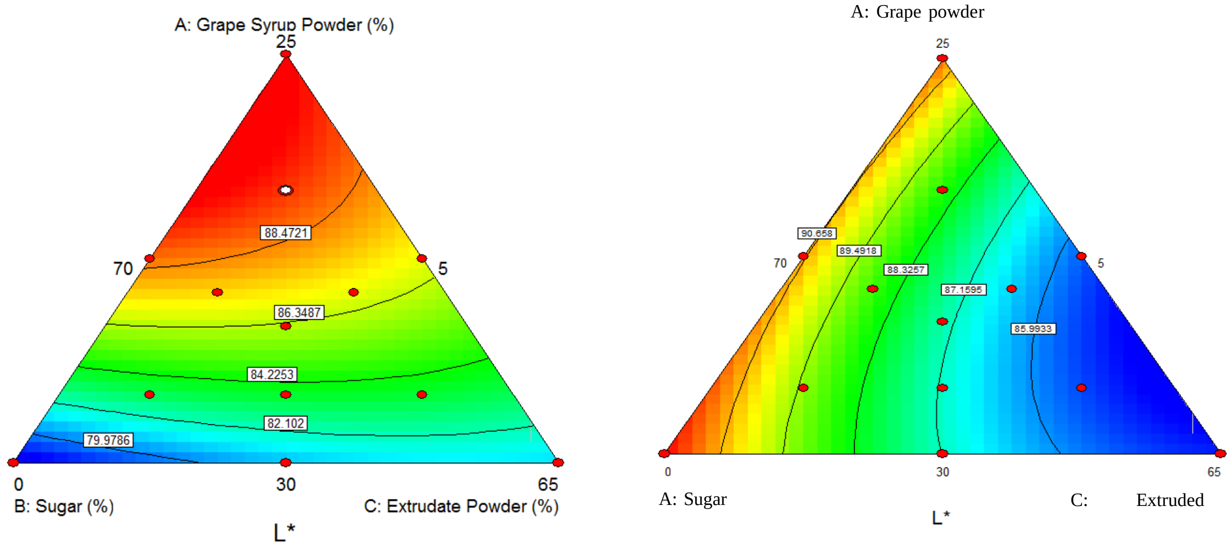

Fig 2 Contour plot for L^* as a function of formulation variables

3-3-The characteristics of instant powder emulsion

Emulsions are important components of food systems and consist of the dispersion of two immiscible liquids. Emulsifying activity is a measure of the capacity of biopolymers to form and stabilize emulsions, while emulsion stability is the ability of biopolymers to withstand process changes such as coagulation, phase separation, coalescence, and sedimentation over a period of time. Emulsion formation is influenced by various factors such as the presence of ions, pH changes, temperature variations, and the presence of thickening and emulsifying agents [25,26]. A two-way statistical model was proposed for emulsifying capacity and stability. Examination of the composition components showed that the interaction effect of the amount of almond-oat extrudate powder with sugar and the interaction effect of the amount of almond-oat extrudate powder with powdered grape syrup powder on the emulsifying capacity of porridge instant powder were significant (P<0.05). The emulsifying capacity range was calculated between 61.9 to 66.1, and emulsion stability was calculated between 59.7 to 65. As observed in Figure 3 (a,b), with an increase in almond-oat extrudate powder and grape syrup powder, emulsifying capacity and emulsion stability increased. The ability to form emulsions is dependent on the surface activity of molecules that have the ability to reduce surface tension. With an increase in almond-oat extrudate powder and grape syrup powder up to approximately 20%, the maximum emulsifying capacity was observed. The interaction of proteins with biopolymers (polysaccharides) and molecules with low molecular weight leads to the formation of complexes with different surface activities, affecting the physical stability, rheology, and structure of these food systems, particularly depending on the physicochemical characteristics of these molecules and the nature and strength of interactions between these components [26]. In the present study, almond-oat extrudate powder contained starch, which is one of the most commonly used polysaccharides with widespread use in emulsion stability. It is worth mentioning that the presence of hydrophobic functional groups in the structure of almond-oat extrudate powder facilitates the absorption of the oil phase at the surface [25]. In addition to polysaccharides such as carrageenan, cellulose, and pectin, almond powder used as a source of protein is rich in protein. With the above interpretations, favorable interaction between polysaccharides and proteins has led to the formation of emulsions [27].

The stability of emulsions against heat was also investigated, and no significant difference was observed between emulsifying capacity and emulsion stability. The reason for the high stability of the formed emulsion is likely due to the reduced mobility of oil particles due to the high viscosity of the produced solution and the presence of biopolymers such as starch and protein, which contribute to stability against heat [28].Based on the results obtained and reviewing the results of researchers during extrusion due to starch gelatinization in the produced product, it has a high-water absorption capacity, which can be suitable for producing various instant powders capable of producing stable emulsions [27].

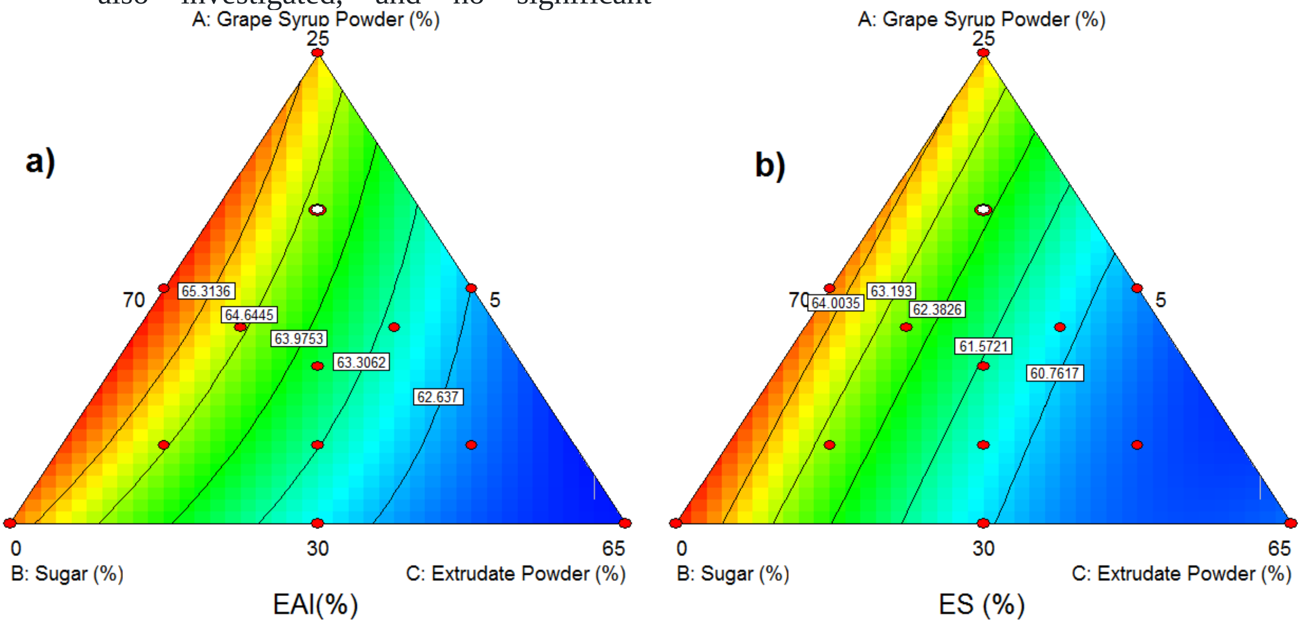

Fig 3 Contour plots for a) EAI and b) ES as a function of formulation variables

3-4- Sensory evaluation of porridge instant powder

The overall acceptance score of the porridge, based on taste, mouthfeel, and color, was determined. According to the results, a two-way statistical model was proposed for the overall acceptance evaluation of the instant almond-oat granule porridge ($P<0.05$). The product was well-received by consumers, with an overall acceptance score ranging between 2.4 and 3.8 as rated by the panelists. As shown in Figure 4, an increase in the amount of almond-oat extrudate powder led to an increase in the overall acceptance score. Behrens et al (2007) indicated that consumers show a greater preference for products that are perceived to have health-promoting properties [29]. Additionally, Gupta et al (2014) stated that the overall acceptance of instant grain powders increases with the addition of chickpeas in the formulation [30].

In the food industry, the production of new products requires consumer acceptance and approval, making research on the best formulations essential. Consumer preference for choosing health-promoting

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instant products, even if they do not have a very desirable taste, is high [29]. The optimal amount of sweetener for different beverages and porridge s varies; for example, the optimal sucrose content is reported to be 7% for instant cold tea [31], 8% for mango beverage, 5.8% for pineapple beverage [32], 12% for instant coffee [33], and 50% based on peanut butter for instant porridge [34].

Regarding grape syrup powder, the type of dietary system and acidity level have a significant impact on sweetness levels [31]. In terms of produced porridge, the presence of large particles and sandy texture in the mouth leads to a decrease in the mouthfeel-related score. The human oral system can detect insoluble particles in water larger than 25 µm. Similar results have been reported by other researchers regarding instant peanut flour powder [34].

According to Perez-Navarrete et al (2006), sensory acceptance of a beneficial protein-based beverage powder made from corn-lima bean complete protein using extrusion process was evaluated favorably [35]. Sandrin et al (2018) investigated the sensory characteristics of instant children's food porridge containing whole oat and rice flour under extrusion conditions with a rotation speed of 50-450 rpm, which was deemed acceptable by the panelists [36].

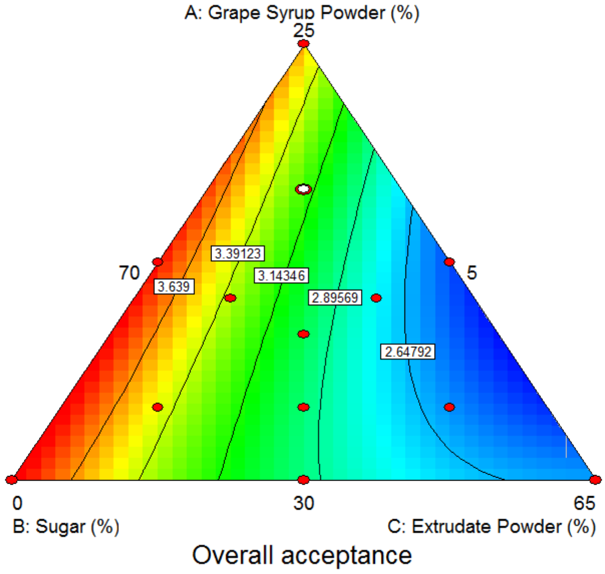

Fig 4 Contour plot for Overall acceptance as a function of formulation variables.

3-5- Optimization

Optimal formulation was determined using numerical optimization and graphical methods, and conditions for optimal process execution were obtained using the desirability function (Figure 5). The settings applied for the optimization process included formulation components (almond-oat extrudate powder, grape syrup powder and sugar) within the experimental range and maximizing emulsification properties, brightness index, and sensory evaluations as the objectives of the experiments in the statistical analyses. To ensure the accuracy of the conditions, the experiment was repeated under optimal conditions. The lack of significant difference between the values obtained from the models and experimental observations effectively proved the model's efficiency ($P<0.05$).

The results of the formulation optimization for instant porridge with the highest acceptability rate (0.924%) included 69.9%

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almond-oat extrudate powder, 26.9% grape syrup powder, and 3.13% sugar. Consequently, the optimal sample exhibited emulsification capacity of 65.82, emulsion stability of 64.16, brightness index of 89.89, overall acceptance of 3.75. Based on this, the sugar consumption amount decreased by 37.5%, which is about one-tenth less than existing commercial samples containing 25-30% sugar. Subsequently, the desired optimal sample was produced based on the proposed formulation, and its physicochemical, nutritional properties, and zeta potential were examined. The nutritional and physicochemical properties of the optimal sample are listed in Table 2.

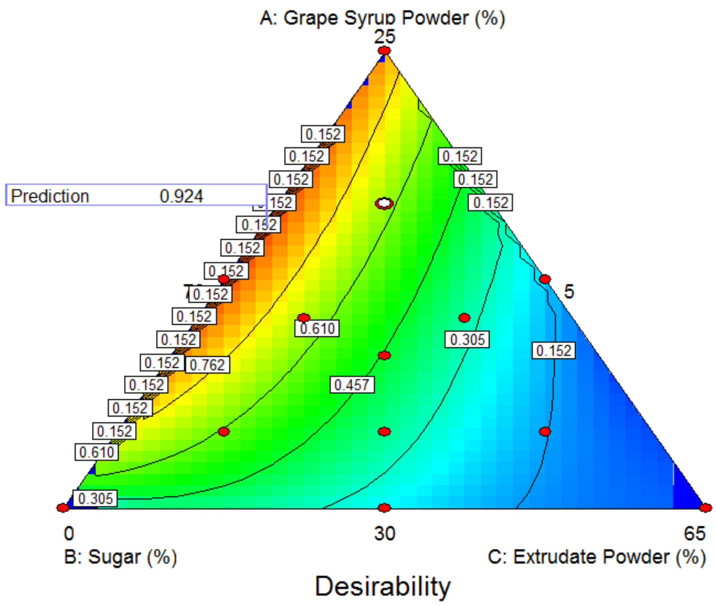

Fig 5 Contour plot for Desirability of optimization as a function of formulation variables.

Table 3: Nutritional and chemical properties composition of optimized instant porridge

Composition	Percent/per 100 g
Protein (%)	0.23±13.9
Ash (%)	0.02±2.23
Fat (%)	0.49± 3. 5
Total fiber (%)	0.16±3.97
Soluble fiber (%)	0.22±2.09
Insoluble fiber (%)	0.15±1.72
Moisture (%)	0.28± 4.8

* Data are reported in two replications in terms of (Mean ± SD value).

3-6- Measurement of Zeta Potential of the Optimal Sample

The purpose of studying the particle size distribution of instant porridge powder is to determine the size and distribution of particles present in the powder and to investigate its effect on the physical and chemical properties of the final product. By conducting this study, it is possible to improve the quality of the product and increase efficiency in the production process. Additionally, particle size distribution is very important for many industries such as pharmaceuticals, food, and chemicals, and is used as a controlling

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parameter in the production processes of these industries. In an emulsion system, the difference in potential between the stationary ion layer (stern layer) and the moving layer (diffusion layer) in the ionic atmosphere around charged particles is called zeta potential. Zeta potential is actually an indicator of the surface electrical charge of particles and the potential stability of emulsion systems. If all particles in the emulsion have large negative or positive zeta potentials, they tend to repel each other and do not come close to each other, resulting in increased physical stability of the system. However, if the zeta potential is less than a certain threshold where the electrostatic repulsion force cannot overcome the van der Waals attraction force between the droplets, droplet coalescence occurs in the absence of repulsive force [25].

As seen in Figure 6, the solution prepared from instant granules based on almond-oat extrudate powder at pH 7 had a negative charge. Its zeta potential value was -22.5 mV. In general, the stability and instability boundary of a suspension can be determined based on zeta potential. Particles with zeta potentials greater than 30 mV or less than -30 mV are stable [26]. Therefore, the emulsion prepared from granules is within the stability range. Various factors such as pH, ionic strength, type and concentration of polysaccharides and proteins used, and their ratio affect the surface charge, electrokinetic mobility, and complex zeta potential. The measurement of negative zeta potential is not surprising because the zeta potential of starch molecules is neutral-negative. On the other hand, by performing extrusion operations in the previous phase during heat treatment of the mixture, covalent bonding between protein and starch is created, increasing the negative electrical charge. It seems that blocking free amino groups of lysine and denaturation of protein and its spatial arrangement are the main factors in increasing the negative surface charge [26,27]. According to the results of Milani et al. (2018), the qualitative properties of the drink powder based on almond-corn textured whole flour, containing textured flour and stevia, showed that the product was classified in the group of powders with high solubility and flowability [11].

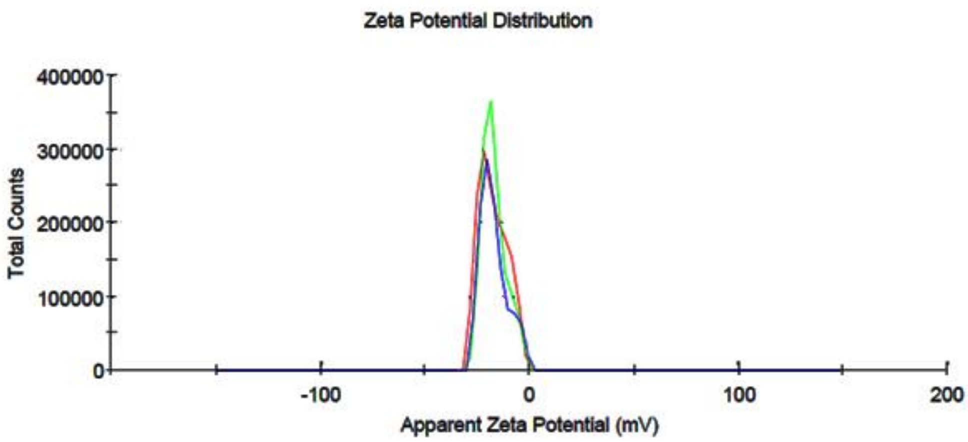

Fig. 6 Zeta potential drink made from instant granule Changes in blood sugar after consuming the optimal sample

In Table 3, the average changes in blood sugar after consuming glucose and almond-oat porridge at different times are observable. According to the results, the lowest level of blood sugar curve after consuming almond porridge was obtained, which was within the low glycemic index range.

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One of the main approaches to reduce the glycemic index of food is to increase dietary fiber. Dietary fiber reduces the absorption of carbohydrates and decreases post-meal blood sugar by creating mucus and viscosity in the intestines. In the present study, adding whole oat flour and almonds increased the fiber content of the samples under investigation, which could be a reason for the reduction in post-meal blood sugar and consequently a decrease in the glycemic index. Other possible mechanisms for reducing the glycemic index may be due to the presence of phenolic compounds and flavonoids in almonds, oat flour, and grape syrup, such as quercetin. Phenolic compounds in the diet regulate glucose metabolism by inhibiting the activities of alpha-amylase and alpha-glucosidase. Additionally, flavonoids have anti-diabetic effects and can regulate blood glucose levels by regulating carbohydrate digestion, insulin secretion, insulin signaling, and glucose absorption. Furthermore, flavonoids can regulate glucose metabolism in the liver through several pathways, including reducing apoptosis and improving beta cell proliferation, stimulating insulin secretion, and reducing insulin resistance [3,4]. Dolapo et al. (2018) investigated the nutritional properties and performance of extruded cassava-soy composite flour by adding different levels of grape pomace, 0%, 10%, and 20%. The results showed that adding grape pomace reduced starch digestion rate and glycemic index while increasing solubility index [37]. According to Pérez et al. (2013), the lowest glycemic index was related to extruded wheat bran cookies [38]. In Sayyedi et al.'s study (2016), the effects of consuming synbiotic yogurt enriched with beta-carotene on glycemic control and blood lipids in type 2 diabetic patients were investigated. According to the results, consuming the product for 6 weeks in type 2 diabetic patients had beneficial effects on serum insulin concentration, insulin resistance, triglycerides, VLDL cholesterol, and total cholesterol to HDL ratio compared to control yogurt [39].

Rachan et al. (2023) investigated the effect of a high-fiber and high-protein dietary supplement on blood sugar levels in patients with chronic kidney disease and glycemic index. The results showed that blood sugar fluctuations after 120 minutes were significantly lower in individuals who consumed the sample containing high fiber and high protein compared to glucose consumers [3].

Table.4 Average blood sugar changes after eating glucose and almond-oat porridge

Blood sugar after consumption of almond-oat porridge (mg/ dL)	Blood sugar after consumption of glucose (mg/ dL)	Time (min)
0	0	0
18.02	36.3	15
33.8	78.9	30
34.4	72.6	45
21.7	58.3	60
23.1	45.3	90
21.2	24.1	120

4-Conclusion

Applying of Strategies such as Incorporating Native Foods into the Industrial Cycle through the Development of Formulation Technology and Process Methods Aligned with the Current Modern Lifestyle, and its Role in Maintaining a

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Healthy Dietary Pattern and International Introduction. The adoption of strategies such as incorporating native foods into the industrial cycle through the development of formulation technology and process methods aligned with the current modern lifestyle will play an effective role in maintaining a healthy dietary pattern and introducing it internationally. Among native foods, Harireh (grains with almond kernels) as a traditional and beneficial food with high nutritional value is recommended for most age groups in society. Considering the changes in lifestyle along with the increase in individuals' nutritional knowledge, the production of ready-to-eat, healthy, and nutritious food products has become a priority in the operational agenda of research and development centers in food industries. In the present study, successful semi-industrial production of instant granola powder from oil-extracted almond as a by-product of processing industries, along with whole oat flour and powdered grape syrup as a natural substitute for color and sugar, was carried out with the approach of producing ready-to-eat products with characteristics of low glycemic index, improved reconstitution properties, and immediate solubility in water and milk. It is worth mentioning that the resulting powder can be effectively used as an additive in various food products such as bread, frozen dough, cakes, pastries, various confections, chocolates, beverages, and dairy products like dairy desserts and ice cream as a substitute for color and sugar.

5-Reference

[1] Trombini , F . R . M ., Mischan , M . M . and Leonel ., M . 2016 , Instant blend from cassava derivatives produced by extrusion , Ciência Rural, Santa Maria , 46. 3: 573-579.

[2] Liu, S, Zhao, L, Zhang, J, Wang, L, Liu, H. (2021). Functional drink powders from vertical-stone-milled oat and highland barley with high dietary-fiber levels decrease the postprandial glycemic response. Journal of Functional Foods. 83, 104548. https://doi.org/10.1016/j.jff.2021.104548.

[3] Rachana, B., Shobana, S., Lalithya, P. V., Sudha, V., Vinita, S., Gayathri, R., Kalpana, N., Ranjit, M. A., & Viswanathan, M. (2023). Glycemic index of a nutritional supplement designed for people with chronic kidney disease. Food Science & Nutrition, 11, 5379–5387. https://doi.org/10.1002/fsn3.3495

[4] Li, F, Zeng, K, Ming, J. 2023. Lowering glycemic levels via gastrointestinal tract factors: the roles of dietary fiber, polyphenols, and their combination, Critical Reviews in Food Science and Nutrition, 10.1080/10408398.2023.2278169, (1-37)

[5] Hashemi, N., Mortazavi, SA, Milani, E, Tabatabai Yazdi, F. (2017). Microstructural and textural properties of puffed snack prepared from partially deffated almond powder and corn flour. J Food Process Preserv., 41(5) 1-12.

[6] Milani, E. Hashemi, N and Hashemi, M. (2024). Physicochemical properties and flow behavior of natural sweetener and colorant from foam-mat dried grape powder. Journal of Food Process Engineering

[7] Mialni E, Hashemi N, Hashemi M. Evaluation of the quality characteristics of the instant porridge (Harireh) powder based on oatmeal- Almond produced by extrusion technology. FSCT (2023). 19 (133) :17-28 URL: http://fsct.modares.ac.ir/article-7-64321-fa.html

[8] Okhravi S, Koocheki A, Mialni E. The effect of extrusion technology on the physicochemical properties of product based on oatmeal-broken rice composite flour to fabricate instant harire. FSCT (2022). 19 (126) :227-237

[9] Šimurina, O. D., Filipčev, B. V., Marić, B. D., Cvetković, B. R., & Bodroža-Solarov, M. I. (2018). Comparative study on the physico-chemical, textural and thermal properties of instant porridges based on spelt and oats. Food and Feed research, 45(1), 27-35.

[10] Gandhi, N., & Singh, B. (2015). "Study of extrusion behaviour and porridge making characteristics of wheat and guava blends." Journal of food science and technology, 52(5), 3030-3036.

[11] Milani E, Hashemi N, Mortazavi A, Tabatabai F, Gazerani S. Optimization of Instant Drink Powder Formulation Based

Powder Technology , Vol . 208 , PP . 244-251 .
[22] 22- Jozinović , A ., Šubarić , D ., Aćkar , Đ ., Babić , J ., Milićevič , B . 2016 , Influence of spelt flour addition on properties of extruded products based on corn grits , Journal of Food Engineering , Vol . 172 , No . 31-37
[23] Charunuch , C ., Tangkanakul , P ., Limsangouan , N . and Sonted , V. (2008) , Effects of Extrusion Conditions on the Physical and Functional Properties of InstantCereal Beverage Powders Admixed with Mulberry (Morusalba L.), Leaves Food Sci. Technol. Res., 14(5) ,. 421- 430.
[24] Jeske, S & Zannini, E & Arendt, EK (2017) Evaluation of Physicochemical and Glycaemic Properties of Commercial Plant-Based Milk Substitutes. Plant Foods Hum Nutr (2017) 72:26–33
[25] McClements, D .J.2016 , Food Emulsions Principles, Practices & Techniques , Third edition , CRC Press , Boca Raton, Pub .1-7
[26] Wang, Y, ., Ai, C ., Wang, H, Chen, C., Teng, H., Xiao, J., Chen, L (2023) Emulsion and its application in the food field: An update review.e food. 4(4)e102. https://doi.org/10.1002/efd2.102
[27] Jeantet , R . and Floury , J . (2016) , Stability of Complex Foods and Dispersed Systems , Handbook of Food Science and Technology 2: Food Process Engineering and Packaging, First Edition. Edited by Jeantet, R., Croguennec, T., Schuck, P and Brulé, G. John Wiley & Sons, Inc. Pub ., 153-185 .
[28] Cui , S . W . (2001) , Polysaccharide gum from agriculture products: Processing structure and functionality, Lancaster, penn ., U . S . A . , Technomic, Pub. Co., 59-66.
[29] Behrens, JH, Villanueva, NDM Da Silva, MAAP. (2007) Effect of nutrition and health claims on the acceptability of soyamilk beverages. https://doi.org/10.1111/j.1365-2621.2006.01206.x. 42,1. 50-56
[30] Gupta K, Verma M, Jain P. (2014) Process optimization for producing cowpea added instant kheer mix using response surface methodology. J Nutr Health Food Eng. 1(5):198–206. DOI: 10.15406/jnhfe.2014.01.00030
[31] Majchrzak, D., Ipsen, A . and Koenig, J . (2015) , Sucrose-replacement by rebaudioside a in a model beverage ,J . FoodSci . Technol , . 52 (9) . 6031-6036
[32] Cardoso , J ., Bolini , H . (2007) , Different sweeteners in peach nectar: idealand

on Almond Meal-Corn Textured Flour. Iranian J Nutr Sci Food Technol 2018; 13 (2) :41-49
[12] AACC. (2000). Approved Methods of the AACC (10thed). American Association of cereal Chemists, st Paul.
[13] Yasumatsu , K ., Sawada , K ., Moritaka , S ., Mikasi , M ., Toda , T. and Tshi , K . 1972 , Whipping and emulsifying properties of soybean products , Agricultural Biochemistry , Vol . 36 , PP . 719-727.
[14] Roongruangsri , W . and Bronlund , J . E . (2016) , Effect of air-drying temperature on physico-chemical, powder properties and sorption characteristics of pumpkin powders , International Food Research Journal , Vol . 23 , No . 3 , PP . 962-972.
[15] Hashemi, N., Milani, E., Mortezavi, S.A., Tabatabai Yazdi, F. (2017). Sticky Point Temperature as a Suitable Method in Evaluation of Shelf Life of Food Powders. Bulletin de la Société Royale des Sciences de Liège, 86, 7–12. https://doi.org/10.25518/0037-9565.6519
[16] Goula , A . M . and Adamopoulos , K . G . (2010), A new technique for spray drying orange juice concentrate , Innovative Food Science & Emerging Technologies, 11, 342-351.
[17] Taufiq , A . M ., Yusof , Y . A ., Chin, N. L., Othman, S. H., Serikbaeva, A. & Aziz, M. G.(2015). Physicochemical properties of tamarind and pineapple fruit pulps and powders , International Food Research Journal, 22 (2) , 707-712
[18] Opaliński , I ., Chutkowski , M . and Hassanpour , A .(2016) , Rheology of moist food powders as affected by moisture content , Powder Technology, 294, 315-322.
[19] Fitzpatrick , J . 2013 , Powder properties in food production systems , In Handbook of food powders Processes and properties (Bhandari B, Bansal N, Zhang Mand Schuck, P) , Woodhead Publishing Limited . U . K ., PP . 299-322 .
[20] Rayo , L . M ., Chagurie Carvalho , L ., Sarda , F . A . H ., Dacanal , G . C ., Menezes , E . W . and Tadini , C . C . (2015) , Production of instant green banana flour (Musa cavendischii, var.Nanicao) by a pulsed-fluidized bed agglomeration , LWT - Food Science and Technology , 63 , PP . 461-469.
[21] Cuq , B ., Rondet , E . and Abecassis , J . (2011) , Food powders engineering , between knowhow and science : Constraints , stakes and opportunities .

the Science of Food and Agriculture, 98(9): 3427-3436.
[37] Dolapo A. Oladiran, Naushad M. Emmambux. (2018). Nutritional and Functional Properties of Extruded Cassava-Soy Composite with Grape Pomace. Starch. 70 (7-8): 12-22
[38] Pérez F, Guadalupe Salazar-García M, Lourdes Romero-Baranzini A, Rosa Islas-Rubio, Benjamín Ramírez-Wong. (2013). Estimated glycemic index and dietary fiber content of cookies elaborated with extruded wheat bran. Plant Foods Hum Nutr. 68(1):52-6.
[39] Sayyedi F, Asemi Z, Goli M, Bahmani F, Alizadeh S, Esmaillzadeh A.(2016). The Effect of Synbiotic Gaz Fortified with Beta-carotene Consumption on Glycemic Control and Blood Lipids of Patients with Type 2 Diabetes. Iranian Journal of Nutrition Sciences & Food Technology. 11(1)1-10.
equivalent sweetness , Food Res. Int., . 40 ,. 1249-1253
[33] Trevizam Moraes , P . C . B ., Bolini , H . M . A . (2010) , Different sweeteners in beverages prepared with instant and roasted ground coffee: ideal and equivalent sweetness , J . Sens . Stud .,. 25 , 215-225.
[34] Howard , B . M ., Hung , Y . C ., and McWatters , S . K . (2010) , Analysis of ingredient functionality and formulation optimization of an instant peanut beverage mix , Journal of Food Science , 75 (1). S8–S19.
[35] Perez-Navarrete, C., Gonzalez, R., Chel-Guerrero, L and Betancur-Ancona, D. (2006). Effect of extrusion on nutritional quality of maize and Lima bean flour blends. Journal of the Science of Food and Agriculture. 86: 2477–2484
[36] Sandrin, R., Caon, T., Zibetti, A.W. and de Francisco, A., (2018). Effect of extrusion temperature and screw speed on properties of oat and rice flour extrudates. Journal of

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مقاله علمی_پژوهشی

تعیین ویژگی تکنولوژیکی، حسی و تغذیه ای پودینگ فوری بر پایه آرد کامپوزیت کنجاله بادام- جو دوسر و پودر شیره انگور

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چکیده

تولید پودینگ فوری غذای کودک از پرطرفدارترین موضوعات پژوهشی به شمار می رود. گرانول سازی روش مطلوب برای تولید فراورده های غذایی فوری است. نگهداری آسان، انحلال و مدت ماندگاری بالاتر از محاسن گرانول به شمار می‌روند. آرد کامل و مواد غنی از فیبر در کنار جایگزینی شکر با ترکیبات شیرین کننده طبیعی، راهکار عملیاتی برای کاهش اثرات نامطلوب در رژیم غذایی پرکالری است. در این پژوهش بر پایه طرح آماری مخلوط تاثیر سطوح گرانول بافت داده شده بادام–جودوسر (٦٥–٧٠٪)، پودر شیره انگور (۲۵–۳۰٪) و شکر (۰–٥٪) بر ویژگی های فیزیکوشیمیایی، روشنی رنگ، فعالیت امولسیون کنندگی، ثبات امولسیون، اندازه ذرات، تغییرات قند خون و پارامتر حسی ف پودینگ تولیدی بررسی گردید. مطابق نتایج بهینه یابی به منظور دارابودن ظرفیت امولسیون کنندگی، ثبات امولسیون، میزان روشنی رنگ و پذیرش کلی٦٥/٨٢، ٦٤/١٦ و٣/٧٥ و ٨٩/٨٩، فرمولاسیون پودینگ فوری شامل ٦٩/٩ درصد گرانول کنجاله بادام- جو دوسر، ٢٦/٩درصد پودر شیره انگور و ٣/١٣درصد شکر تعیین گردید. نوسانات قند خـون پس از ۱۲۰ دقیقه از مصرف نمونه بهینه، بطور معنی داری کمتر از مصرف کنندگان قند گلوکز بود. بطور کلی ادغام تکنولوژی‌های اکستروژن، فوم مت و گرانولاسیون جهت تولید غذای فوری کودک، ایده‌ای نوآورانه برای توسعه فناوری فراورده های غذایی سالم قلمداد می گردد.