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# The Effect of Puffing on the Nutritive Value of Wheat, Chickpea and Their Mixtures

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## ABSTRACT

The protein quality of raw and puffed wheat, chickpea and wheat/chickpea mixtures (in a ratio of 70/30) was evaluated using net protein utilization (PNU) in Sprague Dawley rats. Roasting or puffing was not found to change significantly the food consumption. Puffing chickpea (to get *qudameh*) increased significantly the $NPU_{st}$ from 65 to 74 ($P<0.01$) and the NDPE% from 8.6 to 9.5 ($P<0.01$). Likewise, puffing wheat (to get *Kalieh*) increased significantly the $NPU_{st}$ from 46 to 53 ($P<0.05$) and the NDPE% from 4.1 to 4.6 ($P<0.01$).

The NPU values for the mixture of puffed wheat and chickpea (70/30, w/w ratio) were not significantly different from those of their raw mixtures. This suggests that there was no additional increase in the protein nutritive value due to puffing over that obtained by protein complementation.

The high NDPE% of both *qudameh* and *Kalieh Iqudameh* mixture (70/30 ratio) justifies their use as food supplement for infants and as nutritious snack foods for children.

**Key Words :** Puffing, Nutritive value, Wheat, Chickpea, Protein complementation, Kalieh, Qudameh.

## INTRODUCTION

Legumes and cereals constitute an important dietary source of protein for a large segment of the World's population, particularly in countries where there is a short supply of animal protein (1). Legume proteins provide an adequate supply of the essential amino acid lysine which is the limiting amino acid in cereal proteins and thereby enhance the nutritive value of the proteins in diets made up of cereal-legume mixtures (1). Legumes and cereals naturally contain many toxic and other antinutritional substances which affect their protein quality and may be controlled by suitable cooking (2,3,4).

Wheat in Jordan is the staple food and chickpea is consumed in large quantities (5). Besides being consumed mainly as bread, wheat is also consumed in the form of a traditional product called "Kalieh" which is a puffed or roasted wheat. Similarly chickpea is consumed in many forms among which is the puffed or roasted product called "*Qudamah*" which is a popular traditional snack food.

The aim of this study was to investigate, both the effect of puffing on the wheat and chickpea protein quality and protein complementation on the nutritive value of raw and puffed wheat/chickpea mixture (70/30, w/w) was evaluated.

## MATERIALS AND METHODS

Wheat was puffed at 55°C for 90 sec after the addition of 2% water, whereas chickpea was puffed at 550°C for 2 minutes after the addition of 12% water. The proximate analysis of raw and puffed wheat and chickpea as well as their mixtures (in a ratio of 70/30, w/w) was conducted according to AOAC (1980) (6), and the protein quality was assessed using net protein utilization (NPU) according to the procedure of Miller (1963) (7). The net diatary protein (NDPE)% was calculated according to Platt et al (1961) (8).

For the determination of (NPU), two similar animal experiments were carried out using 23-day old male weanling rats of the Sprague-Dawely strain. The rats were fed a stock diet for two weeks and then divided into 8 groups of 6 rats each in the 1st run and 5 in the 2nd. The mean weight difference between any two groups did not exceed 2g. The diets were fed *ad libitum* for 13 days in the 1st run and for 12 days in the 2nd. Each rat was caged individually and maintained at a temperature of 23+1°C. One of the 8 groups (1) was fed a casein-based diet, the 2nd (II) was fed a protein-free diet, and the other 6 groups were fed the experimental diets which were as follow : raw wheat diet (III), puffed wheat - "*Kalieh*"-diet (IV), raw chickpea diet (V), puffed chickpea- "*qudamah*" - diet (VI), raw wheat/chickpea mix diet in a ratio of 70/30 (VII) and Kalieh/qudamah mix in the same ratio (VIII).

The composition of the 8 diets is shown in table 1. The animals were weighed and killed by chloroform anesthesia. The abdomin, thorax and skull were opened before they were dried in a hot-air oven set at 105°C for 48 hr (7,9). Body water was calculated and carcass nitrogen was then determined by a microckjeldahl method.

The caloric content was calculated from the proximate analysis values of the diet using the Atwater figures of 4,9 and 4 kcal/g for

carbohydrate, fat and protein respectively. The NPU operative was calculated using Miller equation (7) :

$$NPU_{op} = \frac{\text{Carcass N of the experimental group (g)} - \text{Carcass N of the control group (g)} + \text{N consumed by control group (g)}}{\text{N intake (g)}}$$

The NPU standardized was also calculated using the equation of Miller (1963) (7) and Miller and Payne (1961) (10).

$$NPU_{st} = \frac{54 \times NPU_{op}}{54 - \text{Protein energy \%}} - 8$$

Net dietary protein as a percentage of total energy (NDPE %), which is an indicator of both quality and quantity of protein, was calculated according to Miller (1963) (7).

$$NDP\% = \frac{NDP_{op}}{100} \times \frac{25 \times N\%}{\text{kcal/g}}$$

The proximate analysis of the diets was done in triplicate according to methods described by AOAC (1980) (6). Results of food consumption, weight gain and NPU were statistically analyzed using Duncan's multiple-range test (11).

**Table 1. Composition of the experimental diets fed to the 8 groups of rats (g/100g).**

| Component | Diet | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII |
| Casein | 10 | - | - | - | - | - | - | - |
| Corn starch | 72 | 82 | - | - | - | - | - | - |
| Corn Oil | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Mineral mix | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Viamin | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Food products | - | - | 82 | 82 | 82 | 82 | 82 | 82 |

## RESULTS AND DISCUSSION

Food consumption : The proximate analysis of diets is presented in table 2. The Food consumption data of the 2 runs of the experiment are shown in Table 3. The results show that there was no significant difference in food consumption due to puffing. They do not agree with those reported by many authors who found that many types of heat treatment increase food consumption of cereals and legumes (12, 13, 14, 15).

Net Protein utilization (NPU) : The nutritive value of proteins varies according to their origin, amino acid composition and digestibility (16) ; proteins of animal origin have higher quality than proteins of plant origin. Both quality and quantity of the proteins are important. NPU is a method used for the evaluation of the protein quality of foods and food mixtures (8, 17, 18). The NPU results are shown in Table 4. The NPU values of wheat and chickpea in the present study were increased by puffing. Heat treatment is generally thought to improve the nutritional value of cereals and legumes (13, 19, 20, 21). However, other authors (22, 23) reported that heat treatment of chickpea decreased the digestibility and caused amino acid loss, but adverse effects depended on the nature and severity of puffing or heat treatment. It is believed that heat treatment destroys the antinutritional factors especially trypsin inhibitor (2, 3, 4, 24) in legumes; also it is suggested that the positive effect comes from the denaturation of these proteins. These two factors result in the increase of the digestibility which improves the nutritive value of the protein. There was no significant increase in the NPU of wheat/chickpea mixture (70/30, w/w) due to puffing (NPU values of raw and puffed mixtures were 73 and 75 respectively). However, the significant increase of NPU seems to result from protein complementation due to mixing. This suggests that the positive effect on the protein nutritive value resulting from protein complementation exceeds the improvement resulting from the destruction of the antinutritional factors which are due to puffing.

Net dietary protein energy percent (NDPE %) : This is an indicator for both quality and quantity of proteins (9, 17). In the present study, it was shown that the NDPE% values of wheat, chickpea, and wheat mixtures (70/30, w/w) increased significantly as a result of puffing. Platt et al. (1961) (8) recommended NDPE% values of dietary protein mixtures of at least 8.0, 7.8, 5.9 and 4.6% for infants, toddlers, young children and adults respectively. This means that qudameh, with an NDPE% of 9.5 is suitable for feeding man in different life stages and *kalieh* has an NDPE% which is lower than the recommended values for infants and children. However the *qudameh/kalieh* mixture (30/70 ratio) seems to be suitable as a meal for adults and young children.

Therefore, *qudameh* seems to be a convenient substitute of low protein snack foods such as potato chips. It is also recommended that qudameh and/or qudameh/kalieh mixtures be used as nutritious snack foods for children and adults.

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**Table 2. Promixate analysis of the 8 diets used in the experiments.**

| Diet | Component % | | | | | | |
|---|---|---|---|---|---|---|---|
| | Moist. | Prot. | Fat. | Ash. | Fiber | NEF[2] | Energy[3] (kcal/100 g) |
| Caseir | 7.3+0.91 | 9.4+0.22 | 13.1+0.09 | 4.6+0.17 | 0.00 | 65.6 | 418 |
| Protein-free | 7.3+0.06 | 0.5+0.01 | 13.0+0.27 | 3.8+0.09 | 0.00 | 75.5 | 421 |
| Raw wheat | 8.6+0.02 | 9.3+0.09 | 14.8+0.29 | 7.1+0.26 | 1.94+0.03 | 58.3 | 404 |
| Puffed wheat | 3.2+0.03 | 9.9+0.09 | 14.4+0.10 | 5.7+0.16 | 1.93+0.03 | 64.9 | 429 |
| Raw chickpea | 6.1+0.03 | 18.3+0.17 | 17.1+0.35 | 6.3+0.14 | 2.82+0.06 | 49.4 | 425 |
| Puffed chickpea | 3.1+0.01 | 18.5+0.21 | 17.5+0.32 | 6.1+0.19 | 2.82+0.01 | 52.0 | 440 |
| Raw mix | 7.9+0.02 | 11.7+0.22 | 15.1+0.17 | 5.4+0.38 | 2.24+0.01 | 57.7 | 414 |
| Puffed mix | 3.5+0.08 | 12.3+0.19 | 15.4+0.20 | 5.7+0.46 | 2.23+0.04 | 60.9 | 431 |

1. Mean ± SEM; samples were analysed in triplicate.
2. Nitrogen free extract; calculated by difference.
3. Calculated from the values of protein, carbohydrate and fat using the Atwater figures of 4,4 and 9 kcal/g respectively.

**Table 3. Food consumption and net weight gain of rat groups fed casein, wheat chickpea and wheat/chickpea mixtures (values are combined from 2 runs of the experiment).**

| Group | Food consumption (g/day/rat) | Weight gain (g/day/rat) |
|---|---|---|
| Casein | 10.0+0.51[1] | 2.27+0.25[b] |
| Raw wheat | 9.5+.12 | 1.23+0.14[a] |
| Puffed chickpea | 10.0+0.39 | 3.39+0.18[c] |
| Raw chickpea | 10.0+0.39 | 3.39+0.18[c] |
| Puffed chickpea | 10.7+0.87 | 4.30+0.31[c] |
| Raw mix | 10.9+0.60 | 3.01+0.26[b] |
| Puffed mix | 10.1+0.45 | 3.09+0.28[c] |

1. Figures are mean + SEM; values given different letters in the same column are significantly different ($P<0.05$).

**Table 4. The net protein utilization (oparative and adjusted), protein calorie percent and net dietary protein energy percent of rats fed the diferent diets (values are combined from two runs of the experiment).**

| Group | $NPU_{op}$ | $NPU_{st}$ | Pcal% | NDPE% |
|---|---|---|---|---|
| Casein | 74+0.39[1] | 81+0.82d | 9.30+0.11 | 6.7+0.06c |
| Raw wheat | 44+0.31 | 46+0.72a | 9.22+0.05 | 4.1+0.05a |
| Puffed wehat | 50+1.47 | 53+2.06b | 9.21+0.05 | 4.6+0.16b |
| Raw chickpea | 50+0.60 | 65+0.97b | 17.24+0.08 | 8.6+0.12d |
| Puffed chickpea | 56+0.39 | 74+0.80c | 16.82+0.10 | 9.5+0.09e |
| Raw mix | 64+0.54 | 73+0.99c | 11.35+0.11 | 7.2+0.09c |
| Puffed mix | 65+0.30 | 75+0.73c | 11.43+0.09 | 7.5+0.07c |

1. Mean + S.E.M; values given different letters in the same column are significnatly different ($P<0.05$).

مجلة الإمارات للعلوم الزراعية (١٩٩٦) ٨ : ٣٠-٤٠

# أثر النفش الحراري على القيمة الغذائية لبروتينات القمح والحمص وخلطاتها.

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**ملخص :**

جرى في هذه الدراسة تقييم نوعية البروتين لكل من القمح والحمص وخلطتيهما ( بنسبة ٣٠/٧٠) وهما نيئان وبعد المعاملة بالنفش الحراري وذلك باستعمال طريقة " الاستعمال الحقيقي للبروتين " (NPU) في جرذان من صنف داولي .

وقد بينت النتائج أن التحميص لم يؤد إلى تغير معنوي في معدل كمية استهلاك الطعام أما تحميص الحمص (للحصول على القضامة ) فقد رفع الاستعمال الحقيقي المعياري للبروتين من ٦٥ الى ٧٤ (مستوى الثقة < ٠,٠١) ورفع قيم نسبة الطاقة الصافية للبروتين الغذائي (NDPE%) من ٨,٦ الى ٩,٥٪ ( مستوى الثقة < ٠,٠٠١). كما زاد تحميص القمح (لانتاج القلية) قيمة الاستعمال الحقيقي المعياري للبروتين من ٤٦ الى ٥٣ (مستوى الثقة <٠,٠٥) وقيمة الـ (NDPE%) من ٤,١ الى ٤,٦٪ ( مستوى الثقة ٠,٠١) كذلك كانت قيمة الـ NDPE% لخليط القمح والحمص المحمصين أعلى معنويا (مستوى ثقة <٠,٠٥) منها لخليطهما النيىء (٧,٥٪ و ٧,٢٪ على التوالي ) بينما لم تكن الزيادة معنوية في قيمة الاستعمال الحقيقي للبروتين نتيجة التحميص . تشير هذه النتائج إلى أن النفش الحراري لم يحسن القيمة الغذائية لبروتين القمح والحمص أكثر من التحسن الناتج عن تكامل البروتينات بسبب خلطهما معا بنسبة ٣٠/٧٠.

وتبين النتائج العالية لنسبة الطاقة الصافية لبروتينات القضامة وخلطة القلية والقضامة انهما ملائمان لتغذية البالغين والاطفال في سن ٥-١٠ سنوات ، وانهما مناسبان ايضا كغذاء اضافي للأطفال الصغار .

**كلمات مفتاحية :** النفش الحراري ، القمح ، الحمص ، القيمة الغذائية ، تكامل البروتينات .