Seasonal variation in condition and fatty acid composition of coquina clam, *Donax trunculus* (Linnaeus 1758) (Mollusca, Bivalvia) from the Tunisian coast

Variation saisonnière de l’indice de condition et de la composition en acides gras de *Donax trunculus* (Linnaeus 1758) (Mollusque, Bivalve) des côtes tunisiennes

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Running title: Fatty acids of *D. trunculus*

Keywords: Bivalves, condition index, *Donax trunculus*, fatty acids, Gulf of Tunis.
Résumé:

L’analyse saisonnière de la variation de l’indice de condition, du contenu en lipides et de la composition en acides gras du flion *Donax trunculus* (Mollusca, bivalvia) récolté dans trois stations de la côte Nord Est de la Tunisie : Borj Cedria (BC), Rades (R) et Kalaat El Andalous (KA) a été réalisée. Les lipides totaux varient entre 4,8 et 7,3%, entre 5,9 et 8,1 % et entre 5,5 et 10,8 % du poids sec respectivement chez *D. trunculus* de BC, R et KA. L’analyse de la composition en acides gras montre une prédominance des acides palmitique (C16:0), stéarique (C18:0), eicosapentaénoïque (EPA) (C20:5n-3) et docosahéxaénoïque (DHA) (C22:6n-3). Les acides gras polyinsaturés (AGPI) constituent la forme majeure des acides gras chez les *D. trunculus* des trois stations. Les pourcentages des acides gras saturés (AGS) varient inversement avec la variation des pourcentages des AGPI qui sont plus importants durant l’hiver et le printemps. Deux corrélations ont été signalées avec la variation de la température de l’eau, une négative avec les AGPI de la famille (n-3) et une positive avec les AGPI de la famille (n-6).

Abstract

The condition index, the lipid content and the fatty acid composition of the coquina clam *Donax trunculus* (Mollusc, bivalvia) sampled from three stations of the North Eastern coast of Tunisia: Borj Cedria (BC), Rades (R) and Kalaat El Andalous (KA), were analysed. Total lipid content in dry weight ranged from 4.8 to 7.3 %, from 5.9 to 8.1 % and from 5.5 to 10.8 % respectively in BC, R and KA specimens. The analysis of the fatty acid composition showed that the major fatty acids in *D. trunculus* tissues were palmitic C16:0, stearic C18:0, eicosapentaenoic (EPA) C20:5n-3 and docosahexaenoic (DHA) C22:6n-3 acids. In comparison with saturated fatty
acids (SFA) and monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) constituted the highest proportion in *D. trunculus* from different sites. SFA varied during the year inversely to the variation of PUFA which were higher in winter and spring than in summer and autumn. A negative correlation between water temperature and (n-3) PUFA was observed, whereas the (n-6) PUFAs showed a positive correlation with this variable.

1-Introduction

*Donax trunculus* (Linnaeus 1758) Mollusca: Bivalvia, is an Atlantic-Mediterranean warm-temperate species inhabiting the Mediterranean and the Black Sea (Bayed & Guillou, 1985), and the coasts from Senegal to the north Atlantic of France (Tebble, 1966). It is commercially of less interest than the oyster *Crassostrea gigas* (Thunberg, 1793) or the clam *Ruditapes decussatus* (Linnaeus, 1758) (Ruiz- Azcona et al. (1996)), although there has been a large demand for this species in many countries like Spain (Ruiz-Azcona et al. (1996)), Italy (Manca Zeichen et al. (2002)) and Portugal (Gaspar et al. (1999)). Its ecological preferences have been studied in the Mediterranean Sea, along the Algerian (Degiovanni et al. 1972), and the Israeli (Neuberger et al. 1990) coasts and along the French, Spanish and Moroccan Atlantic coasts (Ansell et al. 1980; Mazé et al. 1988; Guillou et al.1991). In the Mediterranean sea, *D. trunculus* occupies a relatively narrow zone in the shallow sub littoral in depths of few centimetres to 2 m and its distribution is limited to moderately- exposed beaches of well-graded fine sands (Mazé & Laborda, 1988). The reproductive cycle and population dynamics have been examined by Moueza & Chassel 1976; Guillou 1982; Mazé 1990; Bayed 1998, Gaspar et al. 1999; Manca Zeichen et al. 2002 and Dhaoui Ben Kheder et al. 2003. During the first year of life, at a length of
16 mm, the species is already capable of reproducing (Moueza & Frenkiel-Renault, 1973). *D.trunculus* is gonochoric; no hermaphroditism or sex reversal was encountered (Gaspar et al. 1999). Sex can easily be identified macroscopically when the gonads are fully developed, as there are differences in color: dark blue in females and yellow-white in males (Manca Zeichen et al. 2002). Generally, gametogenesis takes place during winter and spring and gamete emission starts in late spring and continues until summer (Moueza & Frenkiel-Renault, 1973; Manca Zeichen et al. (2002).

In a recent study, Dhaoui Benkheder (2003) described the general features of the reproductive cycle of *D. trunculus* in two sandy beaches located in the Gulf of Tunis: Kalâat El Andalous and Raoued. It was characterised by a large gametogenic cycle comprising two phases: a resting phase (autumn) and a gametogenic one, including ripeness and spawning, during the rest of the year. Life span of *D. trunculus* decreases with latitude: from 5 years along French Atlantic coast to 2-3 years on the Moroccan coast and Mediterranean (Gaspar et al. 1999). Ruiz-Azcona (1996) has described the larval rearing of *D trunculus* and showed that growth was greater when larvae were kept at 20°C seawater and fed with multispecies of microalgae including *Chaetoceros gracialis*.

In Tunisia, *D. trunculus* shows a large distribution with high density along the sandy beaches especially in the Gulf of Tunis coasts. These are high productive areas of exposed well-graded sandy beaches, which could be representative of the habitat of the genus (Gaspar et al. (1999); Manca Zeichen et al. (2002)).

Several authors (Martinez (1991); Orban et al. (2004)) have shown that seasonal metabolic activities in molluscs result from complex interactions among factors like food availability, growth, reproduction and
environmental parameters such as temperature. In general, when food is abundant, energy in marine bivalves is stored in the form of glycogen, protein and lipid prior to gametogenesis (Barber & Blake (1985)).

To the best of our knowledge, information concerning the quality requisites of *D. trunculus* in lipid and fatty acid composition barely exists. The aim of this work is to study the natural seasonal variations in condition index, lipids and fatty acid composition of *D. trunculus* and to examine the potential influence of some environmental parameters along the reproductive cycle.

2-Materials and methods

2-1 Sample collection and environmental parameters:

The specimens of *D. trunculus* used in this study were collected from three stations BC, R and KA situated in the gulf of Tunis (Fig. 1, tab. 1). The geological parameters of this coastal area are affected by many factors such as the presence of the Medjerda River in Kalâat El Andalous plain, Méliane River in Radès and of other minor fresh water streams. Specimens were collected using a specially designed hand dredge, at approximately monthly intervals between July 2004 and June 2005. Along the sandy beach of KA and R specimens were collected at 30 cm water depth, and from BC at a depth of 50 cm. Data on the surface water temperature and salinity of the areas of collection were measured once per sampling day (between 8 am and 10 am) using an SCT meter (Salinity, Conductivity and Temperature) (YSI-Model 33).

2-2 Biometric measurement and condition index:

Fifty adults of similar size (anteroposterior length≥ 22 mm) were collected and placed in running filtered sea water (24 hours at least) to empty their guts before being dissected and stored at – 30 °C until the analyses were carried out. Thirty individuals were randomly selected for biometric
measurements. Thickness, length and width were measured using a 0.05 mm precision calliper, and reproductive activity was assessed using Walne (1976) maturity index (condition index (CI)), based on the ratio of meat dry weight: shell dry weight \times 100. This index is commonly used to evaluate the healthy state of bivalves, and adopted in foreign trade as a quality criterion (Orban et al. 2006). The ratio also reflects the seasonal fluctuations, the gametogenic cycle and the environmental conditions (Lucas and Beninger (1985)). Soft tissues were carefully separated from shells and washed in distilled water to remove dirt. For dry weight determination, both soft tissues and shells were dried in an oven to a constant weight at 60°C.

2-3 Lipid content and fatty acid composition:

Lipids and fatty acids from coquina clams from each station were sampled seasonally (in July 04 (summer 04), October 04 (autumn 04), January 05 (winter 05) and April 05 (spring 05). Total lipid from each sample (six replicates of the whole animal per season and per station) was extracted with chloroform: methanol (2:1, v/v) using the method of Folch et al. (1957). Following solvent evaporation under nitrogen, lipids were transferred into a pre-weighed 2 ml vial. The solvent mixture was again evaporated under nitrogen and the extracts were further dried overnight in a vacuum desiccator. After weighing, lipids were redissolved in chloroform: methanol (2:1, v/v) with 0.01% butylated hydroxy toluene (BHT, Sigma-Aldrich) added as an anti-oxidant. Total lipids were expressed as g/100g dry weight (DW). Fatty acids from total lipids were acid catalysed transmethylated with toluene and 1% sulphuric acid in Methanol overnight (16 h) at 50 °C (Christie (1982)). Nonadecanoic acid (C19:0) was added to each sample as an internal standard. The resulting fatty acid methyl esters
(FAME) were extracted with hexane: diethyl ether (1:1, v/v) and purified by thin layer chromatography (TLC). The FAME were subsequently analysed by high resolution gas chromatography (GC 8000 Series, Fisons Instruments, Rodano, Italy), using a cold on-column injection system, a flame ionisation detector (FID) and a fused silica capillary column (30 m x 0.25 mm inner diameter, 0.25 µm film thickness Tracer, TR-WAX, Teknokroma, Barcelona, Spain), with Helium as a carrier gas. Oven temperature was increased from 50 to 180°C at 40°C/min and then to 220°C at 3°C/min. Peaks were recorded in a personal computer using a software package (version 4.6.0.0. Azur, Datalys, St Martin d’Heres, France). Individual FAME were separated and identified by comparison of their retention times with those of well characterized fish oils and commercial standards (FAME 37, Supelco). The relative amount of each FA was expressed as a percentage of the total amount of FA in the analyzed sample.

2-4 Statistical methods:

The results of the seasonal variations of condition index, lipids and fatty acid composition of *D. trunculus* in the three sites of collection are reported as means ± standard deviations. After checking for normality and correcting if necessary transforming data, One-Way analysis of variance (ANOVA) was performed using the STATISTICA 6.0. Tukey Honest Significant Differences (HSD) multiple comparisons test was conducted to determine differences among the means at a significance level of 5 %. The Pearson’s correlation coefficient was used to study relationships among the major fatty acids groups, the reproductive cycle and the environmental parameters.

3-Results

3-1. Temperature and salinity
The mean sea water temperature and salinity are shown in (Fig. 2). The water temperature followed the same trend for the three sampling sites: the highest temperature was recorded during July 2004 in R (30 °C) and KA (27 °C), and during August 2004 in BC (27 °C), whereas The minimum temperature of 7°C, 8.5°C and 9.5 °C was measured during January 2005 respectively in BC, R and KA sea water.

Over the sampling period, salinity depended on the amount of rainfall, and also on the fresh water outflow from the rivers. It ranged from 34 to 39 ‰, from 23 to 38 ‰ and from 32.5 to 38.5 ‰ respectively in BC, R and KA water surfaces. In fact, the Gulf of Tunis is influenced by the discharge of Medjerda and Méliane wadi respectively in KA plain and R beach, this may explain the sharp decrease of the salinity registered in February (23 ‰) and May (28 ‰) in R. During these periods of the year precipitations were abundant and more frequent.

3-2. Biometrics and condition index

The biometrics of *D. trunculus* harvested along the gulf of Tunisia during the experimental period, showed that the length of specimens ranged from 23 mm to 32 mm (table 2). The evolution of the reproductive activity was followed through CI in mature individuals (Shell length > 16 mm) (Fig.3a). A steady increase in the index was observed since late summer. This increasing trend continued until winter for R specimens and until autumn for BC and KA specimens. During winter, the CI rose progressively until reaching the spring values for the sexually ripe BC and KA animals. Since autumn, CI remained more or less constant throughout the season for R *D. trunculus*. The change in percentage dry weight followed closely the seasonal changes in CI. In fact, the decrease in the CI values in summer and late autumn corresponded to the loss of dry weight (Fig. 3b).
3.3. Lipid content

Seasonal total lipid content (TLC) in *D. trunculus* from the three sampling sites ranged from 4.8 to 7.3, from 5.9 to 8.1 and from 5.6 to 10.8 g/100g DW respectively in BC, R and KA (fig. 3c). The highest TLC was registered during the summer in R and KA and during the winter in BC. This winter value coincides with the gametogenesis period of *D. trunculus* (reserve accumulation). The summer lipid content in KA specimens was significantly higher than those of autumn, winter and spring. In contrast there was no variation in the TLC of the *Donax* sampled in R and BC throughout the season.

3.4. Fatty acid composition

PUFA of *D. trunculus* harvested from the three sites were generally the major forms of fatty acids during the year followed by SFA (Table 3). The PUFA showed a similar pattern in the individuals harvested from the different sites. They were generally low during summer (31.6 ± 2 % in R, 32.9 ± 1.8 % in KA and 38.7 ± 2.2 % in BC) and increased continuously until reaching significantly higher values during winter in BC (46 ± 2.2 %) and during spring in R (39.5 ± 2 %) and KA (38 ± 2 %). No differences were obtained between winter and spring PUFA percentages except for the KA clams that showed autumn (33 ± 2%) and winter (34.7 ± 5.7%) PUFA values more similar than winter and spring ones. In view of the high standard deviations registered in winter it could be argued that PUFA from KA clams followed a slightly different trend than those from BC and R.

SFA had an irregular seasonal trend in the individuals from the three sampling stations. They varied seasonally in BC and R specimens and remained more or less stable throughout the season in KA. The significantly lowest values were registered during winter (25.8 ± 1.3 %, 28.8 ± 1.9 % for
R and BC respectively), whereas the highest ones were measured in autumn
and summer in R \( (32.5 \pm 1.1 \%) \) and BC \( (34.7 \pm 2.4 \%) \) specimens
respectively.

MUFA represent the lowest proportion of total fatty acids. No significant
seasonal changes were observed in BC and KA clams, whereas in R, MUFA
registered in autumn were significantly lower than those of winter and
spring.

SFA, MUFA and PUFA differed significantly among stations. In fact, SFA
and MUFA obtained in R differed significantly from SFA and MUFA from
KA clams, whereas PUFA from BC clams were significantly higher than
those of R and KA.

The fatty acid analyses showed that among SFA, C14:0, C16:0 and C18:0
were present at the highest levels through all seasons. The level of MUFA
was highly dependent of the levels of C16:1n-7, C18:1n-9; C18:1n-7 and
C20:1n-9. The most abundant PUFA were C20:5n-3 (EPA), C22:5n-3
(DPA) and C22:6n-3 (DHA) followed by the arachidonic acid (C20:4n-6),
prefector of eicosaenoids. The seasonal profile of C18:3n-3, C20:5n-3 and
C22:6n-3 reflected that of total PUFA, which varied significantly during the
seasons in BC and R specimens, DHA being the major PUFA. A
comparison of n-3 PUFA and n-6 PUFA suggests that n-3 PUFA were in
significantly higher proportion, and n-6 PUFA contained higher percentages
of C20:4n-6 than C18:2n-6 and C20:2n-6. The correlations between (n-3)
PUFA and temperature were negative \( (r = -0.86, p = 0.0000003 \) in R, \( r = -0.68, p = 0.0006 \) in BC, \( r = -0.47, p = 0.02 \) in KA). However, (n-6) PUFA
showed a positive correlation with this variable \( (r = +0.68, p = 0.0004 \) in
KA), \( (r = +0.73, p = 0.0001 \) in R) and \( (r = +0.527, p = 0.014 \) in BC). The
total (n-6) PUFA and (n-3) PUFA from the individuals collected at the three
sites showed a positive correlation with C18:2n-6 and C18:3n-3 respectively. No correlation was found between C20:5n-3 and C22:6n-3 fatty acids.

Two C22 dienoic, C22:2i and C22: 2j, acids appeared successively between the C22:1n-9 and C22:5n-6. They were probably non-methylene interrupted dienoic (NMID) FA with two double bounds. These FA are seemingly ubiquitous lipid mollusc components (Ojea et al., 2004). They were present at low percentages: between 0.4 % and 4.3 % in all samples. The increase in C22:2j percentages coincided with a decrease in the EPA of *D. trunculus* from the three stations (*r* = - 0.734, -0.553, -0.526 for BC, KA and R) whereas an increase in C22:2i coincided with a decrease in the levels of DHA only in R clams (*r* = - 0.657).

4-Discussion:

4-1. Biometric characteristics and condition index

It is well known that CI is influenced by seasonal factors, including sexual maturity and food availability (Matozzo et al. 2005). At the beginning of the spawning period when temperature was highest (during summer), the values of CI were lowest and coincided with the minimum values of dry weight in the different sites. This decrease in CI values may reflect the major biological effort expended in the production and release of gametes. The tissue dry weight increased gradually during spring (gametogenesis period) in the three sites, while the CI remained more or less constant in R and KA coquina clams because the shell and body growth occurred throughout this period (Gaspar et al. 1999). At the beginning of autumn, the abundance of food available in the sampling area allowed recovery of the tissue dry weight which was accompanied by an increase in the values of CI. According to Laruelle et al. 1994, who worked on *R. decussatus*,...
temperature has a positive effect on gametogenesis. It may have a direct
effect on the metabolic rate of the animal, but also an indirect effect through
the availability of food, since the maximum rate of increase in weight occurs
during spring, when both the sea temperature and food supply increase
rapidly. In the work of Ruiz Azcona, 1996, *D. trunculus* was thermally
induced to spawn at 25°C which corresponds to the temperature reached in
summer in the three sampling areas of our study. Similar observations of
temperature effect on gametogenesis have been made by Lubet (1976) for
populations of *Ostrea edulis* (Linnaeus, 1758) from the Atlantic coast of
France and by Mann (1979) for *O. edulis* under laboratory conditions.
Salinity in the Gulf of Tunis was relatively stable throughout the year. It
only declines in winter especially in R coinciding with especially rainy
periods. Apparently, the fluctuations observed did not have an important
effect on *D. trunculus* reproduction. Similar results have been reported for
oysters from San Cibran (Galicia, Spain) (Ruiz et al. 1992).
Several authors showed that gametogenesis and spawning of *D. trunculus*
may all have proceeded together (Ansell et al. 1980, Bayed 1990 and
Gaspar et al. 1999). During most of the year, mature individuals in
gametogenic phase can be present together with individuals in resting phase.
This could explain the high levels of standard deviations registered in the
percentages of dry weight during the year. Similar observations on the
reproductive cycle of *D. trunculus* were made by Moueza and Frenkiel-
Renault (1973) in the Mediterranean sea (Azur Plage, the Algerian coast),
by Gaspar et al. (1999) in the Atlantic (off Faro, Southern Portugal), and
Bayed et al. (1990) in the Moroccan Atlantic coast. It is generally accepted
that, aside from gametogenic cycle influences, the blooming of
phytoplankton during the year may affect the CI and the biochemical
composition of bivalves relaying on plankton as the main food source (Pollero and Brenner (1979)). For this reason the availability of food represents a very important factor to take into account.

4-2. Lipid content

The comparatively high lipid levels of *D. trunculus* from the three locations during summer (spawning season) indicate that lipids may play some role in the maturation of gametes (Awaji and Suzuki (1999)), similar to that in finfishes (Henderson et al. (1984)). Besides, the higher lipid contents in summer suggest that the warm seawater might have promoted accumulation of lipids, perhaps related to a high metabolic activity in this season. In fact, Mackie and Ansell (1993) reported that environmental factors apparently play a dominant role in determining events in the storage cycles of bivalves. Similar variations were found by Ansell et al. 1980 in *D. trunculus* from Azur Plage (Algerian coast) and indicated that the highest values of the lipid content increased during summer in sexually ripe animals, and decreased in autumn and winter. In this study, the mean lipid contents were low, similar to those observed also for *D. trunculus* by Ansell et al. (1980) and for other bivalves like *Pinctada fucata* (Gould 1850) by Saito (2004) and for *C. gigas* by Dunstan et al. (1993).

The variation of lipid content could be explained by the abundance and quality of the available food in the environment at a period of phytoplanktonic bloom, and by the accumulation or utilization of lipid reserves prior to gametogenesis. It should be emphasized that the period of lipid increase in specimens from BC (winter), coincides generally with the gonadal maturation, whereas the decrease in lipid content during autumn and spring could also be associated to its utilization for metabolic energy purposes.
4-3. Fatty acids:

The results of the variations in fatty acids composition during this study clearly indicate that PUFA, especially DHA were generally the predominant forms of fatty acids measured in *D. trunculus* from the three stations. This has also been reported for other bivalves, such as *R. decussatus* (Ojea et al. (2004)) and oyster *C. gigas* (Dridi et al. (2007)).

The seasonal variations of PUFA could hardly be correlated with the different phases of the annual reproductive cycle of the animals and with temperature, although the highest values registered in winter (for BC specimens) and spring (for R and KA) just preceded the more regular spawning period which occurred in late spring and during summer. This may explain the main function of these fatty acids in gamete formation.

During the period under study, *D. trunculus* was characterised by high levels of n-3 PUFA (24.5 - 34.9, 19.5 - 31.2, 21.1 - 29.7 % of total fatty acids for the individuals from BC, R and KA respectively). These are important FA in the human diet, especially for their prevention of cardiovascular diseases. Low levels of n-6 PUFA (6.4 - 9.7, 5.6 - 7.8, 6 - 7.7% of total fatty acids in specimens from BC, R and KA respectively) together with relatively high n-3/n-6 PUFA ratios (3.5 - 5.6 in BC, 2.8 - 7.4 in R and 3.3 - 5.6 in KA) contribute to a positive bromatological evaluation of the lipid quality of *D. trunculus* from the South coast of the Mediterranean Sea (Gulf of Tunis).

Taking into account the low lipid content of the three *D. trunculus* populations, it may be assumed that the high percentages of EPA and especially DHA in their total lipid fraction reflect the preferential association of these fatty acids with phospholipids in cell membranes, as reported in the bivalve *Chamelea gallina* (Linnaeus, 1758) by Orban et al.
These FA are implicated in the structure and function of cell membranes (Pazos et al. (2003)). The DHA and EPA peaked in spring and winter, coinciding with the period of gametogenesis. The same result was reported by Abad et al. (1995) and Dridi et al. (2007) for the oyster.

The two C22 NMID were present at low percentages (between 0.4 % and 4.3 %) in all samples. The role of 22:2 NMID is unknown, but the association with membrane lipids and the selective retention in starved animals suggests a structural/metabolic function and/or a strong resistance against degradation (Klingensmith (1982)). Molluscs have generally active FA elongation and desaturation systems permitting the de novo synthesis of NMID FA. These are the only PUFA that are synthesized by marine molluscs (Abad et al. (1995); Ojea et al. (2004)). Zhukova (1991) proposed that the biosynthesis of these FA occurs via the n-7 MUFA pathway until C20:1n-7, which is desaturated by ∆5 desaturase to C20:2n-5 and then elongated to C22: 2n-7. It is possible that facing a deficiency of dietary unsaturated FA, including the n-3 and n-6 PUFA, the molluscs synthetize NMID FA to support the necessary fluidity of the cell membrane (Abad et al. (1995)). In fact, Ojea et al. (2004) reported that 22:2i and 22:2j in the polar lipids of R. decussatus were negatively correlated with EPA, and 22:2j was also negatively correlated with DHA. In other study, Klingensmith (1982) found an inverse relationship between n-3 PUFA, especially EPA and DHA, and NMID FA in the clam Mercenaria mercenaria (Linnaeus, 1758). Similarly, in the present work, the increase in C22:2j and C22:2i coincides with low levels of EPA and DHA respectively. The increased PUFA, at colder temperature during winter and spring is mainly correlated with the high n-3 PUFA concentration especially EPA
and DHA. It has been reported that PUFA content in fish and shellfish varies inversely with water temperature (Chu and Greaves (1991); Ingemansson et al. (1993)). Several authors (Sargent (1976); Holland (1978); Dunstan et al. (1999)) pointed out that a decrease in temperature produces generally an increase in PUFA and a decrease of SFA in order to maintain the fluidity of the cell membranes.

In conclusion, the seasonal changes observed in lipids and FA composition of *D. trunculus* from the Gulf of Tunis (the Mediterranean coast of Tunisia) follows a trend typical of bivalve molluscs. In fact, apart from influences of the reproductive cycle, the coquina clam *D. trunculus*, like the filter-feeders on phytoplankton and suspended particulate organic matter are highly dependent on the dietary resources available in their immediate habitat, and therefore on the water temperature. Due to their low lipid and high percentage of healthy n-3 PUFA especially in winter and spring (periods of reserve accumulation), *D. trunculus* can be considered as a food item with interesting dietetic properties.

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Figure legends:

Figure 1: Localisation of the three sampling sites in the Gulf of Tunis (North Tunisia).

Figure 1: Localisation des trois stations d’étude dans le Golfe de Tunis (Nord de la Tunisie)

Figure 2: Monthly variation of water temperature and salinity in Borj Cedria (BC), Radès (R) and Kalâat El Andalous (KA) during the year 2004-2005.

Figure 2: Variation mensuelle de la température et de la salinité de l’eau dans les stations de Borj Cedria (BC), Radès (R) et Kalâat El Andalous (KA).

Figure 3: Seasonal variations in Condition Index (a), percentage of dry weight (b) and Lipids (g/100g DW) (c) in D. trunculus from Borj Cedria (BC), Radès (R) and Kalâat El Andalous (KA) during the year 2004-2005.

Figure 3: variation saisonnière de l’indice de condition (a), des pourcentages de la matière sèche (b) et du contenu en lipides (g/100g PS) (c) chez D. trunculus de Borj Cedria (BC), Rades (R) et Kalâat El Andalous (KA).
Table legends:

Table 1: Geographic position of Borj Cedria (BC), Radès (R) and Kalâat El Andalous (KA) in the Gulf of Tunis.

Tableau 1: Position géographique de Borj Cedria (BC), Radès (R) et Kalaat El Andalous (KA) dans le Golfe de Tunis.

Table 2: Seasonal biometric characteristics of the shells of coquina clam Donax trunculus harvested from Borj Cedria (BC), Radès (R) and Kalâat El Andalous (KA) during the year 2004-2005.

Moyenne de 30 individus ± écartypes

Table 3: Seasonal variations of the fatty acid composition (% of total fatty acids, means of six replicates ± standard deviation) in the total mass of D. trunculus harvested from Radès (R), Kalâat El Andalous (KA) and Borj Cedria (BC) during 2004-2005.

Figure 1
Figure 3

(a) Condition index

(b) % Dry weight

(c) g/100g DW
Table 1

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Table 2

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<td>14.6 ±0.7</td>
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<td>Fatty acids</td>
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**Table 3**
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<th>Lipids</th>
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