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Improving wheat flour properties for spaghetti processing using some improvers

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Abstract

Four combinations of *ß*-carotene, *L*-ascorbic acid,lipaseand Iso-amylase, were used to improve the quality of spaghetti made from wheat flour 72% extraction rate (WF)and compared against control(1) from semolina and control(2) from (WF). Chemical composition, cooking quality, color parameters, textural properties as well assensory evaluation of spaghetti were performed. Added *ß*-carotene to (WF) improveonly color properties.*ß*-carotene and *L*-ascorbic acid in (WF) improve color , cooking quality ,sensory evaluation and textural properties of spaghetti. And more was with added of*ß*-carotene,L-ascorbic acid and lipase in all properties.Combining the four improvers*ß*-carotene with *L*-ascorbic,Lipase and Iso-amylase gave the best improve in color,cooking quality ,texture and sensory scores of spaghetti compared to control(1) from semolina , with about 60% reduction in cost of raw material of spaghetti. The study may help manufacturers to use special combinations of improvers with wheat flour72% for produce good quality spaghetti.

Keywords: wheat flour72%, semolina, lipase, Iso-amylase, *L*-ascorbicacid,*β*-carotene, spaghetti,

Introduction

Pasta (spaghetti)is a popular food worldwide known for its ease of preparation, good storage stability (dried form), low cost, and simple preparation with a low glycemic index (GI). Pasta consists mostly of carbohydrates (70–76%), protein (~10–14%), lipids (~1.0%), dietary fiber (~1.0%), and small amounts of minerals and vitamins ***(Sissons, 2022).***Durum wheat semolina is the best raw material for pasta making, due to its physicochemical, rheological, nutritional, and sensory properties.Durum wheat proteins are characterized by typical viscoelastic behavior, which allows good networking of the matrix, optimal dough formation during mixing and extrusion phases, as well as the most appreciated quality *(**Curielet al.,** (**2014**);**Deng, and Manthey, (2017) and Romano et al.,2021).***

In some cases**,**common wheat flour is used to produce pasta, usually when the supply of durum is limited or the price is too high ***(Sissons, 2022)***. However, pasta made from wheat flour 72% or from blends of wheat flour 72% with durum wheat semolina is considered to be of lower quality than pasta from durum semolina (***Wiseman, 2001).***Nevertheless, the addition of soft wheat flour 72 % reducesthe quality of the spaghetti product,where the soft wheat flour 72 % contains less protein, including gluten proteins, low gluten quality, and gluten and starch type which results in lower product quality, lower firmness, and higher cooking losses. In addition, wheat flour has finer starch granulation than durum semolina ***(Sobotaet al., 2017); (Duda, et al., 2019).***

These parameters may induce higher cooking losses, enhance stickiness, and reduce pasta firmness, which results from a higher degree of damage to starch granules (***Manthey&Twombly, 2013).*** Moreover, in comparison with semolina, wheat flour contains lower amounts of carotenoids, which give a pale yellowish color

(Leenhardtet al., 2006).it is utmost to use alternative ingredients in pasta formulation results in interesting modifications in quality as well as nutritional and sensory characteristics ***(Romano et al.,2021).***One of these alternativesto produce high-quality pasta from a mixture of durum semolina and strong wheat. Replacing up to 50%of the semolina with strong flour in eggless pasta yields a product that meets all the criteria. Semolina durum can be fully replaced by strong wheat flour, which can significantly reduce production costs in countries where access to durum wheat is limited ***(Teteryczet al., 2019).***

Another concern is the potential application of enzymesto improve pasta quality. They are biocatalysts derived from plants, animals, or microorganisms, which are generally reported as safe. The application of enzymes strengthensthe domestic wheat flour by diminishing the undesirable effect of damaged starch in flour related to pasta quality***(Raveendranet al., 2018; Moon, &Kweon, 2021).***Lipase enzyme increases the number of amyloses–lipid complexes in the flour, which, in turn, inhibits the swelling of starch granules as well as the leaching of amylose that frequently occurs during cooking. In addition of lipase may be increases these complexes by more than 60%.

Pasta treated with lipase has higher firmness, reduced stickiness, improvement of tolerance against overcooking, as well as color stability. In addition, lipase reduces the speckled appearance of pasta dough and also increases color stability during dough sheeting and pasta forming ***(Colakoglu, and.Özkaya, 2012) ;Pszczola2001) and (Widjaya et al. 2008)***Iso-amylase (EC 3.2.1.68), grouped in the GH13 family, hydrolyses α-(1, 6)-bonds removing the side chains from amylopectin transfer to amyloses.It effectively reduces the high water uptake due to arabinoxylan and damaged starch in poor-quality flour, so it is essential for gluten development, processing, and Pasta/

noodles quality.***(Marc et al. (2002);Ângeloetal. 2015; Moon, and Kweon, 2021).*** *ß*-Carotene added to flour noodles had higher weight and volume gains; less cooking loss decreased lightness, and increased rednesswith preferred appearance, flavor, taste, texture, and overall acceptability than the flour noodle samples. However, the texture profile parameters of the cooked noodles varied considerably for gumminess and hardness ***(Leeet al., 2002;Leenhardt, et al.,2006).***

L-ascorbicacid (150-180 ppm) is used for many years as an addition to improve the physical properties and technologicalmixture of different flour products. Also, *L*-ascorbicacid indirectly strengthens the protein by the oxidation of gluten maintaining the structure of dough and improving the elasticity. In addition, it gives the good texture properties of gluten can help to increase the firmness of pasta. Moreover, it increases the strength of the available gluten in the flour ***(Jyotsna et al.2004; Majlinda, 2018).*** In Egypt, about 90 percent of the annual production of pasta is made using a wheat flour 72 % extraction rate and only 10 percent using semolina***(Abdel-Haleem et al.,2012).***

The present work investigate the effect of permitted improvers(*ß*-carotene , *L*-ascorbic, Lipase and Iso-amylase)on the quality performance of spaghetti made from commercial domestic wheat flour 72%.

Materials and Methods

Materials.

Semolina flour was obtained from ReginaMills, Industrial area 3,10th. Ramadan City, Egypt andwheat flour 72%extraction rate (WF) from Five Stares Milles, El-Swiss City, Egypt.*L*-ascorbic acid, Lipase enzyme, Iso amylase enzyme, and yellow color (*ß*-carotene) with purity 100% were obtained from Muhlenchemie Companyfor Flour Improvers (Rana group) Egypt.All other chemicals were of reagent grade and were obtained from El-GomhoriaCompany for Chemicals., Egypt.

Methods.

Spaghetti formulation and processing.

Spaghetti wasprocessed according to ***Dudaet al. (2019),*** in The New Egypt Company for Pasta Products, VavaCompany for Pasta production lines, Land No 017. Industrial Development Group***,*** 6 October City, Egypt, Each spaghetti formulas (Table 1) werehydrated to obtain a water content of35%, and thenmixed with additives for 25 min to form the dough,Spaghetti dough was extruded by spaghetti die , then dried in a humidity chamber using Vavapasta lines. The drying parameters were as follows: 50◦C/ 3 h, relative humidity of 75%; 65 ◦C/11 h, relative humidity of 85%; 45◦C/ 3.5 h, relative humidity of 60%.Dried spaghetti was left to rest for 3 h at room temperature and 70% relative humidity until stabilization take place, then spaghetti was packed in polyethylene (PE) bags**.**

Chemical analyses of wheat flour72%, semolina, and cooked Spaghetti.

The contents of moisture, crude protein, crude fat, ash, wet gluten, dry gluten, gluten index, quality, total starch, damaged starch and ß-carotenewere determined according to the ***AACC International (2010)*** Approved Methods 44-16, 46-30, 30-10, 08-01, 38-12.02,76-13, 76-31.01and 14-50, Crude protein (N X 5.7), and total carbohydrates by difference.Amylose /amylopectin contents were determined according to ***Hai-Wei Maand Mei Deng (2017).***All chemical tests were carried out in triplicate.

CookingQualityof spaghetti.

Spaghetti cooking quality was determined according to the ***AACC International (2010)*** approved method 66-50.01. Spaghetti samples were cooked in boiling distilled water. Optimum cooking time (OCT)was reached when the white center, in the cooked spaghetti's center core, disappeared after compressing it between two pieces of glass at intervals of 30 s. cooking loss (CL), expressed as grams of matter loss/100 g of raw spaghetti, was evaluated in terms of amount of solids lost into the cooking water.The **(**Weight increase (**%)** (WI), and the volume increase (%) (VI) were used to express the increment of spaghetti weight and volume during cooking.

Color measurements of Spaghetti.

Color parameters of cooked and uncooked Spaghetti were measured using Hunter Color measurement (Labscan XE system, USA) according to ***Ugarcic-Hardiet al. (2007).*** The color expressed in (*L*) is the measure of the brightness (lightness) from black (0) to white (100). (A) is the function of the red-green difference. Positive A indicates redness, and negative (*a*) indicates greenness. Positive (*b*) indicates yellowness, and negative (*b*) indicates blueness. Units within (L), (*a*), and (*b*) systems give an equal perception of the color difference to a human observer.

Texture Profile Analysis of Spaghetti.

Elasticity (kilopascal= kPa),Hardness(Newton = N), Chewiness (N), and Firmness (N) parameters of cooked spaghetti were evaluated by ***Bourne, (2002)*****,** usinga Texture analyzer (Brookfield CT3 texture analyzer) equipped with a 30 kg load cell. Four measurements were performed per treatment and the averages was reported.

Sensory Evaluationof Spaghetti.

Sensory evaluation was carried out forcooked spaghetti samples according to,***Jayasenaet al. (2008).*** The mean for each attribute resulting from 10 members from Food Technology Research Institute, Agricultural Research Center,scoredspaghetti samples for Color before cooking ,Color after cooking, Appearance, Taste, Odor, Texture, Stickiness and Overall acceptable **.**on a hedonic scale from one (dislike extremely) to nine (like extremely).

Statistical Analysis.

The data were statistically analyzed using ***SPSS (2000).*** One-way analysis of variance (ANOVA) was performed using**,** SPSS software version 6.0 (SPSS Institute Inc., Cary, NC, USA). A value of $P \leq 0.05$ was considered statistically significant.

Results and Discussion

Chemical composition of semolina and wheat flour 72% extract rate (WF).

The content of protein in the raw materials used was varied as shown in Table 2. Semolina had higher protein content (14.5%) in comparison to wheat flour(12%).These results are near from those reported by ***Teteryczet al,, (2019),.*** Also, ash and crude fiber were higher in semolina (0.70 and 0.68%, respectively) in comparison to wheat flour (0.55 and 0.51%, respectively).Carbohydrate content was higher in wheat flour 86.5% compared with 83.60% for semolina.Our results are in agreement with the work by ***Teterycz et al., (2019).***

The content of gluten in the raw materials used in the present study was varied (Table2). The high gluten content in semolina (37% wet gluten ,14.5% dry gluten and 85%Gluten index (quality)) determines the high cooking quality of the pasta and reduction of cooking losses in comparison to (26%wet gluten ,11% dry gluten and77%Gluten index (quality)) for wheat flour. Our results are higher than those reported by ***Teteryczet al., (2019).*** They reported gluten content in semolina to be 30.79%. High gluten content in the raw material is also responsible for the formation of a strong protein matrix in the pasta, which prevents the starch from rupturing during cooking, additionally improving the texture parameters of the pasta product ***(Diantom et al., 2016; Sobota and Zarzycki, 2013; Teteryczet al., 2019).***

Semolina contains total starch (75.6 g) and (36%) amylose,while the value for WF(80.4g) and (32%) respectively , these results agree with that reported by ***Lafiandraet al., (2012)*** and ***Teteryczet al., (2019).*** The neutral yellow color is the one important properties of semolina for the presence ofß-carotene so,theß-carotene contained in raw semolina which uses in our research was 7ppm while wheat flour was 1 ppm. The same results were obtained by ***USDA (1991).***

Chemical characteristics of Spaghetti.

The nutrient content of the spaghettis blends was given in Table (3) showed that protein in all wheat flour blends (control2,F1,F2,F3 and FF4) values were (11.8-11.9%) were significant lower than (14.4%)control1 form semolina. This agree with the work by ***(Walsh, and Gilles, 1971). (Teterycz et al., 2019)*** who reported a decrease in protein and cooking quality when using wheat flour in pasta.

The amount of amylose % in samples control (2),F1,F2and F2 were recorded significant lower than that present in control (1) from semolina values were (32.6,33.0,33.2and 33.3%) and (37.0%) respectively except (F4)sample gave value higher thanof amylose content (40.5%)with no significant with control (1)**.** Also, it was observed that amylopectin decreased to 59.5% in sample F4 which is lower than control (1) semolina (63%). This may be resulted from the action of the Iso-amylase enzyme in (F4) which acted on amylopectin converting it into amylase by hydrolyses of α-(1,6)-bonds removing theside-chains from amylopectinthis results in agreement with ***(Schomburg and Salzmann, 1991).***

ß-carotene content in control (1) from semolina was (6.0ppm) and not found in control (2) from wheat flour without additives, while spaghetti samples made from wheat flour with additives were (8.0-6.0 ppm). This increasing may be due to theadded of *ß*-carotene in formulas, while the decrease between samples made from wheat flour may be due to the oxidation effect of *L*-ascorbicacid and enzymes lipase which oxidation of gluten and pigments. ***Walsh and Gilles, (1971)***reported that the addition of *L*-ascorbicacid during the mixing of the dough decreased of semolina pigments.

Cooking Quality of Spaghetti.

Cooking time is one of the most important quality parameters of spaghetti for consumers. They expect the product to take as little time as possible to prepare. The cooking time decreased by replacing semolina with wheat flour. The minimum cooking time depends mainly on the protein content and starch granulation in the pasta. High levels of gluten proteins, which form a strong matrix, limit the access of water to the starch, thus prolonging the time of starch gelatinization. It may also be influenced by the thicker granulation of semolina ***(Grant et al., 1993;Sobota, andZarzycki,2013).***

In table (4),cooking time decreased from (6.0 to 9.3 min) than semolina (10.0 min) , however F4 sample didn't recorded significant with control(1).This improving may be due to adding *L*-ascorbicacid and enzymatic improvers. Our results agree with the work ***byMartínezet al., (2007). Zweifel et al ., (2003); De Noni and Pagani(2010),*** and **Martinez *et al.,*(2016),** reported that pasta with higher gluten content and quality presented better cooking properties, according to increased optimum cooking time, decreased cooking losses and water absorption observed in these samples. Also, they explained that the increase in gluten content favors the formation of a firm structure, limiting water diffusion to the center of pasta and in consequence decreasing the migration of solid to the cooking water.

Results in Table (4)showed that, forweight increase (%) inspaghetti with improvers F1,F2,F3and F4 were (2.3, 2.8, 3.0 and3.2%,)respectively compared with 3.3%in control (1) semolina and 2.00 in control (2).this increase maybe due to improvers such as (*L*-ascorbicacid, lipase enzyme, and Iso-amylase enzyme)respectively. This agrees with work by ***Jyotsnaet al,(2004),*** They reported that the addition of *L*-ascorbic acid at two levels: 0.01 and 0.02% resulted improing in cooked weight % compared to semolina vermicelli value.

Also,results in table (4) showed that the volume increase (%) in spaghetti samples follows the same trend. ***Jyotsnaet al.,(2004)***reported a significant volume expansion in the strands with decreased cooking loss as a result of incorporating *L*-ascorbicacid into vermicelli made from (*Triticumaestivum)* wheat flour.

Dick and Youngs (1988) established that cooking losses should be around 7 % and should not exceed 8 % for spaghetti samples made from durum wheat semolina, and water absorption values should be three times over the dry weight if a good quality final product is expected.Results in table (4) showed that cooking loss % was higher in control (2) and decreased other samples ranges were (10.0- 6.0%) and (5.5%) in control(1)and(6.0%)in F4 with no significant with control (1),this decrease in cooking loss maybe due to the effect of *L*-ascorbicacid,lipase enzyme and Iso-amylase enzymewhich the possible role of lipases in delaying starch retro gradation was indicated by the greater extent of formation of amylose-lipid complexes low soluble in cooking water promoted by lipases***,(Ângelo., et al, 2015).***

These results are higher than those reported by ***Martinez et al., (2007).*** According to ***Mondelli (2004)*** and ***Deng and Manthey (2017),*** dry matter losses depend to ahigh degree on the content and quality of protein substances in the raw material used for pasta production**.**The addition of *L*-ascorbicacid resulted in a decrease in cooking loss (F2, F3, and F4), this agrees with work by ***Jyotsnaet al, (2004);*** they reported that cooking loss decreased to a considerable extent with the use of 0.01% *L*-ascorbicacid. Alsothis may be caused by the effect of lipase and Iso-amylase enzymes in F3 and F4 which acted on amylopectin converting it into amylose since the correlation between cooking loss and amylose content in cooking water was observed. This result is in agreement with ***Martinez et al., (2007).Widjaya et al., (2008)*** found tha tthe incorporation of lipase into pasta dough improves the outer layer structure of the pasta strands and leads to the formation of lipid-starch complexes, increased over cooking tolerance, reduced stickiness, and decreased cooking loss.

Color Parameters of Spaghetti samples.

The color of raw spaghetti is an important quality factor for consumers. In pasta products made from semolina, the higher value, is the more desirable the product ***(Rayas-Duarte et al. 1996).*** Among of(*L**), (*b**), and (*a**) parameters, the first two are considered more important as color attributes ***(Martinez et al., 2007).***

The color of pasta is determined by the pigment content in the raw materials, in this case, durum semolina and wheat flour. Durum wheat grains are richer in carotenoids than wheat grains and, therefore, durum-based products have a darker and more yellow color ***(Leenhardtet al., 2006).***

Color parameters of spaghetti samples are shown in Table (5), treatment with four improvers increases the white color (L*) and brightness of uncooked spaghetti or spaghetti from (70.4to 80.5) and (58.9)in control (2) while control (1) was the recorded higher value (80.3). Further, lipase reduces the darkening rate of raw pasta. Raw pasta treated with lipase resultedin significantly less darkness than the spaghetti semolina sample***. Si and Lustenberger, (2000) and***

(2002),reported that in cooked white salted pasta,brightness is a very important parameter too. Whiteness/brightness of cooked white spaghetti is increased by treatment with lipase.

Also, the (*L**) parameter indicating the brightness of spaghetti decreased significantly as proportion of spaghetti from semolina while wheat flour samples increased, cooked spaghetti with improvers were increased from (66.6 to 75.30) compared with (77.85) in control(1)while, control (2) was the lower sample (60.33), this may be due to the addition of *ß*-carotene*, L-ascorbic* acid, lipase and Iso-amylase resulted in a slight increase in (*L**) values results of treatment with lipase increased the brightness of spaghetti produced from wheat flour. These results agree with the work by ***Teterycz et al., (2019).***

Also,our results agree with ***Si and Lustenberger, (2000).*** They reported that pastamade with slight Lipase addition also reduced the darkening rate during storage of raw pasta.During the production of instant pasta, the color of the spaghetti sheet can change within the time frame of production before the pasta is steamed.***Si and Lustenberger, (2000*)** reported thatthe color effect of the lipase maybe even more than what is measured in cooked spaghetti dough sheets. They referred this to as the increased surface of pasta which makes it even more accessible for oxidation than the pasta dough sheets.Also, the addition of lipase increased (*L**) values. These results agree with ***Widjayaet al.,(2008).*** They reported that the incorporation of lipase in the formulation affected the (*L**) value positively.

On the other hand, the decreasing of results in(*a**)parameter is quality factor in spaghetti**.** (*a**) parameter was recorded decrease in uncookedand cooked spaghetti for F1,F2,F3 and F4 samples compared with control(1)while, control (2) was the higher sample.

As well as, the increasing of results in (*b**) parameter is quality factor in spaghetti**.**The(*b**) parameter was recorded decrease in (control (2) and F1) but the(*b**) levels were increased in F2 and F3. While F4 was very near to control(1),this similarity between the F4 sample and control (1) with no significant ,these maybe due to the combination of ß-carotene*,L*-ascorbicacid, lipase, and Iso-amylase enzyme.These results agree with the work by ***Teteryczet al., (2019).*** Also, ***Jyotsnaet al., (2004),***reported an improvement in the yellow index values was noted in samples where *L*-ascorbicacid was added. ***Walsh and Gilles, (1971),*** reported that the addition of *L*-ascorbic acid increased the yellowness of spaghetti.

Sensory characteristics of spaghetti.

Sensory acceptability scores of spaghetti are shown in Table (6), color of uncooked spaghetti of wheat flour were improved by added of improvers from (5.1)in control(2) to (7.0,7.3,7.4 and 8.0) in (F1,F2,F3 and F4) respectively while compare with(8.2) in control (1) while (F4) with four improvers resulted similar score with on significant differences among them.In the sameway, the lowest value in color befor cooking of spaghetti in control (2) as well as, color of cooked spaghetti was improved with additives blends . Also,(Appearance, , odor, and stickiness) followed the same trend.However, the taste and texture are the important characteristics for consumers,spaghetti made from (WF) with improvers were improved in taste (from 5.4 to 8.0) compared with (8.2) in control (1), while control (2) was reject sample**.**Also, texture were improved in spaghetti made from (WF) with additives values were (from 5.0 to 8.5) compared with (8.6) in control(1) while control (2) was (4)**.**

Spaghetti samples made from wheat flour recorded valuesof the overall acceptablefrom (5.9- 7.6) in (F1-F3) while (F4) the nearest score to control (1) with no significant value was(8.6) and (8.7) in control (1),this improving maybe due to adding improvers (*ß*-Carotene, *L*-ascorbicacid, lipase, and Iso- amylases in formulation.Therefore,(F4) made from(WF)and all improvers was the best formula and on significant differences with control (1). sensory evaluation of pasta made from both wheat flour and semolina was also performed by ***Pszczola, (2001)***who explained the improvement of the texture by having a smoother surface, firmer, and reduced stickiness to be achieved by the ability of the enzyme to increase the number of amylose-lipid complexes in the flour which inhibits the swelling of starch granules as well as the leaching of amylose that occursfrequently during cooking.

Texture characteristics of spaghettisamples.

Texture characteristics are important properties in the evaluation of pasta quality of cooked spaghetti. Textural properties of spaghetti play the main role in overall acceptance by consumer**. *(Gońda-Skawińska1et al. 2020).***

Properties such as (Elasticity (kilopascal),Hardness (Newton),Chewiness (Newton) Firmness (Newton),and Gumminess (Newton) in Table (7) showed that Among all texture attributes, Hardness, firmness, chewiness, and elasticity can be considered positive attributes; these indicate better spaghetti quality as higher sample values.

Hardness of spaghetti made from both semolina and (WF) was increased slightly from (176.8-226.0N) in (F1-F4) and (230.0 N)incontrol (1) while control (2) was (173.2 N).Also,Firmness (N)wasslightly increased from (1.8 -2.4N)in(F1-F4) with the addition of *L*-ascorbicacid, Iso-amylase, and lipase enzymes, and (2.5 N) in control (1),while control (2) was (1.6N).

As well as, Elasticity,ChewinessandGumminessresults were on same path of improvement, coinciding with the addition of more improvements in blends from one sample to another sample (F1-F4).while F4which contain all improvers was closest to the control (1) with no significant differences while control (2)was the lower sample in all texture characteristics this improving maybe due to adding improvers(*ß*-Carotene, *L*-ascorbicacid, lipase, and Iso- amylases in formulations. the results of texture properties in table (7) are related to results in sensory characteristics in table (6),These results agree with. ***Widjayaet al., (2008),*** reported that may have reflected in an increased formation of cross-links in the gluten networks as the level of lipase increased, or the impact may have been on the gelation of starch. ***Si and Lustenberger, (2000) and (2002),*** also, reported that lipase increases the firmness of pasta resulting in a lower relative penetration they mentioned that the mechanism of the beneficial effect of lipase in wheat flour pasta or pasta is notyet fully elucidated, It may be due to a modification of the protein fraction and the starch fraction.

While ***Widjayaet al., (2008)*** reported that the incorporation of a fungal lipase into pasta dough improves the outer layer structure of the pasta strands and leads to the formation of lipid-starch complexes, which result in improved hardness, smoother surface, increased overcooking tolerance, reduced stickiness, and decreased cooking loss**.**They concluded that the ability of this enzyme to increase the strength of the available gluten in the flour makes it very useful to improve the quality of pasta and pasta where lower quality, lower protein flours are used Further more, yellow color, shininess, firmness, chewiness, elasticity, surface smoothness, and superficial defects were evaluated by***Martinez et al. (2007).*** And all were positive parameters by judges.

Economic cost of spaghetti blends.

Table (8) showed that the cost of raw material of ton semolina spaghetti about two and half times or 60% the cost of ton raw material of wheat flour spaghetti samples with improvers .raw material cost was 1500($)par of ton semolina spaghetti while the cost of ton of spaghetti made from wheat flour with improvers were (601.3 ($) - 606.50 ($))**.**This is maybe a comeback to using a small percentage (ppm) from improvers and enzymes with high improving effects in spaghetti technological properties.

Conclusion

Wheat flour 72% extraction rate contains less protein, including gluten proteins, which results in lower spaghetti quality, lower sensory evaluation, cookingquality, colorproperties, textureand highercooking losses. The use of different improvers (*ß*-carotene, *L*-ascorbic, lipase and Iso-amylase) (WF) led to some improvein spaghetti quality compering spaghetti from semolina. but , the usingof all these improvers mixture led to produced spaghetti sample was similar with spaghetti produced from semolina in all parameters and evaluations with no significant in statistical analysis.Adding of improvers with wheat flour in spaghetti reduce the cost of spaghetti by 60% than spaghetti semolina.

Table (1). Formula of spaghetti blends**.**

Raw materials	Control(1)	Control(2)	F1	F2	F3	F4
Semolina (kg)	100	--	--	--	--	--
(*WF) (kg)	--	100	100	100	100	100
ß-carotene (g)	-	--	1.0	1.0	1.0	1.0
L-ascorbic acid (g)	--	--	--	3	3	3
Lipase enzyme /g)	--	--	--	--	2.5	2.5
Iso-amylase enzyme (g)	--	--	--	--	--	2.5

(*WF) = Wheat flour 72%extraction. 1g = 10 ppm.

Table (2). Chemical Composition of semolina and wheat flour 72%extraction rate on dry base.

Chemical Composition(100 g).	Semolina	(*WF)
Moisture	14.0 [a] ±0.11	14.0 [a] ±0.10
Total protein (g)	14.5 [a] ±0.08	12.0 [b] ±0.04
Fat(g)	0.52 [a] ±0.02	0.44 [a] ±0.07
Ash(g)	0.70 [a] ±0.05	0.55 [b] ±0.06
Crude Fiber(g)	0.68 [a] ±0.08	0.51 [b] ±0.05
Total Carbohydrate(g)	83.60 [a] ±0.17	86.5 [a] ±0.21
Gluten quality		
Wet gluten (g)	37.0 [a] ±0.06	26.0 [b] ±0.09
Dry gluten (g)	14.5 [a] ±0.05	11.0 [b] ±0.07
Gluten index (%)	85 [a] ±0.13	77 [b] ±0.11
Starch properties		
Total starch (g)	75.6 [b] ±0.13	80.4 [a] ±0.15
Damaged starch (g)	4.0 [b] ±0.04	4.60 [a] ±0.09
Amylopectin (%)	64.0 [b] ±0.16	68.0 [a] ±0.014
Amylose (%)	36 [a] ±0.09	32 [b] ±0.06
ß-carotene (ppm)	7.0 [a] ±0.02	1.0 [b] ±0.07

(*WF) = Wheat flour 72%extraction .Means within a row showing the same letters are not significantly different (P≥ 0.05).

Table (3). Chemical characteristics of Spaghetti on the dry base.

Spaghetti samples	Protein %	Amylose %	Amylopectin %	ß-carotene (ppm)
*Control1	14.4 ^{a} ±0.05	37.0 ^{a} ±0.06	63.0 ^{b} ±0.04	6.0 ^{b} ±0.06
*Control2	11.9 ^{b} ±0.04	32.6 ^{b} ±0.07	67.4 ^{a} ±0.04	0.00
F1	11.8 ^{b} ±0.03	33.0 ^{b} ±0.02	67.0 ^{a} ±0.08	8.0 ^{a} ±0.04
F2	11.8 ^{b} ±0.07	33.2 ^{b} ±0.05	66.8 ^{a} ±0.04	7.0 ^{a} ±0.08
F3	11.9 ^{b} ±0.05	33.3 ^{b} ±0.04	66.7 ^{a} ±0.05	7.0 ^{b} ±0.07
F4	11.9 ^{b} ±0.03	40.5 ^{a} ±0.06	59.5 ^{b} ±0.03	6.0 ^{b} ±0.05

*Control1=Spaghetti semolina. Control2= wheat flour 72%

F1: spaghetti (WF72% and ß-carotene). F2: spaghetti (WF72% , ß-carotene, and L-ascorbicacid). F3: spaghetti (WF72%, ß-carotene, and L-ascorbic acid and Lipase enzyme) .F4: spaghetti (WF72% ß-carotene, L-ascorbic acid, Lipase enzyme, and ISO-amylase enzyme).

Means within a column showing the same letters are not significantly different (P≥ 0.05).

Table (4). Cooking Quality of Spaghetti.

Samples	Optimum cooking time (min)	(Weight increase) (%)	Volume Increase) (%)	Cooking losses (%)
control 1	10.0 ^{a} ±0.06	3.3 ^{a} ±0.05	3.5 ^{a} ±0.03	5.5 ^{a} ±0.04
Control 2	6.0 ^{c} ±0.07	2.0 ^{c} ±0.06	2.3 ^{c} ±0.08	10.0 ^{c} ±0.07
F1	6.4 ^{c} ±0.05	2.3 ^{c} ±0.04	2.5 ^{c} ±0.06	9.5 ^{c} ±0.05
F2	7.7 ^{bc} ±0.07	2.8 ^{b} ±0.08	2.9 ^{b} ±0.05	7.0 ^{b} ±0.06
F3	8.5 ^{b} ±0.04	3.0 ^{ab} ±0.03	3.1 ^{a} ±0.08	6.2 ^{a} ±0.03
F4	9.3 ^{a} ±0.04	3.2 ^{a} ±0.06	3.4 ^{a} ±0.02	6.0 ^{a} ±0.06

*Control1=Spaghetti semolina. Control2= wheat flour 72%.

Means within a column showing the same letters are not significantly different (P≥ 0.05).

Table (5). Color Parameters of uncooked and cooked spaghetti.

Spaghetti Samples	Uncooked			Cooked		
	*L**	*a**	*b**	*L**	*a**	*b**
Control 1	82.3 ^{a} ± 0.04	1.9 ^{d} ± 0.05	25.9 ^{a} ± 0.04	77.8 ^{a} ± 0.05	1.9 ^{c} ±0.06	23.2 ^{a} ± 0.05
Control 2	58.9 ^{e} ± 0.05	5.1 ^{a} ± 0.08	16.1 ^{e} ± 0.09	60.3 ^{d} ± 0.06	4.8 ^{a} ±0.03	15.1 ^{c} ± 0.09
F1	70.4 ^{d} ± 0.06	4.2 ^{a} ± 0.08	19.3 ^{d} ± 0.08	66.6 ^{c} ± 0.04	3.5 ^{b} ±0.06	17.6 ^{b} ± 0.06
F2	74.2 ^{c} ± 0.05	3.5 ^{b} ± 0.07	21.6 ^{c} ± 0.05	70.5± 0.02 ^{b}	2.9 ^{b} ±0.04	19.7 ^{b} ± 0.08
F3	78.1 ^{b} ± 0.07	2.9 ^{c} ± 0.04	22.8 ^{b} ± 0.03	74.8 ^{a} ± 0.06	2.4 ^{b} ±0.05	21.5 ^{a} ± 0.05
F4	80.5 ^{a} ± 0.0	2.0 ^{d} ± 0.05	24.9 ^{a} ± 0.06	76.3 ^{a} ± 0.08	2.0 ^{c} ±0.03	22.7 ^{a} ± 0.06

*Control1=Spaghetti semolina. Control2= wheat flour 72%.
Means within a column showing the same letters are not significantly different (P≥ 0.05).

Table (6). Sensory acceptability scores of uncooked and cooked spaghetti.

Spaghetti Samples	Color Uncooked	Color cooked	Appearance	Taste	Odor	Texture	Stickiness	Overall acceptable
	(9)	(9)	(9)	(9)	(9)	(9)	(9)	(9)
Control 1	8.2 ^{a} ± 0.03	7.8 ^{a} ± 0.05	8.4 ^{a} ±0.07	8.2 ^{a} ±0.05	8.4± 0.03 ^{a}	8.6 ^{a} ± 0.05	8.8 ^{a} ±0.08	8.7 ^{a} ± 0.15
Control 2	5.1 ^{d} ± 0.09	4.9 ^{b} ± 0.03	5.2 ^{d} ±0.04	4.7 ^{c} ±0.05	5.8± 0.96 ^{c}	4.0 ^{c} ±0.06	4.4 ^{c} ±0.07	4.2. ^{d} ± 0.11
F1	7.0 ^{d} ± 0.09	6.8 ^{a} ± 0.03	6.2 ^{c} ±0.05	5.4 ^{c} ±0.02	6.8± 0.26 ^{c}	5.0 ^{c} ±0.03	5.5 ^{c} ±0.05	5.9. ^{c} ± 0.14
F2	7.3 ^{c} ± 0.03	7.2 ^{a} ± 0.03	7.3 ^{b} ±0.09	7.6 ^{b} ±0.03	7.6± 0.09 ^{b}	7.2 ^{b} ±0.09	7.8 ^{b} ±0.06	7.4 ^{b} ± 0.10
F3	7.4 ^{a} ± 0.02	7.7 ^{b} ± 0.07	7.9 ^{a} ±0.02	7.8 ^{a} ±0.03	8.0± 0.02 ^{a}	7.8 ^{b} ±0.09	8.0 ^{a} ±0.07	7.6 ^{b} ± 0.12
F4	8.0 ^{a} ± 0.05	7.7 ^{a} ± 0.03	8.2 ^{a} ±0.03	8.0 ^{a} ±0.07	8.2± 0.03 ^{a}	8.5 ^{a} ±0.07	8.6 ^{a} ±0.03	8.6 ^{a} ± 0.13

*Control1=Spaghetti semolina. Control2= wheat flour 72%.
Means within a column showing the same letters are not significantly different (P≥ 0.05).

Table (7). Texture characteristics of cooked spaghetti.

Spaghetti Samples	Elasticity (kPa)	Hardness (N)	Chewiness (N)	Firmness (N)	Gumminess (N)
Control 1	26.6± 0.05^{a}	230.0^{a} ± 0.13	65.4^{a} ± 0.02	2.5^{a} ± 0.07	2.6^{a} ± 0.12
Control 2	13.21^{c} ± 0.15	173.2^{d} ± 0.23	41.5^{c} ± 0.10	1.6^{c} ± 0.22	1.4^{c} ± 0.11
F1	14.5^{c} ± 0.13	176.8^{d} ± 0.20	42.8^{c} ± 0.10	1.8^{c} ± 0.20	1.4^{c} ± 0.09
F2	20.2^{b} ± 0.10	207.5^{c} ± 0.02	56.3^{b} ± 0.17	2.1^{b} ± 0.14	2.0^{b} ± 0.25
F3	22.1^{a} ± 0.07	214.6^{b} ± 0.10	58.0^{b} ± 0.11	2.2^{a} ± 0.09	2.2^{a} ± 0.16
F4	23.8^{a} ± 0.02	226.0^{a} ± 0.05	62.8^{a} ± 0.13	2.4^{a} ± 0.05	2.5^{a} ± 0.22

(Newton = N), (kilopascal= kPa),

*Control1=Spaghetti semolina. Control2= wheat flour 72%.

Means within a column showing the same letters are not significantly different (P≥ 0.05).

Table (8). Economic cost of spaghetti blends.

Raw materials	Price/* ($)	Use percent / cost($)											
		Control (1)		Control (2)		F1		F2		F3		F4	
semolina (ton)	1500	1	1500	-	-	-	-	-	-	-	-	-	-
Wheat flour 72% (ton)	600	-	-	1	600	1	600	1	600	1	600	1	600
ß-carotene(kg)	130	-	-			10(g)	1.3	10(g)	1.3	10(g)	1.3	10(g)	1.3
L-ascorbic acid (/kg)	40	-	-			-	-	30 (g)	1.2	30(g)	1.2	30(g)	1.2
Lipase enzyme (kg)	90	-	-			-	-	-	-	25(g)	2.25	25(g)	2.25
ISO-amylase enzyme(/ kg)	70	-	-			-	-	-	-	-	-	25(g)	1.75
Total cost		1500($)		600 ($)		601.3($)		602.5 ($)		604.75($)		606.50($)	

Raw material prices obtained from :1- Regina Mills-2. Muhlenchemie Company for Flour Improvers (Rana group)- and local market - Egypt. *** ($)**=USD

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تحسين خصائص دقيق القمح المستخدم في صناعة الاسباجيتى باستخدام بعض المحسنات.

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الملخص العربى

في هذا العمل،تم استخدام أربع مجموعات من البيتا كاروتين ،حمض الأسكوربيك ، وانزيم الليبز ، و انزيم الايزو-امبايز، لتحسين جودة دقيق القمح استخلاص 72٪ المستخدم في تصنيع المكرونة الاسباجيتي تم انتاج أربعة خلطات ، مقارنة بكنترول (1) من السيمولينا وكنترول (2) من دقيق القمح 72٪. تم دراسة تأثير هذه المواد المضافة على التركيب الكيميائي وجودة الطهي وخواص اللون والخصائص جودة الطهي للاسباجيتي المطهية. كما تم إجراء التقييم الحسي للاسباجيتي المطبوخة وخواص القوام والتكلفة الاقتصاديه. وجد ان اضافه البيتا كاروتين الي دقيق القمح 72% في العينة1 ادي الي تحسن اللون . كما وجد ان اضافه البيتا كاروتين وحمض الاسكوربيك ادي الي تحسّن اللون وخصائص الطهي لعينة الاسباجيتي. كما أدى اضافة البيتا كاروتين وحمض الاسكوربيك و انزيم الليبيز إلى مزيد من التحسينات في السباجيتي في خصائص اللون و خواص الطهي والتقييم الحسي وخواص القوام .ايضا أدى اضافة البيتا كاروتين وحمض الاسكوربيك و انزيم الليبيز وانزيم الايزو-امبايزإلى اعلي تحسين في خواص الجودة للاسباجيتي المنتجة مقارنة بالكنترول المصنع من السيمولينا، مع انخفاض بنسبة 60٪ تقريبًا في تكاليف المواد الخام المسخدمه في إنتاج الاسباجيتي ،. قد تساعد هذه الدراسة مصنعي المكرونة

على تحسين عمليات إنتاجهم باستخدام مجموعات خاصة من المحسنات والتحول إلى انتاج الاسباجيتي من دقيق القمح مرتفعه الجودة.